Multiple Framework Contract for the Support to Structural Reforms in EU Member States

Lot 1: Support for the development and implementation of reforms

Digital Transformation of the Greek Industry

Deliverable 1:
Report on the Current Situation – digitisation in Greek Industry and international trends

February 2021

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European Commission

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Contents

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List of Abbreviations

The following Abbreviations list contains all the key terms contained in the document in order to provide a clear view of the terminology used throughout.

3D	Three-dimensional
ACTPHAST 4.0	Access Centre for Photonics Innovation Solutions and Technology Support
AG	Arbeitsgemeinschaft (Working Group)
Agri	Agriculture
AI	Artificial Intelligence
AM	Additive Manufacturing
API	Application programming interface
AR	Augmented reality
BDSF	Belgium Digital Skills Fund
BLS	Bureau of Labor Statistic
BMBF	Bundesministerium für Bildung und Forschung (Germany's Federal Ministry of Education and Research)
BMWI	Bundesministerium für Wirtschaft und Energie (Germany's Federal Ministry for Economic Affairs and Energy)
CAGR	Compounded Annual Growth
CapEx	Capital Expenditures
CAPITAL	Collaborative capacity program on ITS Training-education and liaison
CDW	Construction and demolition mineral waste
CE	European Conformity
CERT	Computer emergency response teams
Cobots	Cooperating Robots
CPPS	Cyber Physical Production Systems
CRM	Customer Relationship Management
CS4IR	Fourth Industrial Revolution Initiative
CSIRT	Computer Security Incident Response Team
C-suite	Chief Executive Suite
CVD	Chemical vapor deposition
DCAT	Data Catalog Application Profile
DEI	Digitising European Industry
DEOI	Digital Economic Opportunity Index
DESI	Digital Economy and Society Index
DigComp	Digital Competence Framework
DIH	Digital Innovation Hubs
DMI	Digital Manufacturing Index
DTEI	Digital Transformation Enablers Index
DTII	Digital Technology Integration Index
DTM	Digital Transformation Monitor
DTS	Digital Transformation Scoreboard
e.g.	Example given

EBP	European Blockchain Partnership
EC	European Commission
ECHORD++	European Coordination Hub for Open Robotics Development
e-commerce	Electronic Commerce
ECS	Electronic Components and Systems
ECSEL	Electronic Components and Systems for European Leadership
e-Documents	Electronic Documents
EEG	Electroencephalography
e-Forms	Electronic Forms
EGDI	eGovernment Development Index
EGE	European Group on Ethics
eGovernment	Electronic Government
EIB	European Investment Bank
e-ID	Electronic ID
EIF	European Investment Fund
eInvoicing	Electronic Invoicing
EIS	European Innovation Scoreboard
ENISA	EU Agency for cybersecurity
EOPPEP	National Greek Certification Organisation
EPAnEK	Operational Programme “Competitiveness, Entrepreneurship & Innovation
ERDF	European Regional Development Fund
ERP	Enterprise Resource Planning
ESA	European Space Agency
ESF	European Social Fund
etc.	Et cetera
EU	European Union
EU 28	European Union 28
Euros	EUR
EY	Ernst & Young
FCA	Financial Conduct Authority
FH	Fachhochscule
FinTech	Financial Technology
FoF	Factories of the Future
FOP	Future of Production
FTE	Full time equivalent
FTTP	Fibre to the Premises
GB	Gigabyte
GBP	Great British Pounds
GCI	Global Cybersecurity Index
GCloud	Government Cloud
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GE	General Electric

GM	General Motors
Gmbh	Gesellschaft mit beschränkter Haftung
GSRT	General Secretariat for Research & Technology
HFE	Hellenic Federation of Enterprises
HMI	human-machine interface
HOU	Hellenic Open University
HPC	High-performance computing
Hphos	Hellenic Photonics Clusters
HR	Human Resources
HSA	Hellenic Space Agency
HVMC	High Value Manufacturing Catapult
i.e.	Id est
I4.0	Industry 4.0
ICT	Information and Communications Technology
IDC	International Data Corporation
Idf	Industrie du Futur
IDI	ICT Development Index
IIoT	Industrial Internet of Things
ILT	Institute of Laser Technology
INCIBE	Spanish National Cybersecurity Institute
Industry 4.0	Fourth Industrial Revolution
IoNT	Internet of Nano Things
IoT	Internet of Things
ISO	International Organisation for Standardisation
IT	Information Technology
JRC	Joint Research Centre
KEEE	Union of Hellenic Chambers
km/hour	Kilometres per hour
KWh	Kilowatt hours
LED	Light Emitting Diode
M2M	Machine-to-machine
MBps	Megabytes per second
MEMS	Microelectromechanical systems
MES	Manufacturing Execution System
MIA-RTDI	Managing and Implementation Authority for Research, Technological Development and Innovation
MINECO	Ministry of Economy and Investments
MNO	Mobile Network Operator
MOOCs	Massive Open Online Courses
NACE	National Association of Corrosion Engineers
NCS	National cybersecurity strategies
NDS	Greek National Digital Strategy
NEMS	Nanoelectromechanical systems
NGA	Next Generation Access

NGO	Non-governmental organisation
NIS	Network and Information Security
NRI	Networked Readiness Index
NSRF	National Strategic Reference Framework
OpEX	Operational Expenditures
OSS	open source software
P&G	Procter & Gamble
P2030	Produktion 2030
PCT	Patent Cooperation Treaty
PhD	Doctor of Philosophy
PISA	Program of International Student Assessment
PPP	Public-Private Partnership
PVD	Physical Vapor Deposition
R&D	Research and Development
RBVC	Robert Bosch Venture Capital
Rev.	Revision
RFID	Radio-frequency identification technologies
RIS3 Strategy	Research and Innovation Strategy for Smart Specialisation
RWTH	Rheinisch-Westfälische Technische Hochschule (Research university in Aachen, Germany)
SAE	Smart Anything Everywhere
SC	South Carolina
SCADA	Supervisory control and data acquisition
SEAD	Secretary of State for Digital Advancement
SEE-ITS	Intelligent Transportation Systems in South-East Europe
SESAME NET	Supercomputing Exercise for SMEs
SEV	Greek Industries Association
SFBB	Superfast Broadband
SI	Smart Industry
SIM	Subscriber identity module
SLP	Short Learning Programmes
SME	Small Medium Enterprises
SPIRE	Sustainable Process Industry
STEM	Science, Technology, Engineering and Mathematics
TO	Thematic Objective
UFBB	Ultrafast Broadband
UI	User Interface
UK	United Kingdom
US	United States
USD	United States Dollars
USPTO	United States Patent and Trademark Office
VC	Venture Capital
VET	Vocational education and training
VIPKC	Virtual Engineering Industry Competition Centre

VR	Virtual Reality
WEF	World Economic Forum
WG	Working Group
WGI	Worldwide Governance Indicators
YoY	Year over Year

1 Introduction to Deliverable 1

General information

This report was prepared in the context of the project "Digital Transformation of the Greek Industry" funded by the EU via the Structural Reform Support Programme. This present document constitutes the second draft of the first Deliverable of the project, titled "*Deliverable 1: Report on the Current Situation – digitisation in Greek Industry and international trends*". This report was shaped based on a number of studies cited across the document as well as extensive bibliographic research both with regards to EU's and Greece's Industry 4.0 As-I situation, on a dedicated Industry 4.0 survey ran by the Ministry of Development and Investments, PwC and Accenture and on the technical meetings that were conducted with the Ministry of Development and Investments project team (on 4/10, 01/11, 07/11, 14/11, 19/11 and 17/12 of 2019) as well as the Workshops with Federations of the Greek industry on 11/12/2019 and the technical meetings with the General Secretariat for Research and Technology (10/01/2020), the Ministry of Digital Governance (13/01/2020), the General Secretariat for Public Investments (13/01/2020) and the Hellenic Clothing Industry Association (13/01/2020).

Setting the scene

We live in exponential times, where digital disruption has a profound effect on the way we live and work. In this era of constant change, digital transformation is no longer a matter of choice, but rather a prerequisite for the survival of companies, economies and entire societies. As digitalisation increasingly pervades and converges industries, an entirely new industrial paradigm is emerging: "Industry 4.0". Industry 4.0 is expected to create up to $3.7 trillion in value by 2025.[1] Industries around the world are transforming to increase their productivity and economic performance to ensure social progress. Digital is at the heart of this transformation and can offer unprecedented opportunities.

The Industry 4.0 frontrunners embrace disruption as part of their DNA and inspire people with a vision of how technology enables work to be done differently so that organisations and societies can prosper.

Greece shall move quickly and effectively to manage an accelerated rotation. For this reason, the country needs to embrace a national digital vision and align it with an actionable plan that will positively impact the growth of its economy and its overall prosperity.

However, in order to realize where we want to go, we first need to understand where we currently stand.

This is the scope of our first deliverable. Deliverable 1: "Report on the Current Situation – Digitisation in Greek Industry and International trends" aims at introducing the concept of "Industry 4.0" and demystify the key technological advancements that define this. Having set the context of what Industry 4.0 means, this report explains how Industry 4.0 "reinvents" the products, transforms companies' operating models, democratizes work, shifts value across the value chains and impacts the wider society.

Deliverable 1 also focuses on surfacing the Industry 4.0 state of play across Greece's EU counterparts and highlighting best practices at a national and organisational level, that could act as inspiration for the Greek economy and its businesses.

[1] WEF, The Next Economic Growth Engine Scaling Fourth Industrial Revolution Technologies in Production, http://www3.weforum.org/docs/WEF_Technology_and_Innovation_The_Next_Economic_Growth_Engine.pdf

Finally, the report concludes with the depiction of Greece's Industry 4.0 anatomy both at a national and at an industry level. This enables us to understand the current Industry 4.0 state of play for Greece and easily compare it with its European counterparts, in order to conclude to a set of key observations for Greece's current Industry 4.0 state of play.

Content of the report

The report is structured in the following way:

- **Chapter 1** provides a brief introduction to the report which includes details about its scope, date of publication and authors, in addition to a summary of the content explored within each chapter.
- **Chapter 2** consists of the report's Executive Summary, which summarizes the key takeaways and communicates their value to all the stakeholders involved.
- **Chapter 3** demonstrates the economic significance of industry and manufacturing and analyses industrial growth, trade, and employment trends for the European and Greek economies respectively while zooming into economic activity on the sub sectoral level of manufacturing.
- **Chapter 4** is an introduction to the essence of Industry 4.0, defining its overall concept and presenting key global technology trends in the field.
- **Chapter 5** dives deeper to examine how Industry 4.0 transforms the existing industrial paradigm through reinventing products and services as well as business models and operating models. It also examines Industry 4.0's socioeconomic impact in the workplace and in society as a whole and analyses the ways in which it shifts value across value chains while surfacing new ecosystems.
- **Chapter 6** presents and analyses the current state-of-play of EU countries and the domestic state-of-play of Greece with regards to Industry 4.0. The chapter leverages data from the Digital Economy and Society Index (DESI), the Digital Economic Opportunity Index (DEOI), and the Readiness for the Future of Production Index (FOP) to illustrate digitalisation trends in each country. The chapter then zooms in to the industrial level of analysis. Finally, the chapter analyses key industry 4.0 enabling factors on the domestic and EU level (use of advanced digital technologies, digital infrastructure, etc.).
- **Chapter 7** reviews the national Industry 4.0 strategies currently under implementation in the EU and deep dives on Industry 4.0 best practices for three EU countries. The chapter also focuses on the five DEI pillars in the EU and Greece respectively, presenting a blueprint of Greece's industrial digital performance across all important dimensions, while showcasing initiatives currently in place within each pillar.
- **Chapter 8** analyses the current mechanism, policy mix and measures targeted at Industry 4.0 for the case of Greece. The chapter elaborates on the current funding schemes in Greece which focus on the digitalisation of domestic industry. Finally, the chapter also sets the stage on key stakeholders within the Greek environment that should have a defining participation in the digital transformation of the Greek industry.

- **Chapter 9** showcases the results of the Industry 4.0 Survey launched by the Ministry of Development and Investments, PwC and Accenture in order to capture the perception of organisations within the Greek industry with regards to their I4.0 readiness.
- **Chapter 10 (Appendix I)** includes further data and graphical representations relating to the adoption of advanced technologies and applications, the level of digital knowledge of the population and industrial workforce, the state of digital infrastructure, and the state of integrated eGovernment applications in the EU and Greece respectively.
- **Chapter 11 (Appendix II)** includes our approach regarding the Industry 4.0 Survey, presenting its scope, sample, methodology and all other related information including detailed graphical representations of the survey's findings.

Key messages from Deliverable 1

In these first two pages, we summarize the key messages deriving from Deliverable 1, in order to help the reader better summarize key findings and better navigate throughout the text.

The role of the Industry & manufacturing in the global, European and Greek economy

- Industry is a central pillar to the development of national economies and to the acceleration of economic growth.
- Industry consists the backbone of the European economy. Europe's global competitive advantage on the production of industrial products translated to 25% of the EU's total value-added in 2018, while EU Industry's employment accounted for 22% of total employment in the EU for 2018.
- Industry also plays an important role in the overall Greek economy, as it generated 17,5% of the total Gross value added in 2018 and employed 14% of the total Greek workforce in the same year. In addition, looking at the development of the Greek industrial production from 2013 – 2018 and its projections for 2019 and 2020, a continuous increase is noted since 2015.

The change of the existing industrial paradigm and the socioeconomic impact of Industry 4.0

- Industry 4.0 creates a "tectonic" tilt on the industrial paradigm. Through the reinvention of products, the transformation of organisations' operating models, the introduction of new business models, the "democratisation" of work and the emergence of new ecosystems that disrupt traditional value chains, enterprises throughout the world are able to significantly improve their top and bottom lines. Namely, Industry 4.0 enables organisations to:
    - Increase their revenues and grow through introducing new, innovative products & services, entering into new markets and expanding their presence in new channels
    - Improve customer satisfaction and increase customer penetration and retention
    - Optimize their cost structure and achieve reduced labour costs and increased workforce productivity

Industry 4.0: State of Play in EU countries & Greece

- Countries around the world have started responding to this new Industry 4.0 paradigm, albeit at a variable degree.
- Zooming into Greece, the country lags behind across the adoption of Industry 4.0 and digital technologies and applications
- Exception to Greece's overall low digital maturity is the strength that the country demonstrates on the use of big data analytics. In fact, Greek companies have understood that data is the new digital capital and increasingly exploit the potential of Big Data Analytics.
- Greece's suboptimal position with regards to its digital infrastructure and the provision of digital public services, prevent the Greek enterprises from rapidly adopting new Industry 4.0 technologies and supporting their technology needs

- With regards to human capital, Greece's limited digital skills across its society is also considered a structural inhibitor towards the country's rotation towards Industry 4.0. Nevertheless, if we zoom into Greece's tertiary education, we observe that Greece demonstrates a technically adept human capital, with an overall high number of tertiary graduates and an adequate number of ICT and STEM graduates. These society segments could be leveraged to instigate the Greek Industry's digitisation
- Greek enterprises have performed thus far limited investments regarding in the digital upskilling and reskilling of their industrial workforce. At the same time, the Greek Government does not have in place a structured mechanism to measure the effectiveness of the undertaken digital skills initiatives
- Focusing into the R&D and innovation area, evidence indicates that Greece is home to a burgeoning start-up & Digital Innovation Hubs scene. Nevertheless, at the same time the country ranks low against its EU counterparts both with regards to its R&D investments, as well as regarding the overall number of the issued Greek patents. In addition, R&D appears disassociated with applied research & industry implementation. Contrary to the EU average, where the business sector appears highly involved in R&D, the Greek R&D is mainly dominated by the higher education sector, while Greek organisations appear reluctant to invest in applied R&D
- To reverse this, both the European Commission and the Greek Government actively support the innovation in the Greek Industry through the provision of targeted funding schemes
- The Greek Government has already undertaken a set of measures to transform Greece's regulatory environment through the introduction of a set of directives on digital technologies and a set of laws (i.e. 4622/2019 and 4635/2019) for the simplification and reorganisation of Greece's public administration and for boosting and assisting the Greek business environment
- Nevertheless, Greek enterprises still face structural and regulatory obstacles during their setup and operations, with processes around "dealing with construction permits", "registering property", "getting credit" and "enforcing contracts" scoring particularly low across the annual report on the ease of "Doing Business" for 2020
- Finally, looking at the circular economy, Greece is Europe's lowest ranking country, with regards to the average circular use of materials

EU Industry 4.0 strategies and initiatives & Greek Initiatives towards an industry 40 economy and society

- To support and accelerate the digitisation of their Industries, Governments all over Europe have architected national Industry 4.0 strategies and adopted relevant initiatives
- Although, every country's plan differs significantly with regards to its strategic focus, key audience, policy design, implementation approach, and funding approaches, there are some common traits and characteristics with regards to how these 16 countries have architected their Industry 4.0 strategies. These traits shall also be used for architecting Greece's Industry 4.0 strategy

- In parallel with national Industry 4.0 initiatives, the European Commission acknowledged the new, tremendous opportunities that Industry 4.0 can bring to the European industry. In this context, it launched the Digitising European Industry initiative (DEI) in April 2016. The DEI initiative introduces a framework for the effective coordination between national and EU-level initiatives and promotes relevant policy actions including investments in digital innovation capabilities. In addition, it focuses on the development of ICT standards, explores the creation of favourable regulatory conditions and promotes specific initiatives for the upskilling and reskilling of the human capital.
- Contrary to most of its EU counterparts, Greece lacks a holistic national Industry 4.0 strategy and a structured mechanism to coordinate Industry 4.0 programmes and initiatives. Nevertheless, the new Greek Government has reinvigorated interest in digital and actively supports the digitisation of the Greek Industry. In addition, Greece has already implemented a set of measures, policies and mechanisms, to support the digital transformation of the Greek Industry

Organisations’ perception on their Industry 4.0 capabilities

- The surveyed Greek executives recognize the significance of Industry 4.0 and the changing of the industrial paradigm
- Greek executives perceive their organisations’ increased productivity as the most important direct benefit from implementing Industry 4.0 technologies
- The surveyed Greek enterprises have already adopted a set of Industry 4.0 technologies, albeit at a variable degree. In fact, an alarmingly high percentage of them have not invested yet in any Industry 4.0 technology
- Out of the total set of technologies that underpin the concept of Industry 4.0, Greek organisations appear to currently focus their attention primarily on cloud, cybersecurity, big data analytics and manufacturing-dedicated systems, i.e. SCADA and MES
- Greek executives appear to have initiated their Industry 4.0 transformation, starting mainly from the digitisation of their organisations’ support functions, their Marketing & Sales and their production divisions. Moving forward, the majority of them plan to dedicate additional funding on the digitisation of their production and product development divisions.
- Enterprises’ production lines demonstrate a limited degree of digitisation, although the majority of the respondents claim to have revamped their production equipment during the last two years
- The Greek surveyed executives face multiple challenges during their rotation to Industry 4.0, with the lack of digital skills for implementing Industry 4.0, the limited time to experiment, test and implement new Industry 4.0 technologies, the low level of their clients’ readiness with regards to Industry 4.0 practices and the lack of technical knowhow in implementing Industry 4.0 capabilities being identified as the four top-of-mind challenges
- Greek surveyed executives verify the limited digital skills currently existing in the Greek market. Only 17% of the Greek executives believe that their workforce is currently digitally adept to correspond to the emerging Industry 4.0 needs, with major upskilling required mainly on new technologies, complex problem-solving and soft skills

- The most highly sourced digital skills in the future appear to be around Artificial Intelligence, Cloud, Big Data Analytics and Cybersecurity
- Greek executives welcome the support of the Greek Government to further enable their organisations' digitisation. The deployment of a modern technological infrastructure (e.g. 5G, integrated national fibre optic broadband and wireless networks), the provision of relevant tax incentives and the provision of technical expertise for the design and implementation of Industry 4.0 initiatives are quoted as the most important incentives that the Government should provide

2 Executive Summary

Industry is vital for the global, EU & Greek economy

Industry is a central pillar to the development of national economies and to the acceleration of economic growth. In fact, there is evidence that countries with strong industrial sector have shown more economic growth, had improved national income, promoted living standard of people and decreased unemployment. According to the World Bank, Industry in 2017 contributed 25,4% of the world's total GDP, while the employment in the industry sector reached 23,08% of the worldwide employment.[2] At the same time, exports of goods, which is the key output of Industry, reached the $17,52 trillion.[3]

Industry consists the backbone of the European economy. Europe's global competitive advantage on the production of industrial products translated to 25% of the EU's total value-added in 2018[4], while EU Industry's employment accounted for 22% of total employment in the EU for 2018.[5] The EU is also one of the world's largest players in global trade being the second largest exporter and importer of goods in the world, with only China exporting more goods and the United States importing more. In 2018, trade in goods represented 70% of total EU trade in goods and services.[6] In this context, competitiveness is at the heart of the Commission's agenda and, as we stand on the brink of a new industrial revolution, the Commission is committed to supporting the digital and green transformation of EU Industry.

Zooming into Greece, Industry also plays an important role in the overall Greek economy, as it generated 17,5% of the total Gross value added in 2018 and employed 14% of the total Greek workforce in the same year.[7] In addition, looking at the development of the Greek industrial production from 2013 – 2018 and its projections for 2019 and 2020, a continuous increase is noted since 2015. Projections estimate that the industrial production will continue to grow in 2019 (by 0,9%) and in 2020 (by 3%).[8]

Evidence therefore indicate that Industry is a central pillar of the national economy and its growth can have significantly positive spill over effects to other sectors and to the worldwide economy and society. Nevertheless, at the same time, Industry demonstrates the largest malleability to the underlying technological framework of each time period. Unlike sectors that involve fixed components such as resources, land, and livestock, Industry involves processes which are defined almost completely by the underlying technological conditions of the time period analysed. As such, while Industry 4.0 will undoubtedly transform economic activity across all sectors, Industry is most likely to become the most rigorously transformed and become the driver and enabler of Industry 4.0 that will, in turn, be diffused across all other sectors in the economy.

[2] World Bank, https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?view=chart, https://data.worldbank.org/indicator/SL.IND.EMPL.ZS
[3] World Bank, https://data.worldbank.org/indicator/BX.GSR.MRCH.CD
[4] The European economy since the start of the millennium – A statistical portrait, 2019 edition, https://ec.europa.eu/eurostat/cache/digpub/european_economy/index.html?lang=en
[5] The European economy since the start of the millennium – A statistical portrait, 2019 edition, https://ec.europa.eu/eurostat/cache/digpub/european_economy/index.html?lang=en
[6] The European economy since the start of the millennium – A statistical portrait, 2019 edition, https://ec.europa.eu/eurostat/cache/digpub/european_economy/index.html?lang=en
[7] The European economy since the start of the millennium – A statistical portrait, 2019 edition, https://ec.europa.eu/eurostat/cache/digpub/european_economy/index.html?lang=en
[8] Eurostat, Stochasis Macroeconomic Trends -SectoralForecasts, December 2019. Forecasts have been provided by Stochasis

<u>Introducing the concept "Industry 4.0" and explaining how Industry 4.0 changes the industrial paradigm</u>

But what do we mean exactly with the term "Industry 4.0"? And how can this new concept change the world in which we live?

The concept of "Industry 4.0" is used to describe the fourth industrial revolution, characterised by a fusion of technologies and the use of smart, fully connected devices that blur the lines between the physical, digital, and biological spheres. Industry 4.0 is "fuelled" by a set of foundational technology trends that radically transform the industrial production and manufacturing. These are the following:

Key Industry 4.0 technology trends		
Additive Manufacturing	Cybersecurity	Manufacturing Execution Systems (MES)
Artificial Intelligence	Distributed Intelligence	New Materials
Augmented Reality	Electronic Components & Systems	Simulation
Big Data Analytics	High Performance Computing	Supervisory Control and Data Acquisition Systems (SCADA)
Blockchain	Industrial Robots	The Industrial Internet of Things (IIoT)
Cloud	Machine-to-Machine (M2M)	Photonics, Automation, Sensors & Applications

Industry 4.0 creates a "tectonic" tilt on the industrial paradigm. In more detail:

- **Industry 4.0 "reinvents" the products.** The new, smart products are constantly connected to other devices and to the cloud, become "smart" through the incorporation of sensors and on-board processing capability and evolve through the use of Artificial Intelligence.
- **Industry 4.0 transforms all components of the Operating Model of organisations**; it reshuffles how organisations are organized, which processes are automated, what talent organisations need and to which ecosystems organisations shall become part of.
- **Industry 4.0 introduces new Business Models**: The emerging "as-a-Service" or "pay-as-you go" models enable customers to pay for products' uses on a use-based principle. At the same time, in the Industry 4.0 era, companies need to work out whether they also need a platform strategy.
- **Industry 4.0 "democratizes" Work:** As more areas of labour-intensive activity become automated, new roles will be introduced to ensure the proper deployment and function of automation, while more transactional and routine tasks will become defunct. At the same time, the increasing digitalisation and techno-centricity of industrial production will require new skills from industrial employees, making their constant reskilling and training the new standard. Finally, the rise of machine-assisted work, will enhance human productivity and create new capabilities in the domain of human-machine interaction.
- **Industry 4.0 shifts value across value chains and surfaces ecosystems as the new force:** The rise of smart and connected products significantly disrupts traditional linear value chains defined by clear beginnings and endings within siloed organisations and reshuffle the fundamentals of industries and will blur their boundaries.

- **Industry 4.0 impacts the wider society:** Industry 4.0 technologies are maturing rapidly with seemingly limitless applications. This opens up ethical and societal issues and concerns, such as workforce displacement, loss of privacy, potential biases in decision-making and lack of control over automated systems and robots.
- **Industry 4.0 "realizes" the circular economy:** The circular economy is more than a sustainability initiative – it's about helping industrial companies make and save money by better managing their resources and waste efficiently. As industrial companies continue down this path, they'll need digital solutions that can support their business and operating models – which is why Industry 4.0 is so important. The technologies that underpin Industry 4.0 can make this happen.

Through this "tectonic" tilt, Industry 4.0 enables organisations to:

- Increase their revenues and grow through introducing new, innovative products & services, entering into new markets and expanding their presence in new channels
- Improve customer satisfaction and increase customer penetration and retention
- Optimize their cost structure and achieve reduced labour costs and increased workforce productivity

According to data analysis, EU countries become digitally transformed at a variable degree while Greece appears to lag behind across almost all Industry 4.0 dimensions

Countries around the world have started responding to this new Industry 4.0 paradigm, albeit at a variable degree. This Industry 4.0 rift surfaces through the review of multiple Industry 4.0 related indexes both at a national and at an industry level, namely the World Economic Forum's Future of Production (FOP)[9], the European Union's Digital Economy and Society Index (DESI)[10], Accenture's Digital Economic Opportunity Index (DEOI)[11], the European Union's Digital Transformation Scoreboard[12].

Zooming into Greece, the country appears to lag behind across the majority of Industry 4.0 and digital indicators. In more detail, according to EU's DESI Index, in 2019, Greece ranked 26th out of 28 EU member states with regards to its digital maturity and was positioned at the tail end of the index, with a score 28% lower than that of the European average. Greece's unfavourable rating in the DESI index is aligned with the country's low ranking across Accenture's Digital Economic Opportunity Index (DEOI), where Greece scored at the lowest end of the digital maturity curve in 2018 (22nd out of the 22 countries of the sample) and EU's Digital Transformation Scorecard.

If we further examine the level of adoption of a set of digital technologies that underpin the Industry 4.0 rotation of an economy, it is evident that Greece is suboptimally positioned across all areas below:

- In terms of the adoption of cloud computing technologies, Greece's enterprises show low rates of adoption, with only 13% of enterprises making use of the technology, half the EU average of 26%.[13]

[9] WEF, Readiness for the Future of Production Report 2018, http://www3.weforum.org/docs/FOP_Readiness_Report_2018.pdf
[10] https://ec.europa.eu/digital-single-market/en/desi
[11] Accenture 2018, „Digital Cyprus: Catalyst for Change", https://www.accenture.com/gr-en/insights/digital/digital-cyprus-catalyst-change
[12] Digital Transformation Scoreboard 2018, https://op.europa.eu/en/publication-detail/-/publication/683fe365-408b-11e9-8d04-01aa75ed71a1
[13] Eurostat https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicce_use&lang=en

- With regards to RFID technologies, Greek enterprises also recorded the lowest levels of adoption in the EU along with Hungary and Romania, reporting 7% RFID adoption in 2017.[14]
- In addition, just 2% of Greece's enterprises used industrial robot technology in 2018, demonstrating the country's slow rate of adoption in terms of industrial robotics.[15]
- Greek enterprises have also been moderately too slow in their adoption of Customer Relationship Management (CRM) systems, with just 20% of Greek enterprises using the technology (EU average 33%).[16]
- Greece has also been slow to bring nanotechnology into its industrial landscape, reporting just 52 nanotechnology job positions in 2016. At less than 1 basis point of the total workforce, the Greek economy has yet to make any measurable contributions to the nanotechnology sector.[17]
- With regards to additive manufacturing, 924 job positions are currently classified as Additive Manufacturing related jobs. This is a small part of the workforce, at 0,03%, which indicates that the Greek industry has made some initial steps, in terms of adopting this technology.[18]
- If we shift our focus on circular economy, Greece is Europe's lowest ranking country, with regards to the average circular use of materials as a percentage of total material use, reporting only 1% circular material use.[19]

Exception to Greece's overall low digital maturity is the strength that the country demonstrates on the use of big data analytics. In fact, Greek companies have understood that data is the new digital capital and increasingly exploit the potential of Big Data Analytics. This is evidenced by the fact that 13% of Greek enterprises (compared with 12% of the EU average) invest in data collection and Big Data analytics.[20]

With regards to the dimensions of digital infrastructure, digital skills and digital public services, that drive Greece's Industry 4.0 transformation in Greece, the country is also suboptimally positioned. Nevertheless, Greece demonstrates an adequate STEM-oriented human capital that if appropriately supported could be used as the basis for the setup of a "knowledge-intensive" Industry 4.0 economy. In more detail:

- With regards to the digital infrastructure, in 2019 Greece ranked last among all EU countries (28 out of 28 member-states) according to EU's DESI Index. In fact, Greece's Connectivity score was 31% lower than the European average and 44% lower than Denmark, the EU leader, which recorded a score of 0,74 (out of 1) in 2019.[21]
- Greece's limited digital skills is also considered a structural inhibitor towards the country's rotation towards Industry 4.0.
    - In particular, in 2019 Greece ranked 25th in DESI's Human Capital dimension, with an overall score of 0,33 units, which is 32% lower than the European average. During the past 6 years, Greece's score in the Human Capital dimension has remained stable. The relatively stagnant performance of the country combined with the evolution of digital skill

[14] Eurostat https://ec.europa.eu/eurostat/web/products-datasets/-/tin00126
[15] No data was available with regards to the use of industrial robots by Greek manufacturers
[16] Eurostat, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tin00116&lang=en
[17] https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/library/kets_observatory_second_report.pdf
[18] KETs observatory - https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/library/kets_observatory_second_report.pdf

[19] https://ec.europa.eu/environment/circular-economy/
[20] Eurostat, https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/comprehensive-database
[21] EU's DESI Report 2019, „Connectivity - Broadband market developments in the EU", https://ec.europa.eu/digital-single-market/en/desi

capabilities within other EU member states is creating a widening gap between Greece and EU average in the Human Capital dimension.[22]

  - Nevertheless, Greece has a significant number of people with a track record in tertiary education. In fact, for 2017, Greece contributed 4% of the overall tertiary education students across the EU.[23] In addition, Greece's share of ICT graduates is on par with the average EU country, with 3% ICT graduates, when compared to 4% reported on average in the continent.[24] Finally, with regards to the number of graduates in tertiary education in science, math, computing, engineering, manufacturing, and construction, Greece is also in sync with the EU average, with 18% of Greek graduates pursuing tertiary education in the abovementioned fields.[25] These observations indicate that Greece has an adequate percentage of ICT & STEM graduates that could be "infused" in the Greek industry to accelerate its digitisation. This opportunity can be further enhanced, as an important number of domestic enterprises employ ICT specialists as their workforce. In 2018, 22% of Greek enterprises had ICT specialists on their payroll, ranking the country above the EU average (20%).[26]
  - Despite their appetite to employ ICT-oriented employees, the Greek enterprises appear unwilling to further invest in their human capital's digital upskilling. Only 12% of Greek enterprises offered ICT skills training to their employees in 2018, compared to the EU average of 23%.[27] If we turn our attention to the country's industrial workforce, it appears that with only 13% of manufacturers providing ICT training to their personnel, Greece's industry ranks low among its EU peers, nine points below the EU average (EU average 22%).[28]

- Finally, with regards to the state of eGovernment applications for Greece, according to EU's DESI Index 5th pillar of Digital Public Services, Greece is among the lowest ranking EU countries, positioned at the 27th place among the EU 28.[29]
  - Focusing on the level of eGovernment use, Greece, performs poorly, scoring last among all 28 EU countries, with just 36% of Greek citizens submitting forms to public authorities over the internet during 2018.[30]
  - In terms of the digital public services for businesses, Greece also scores poorly, indicating that the country must significantly upgrade its current framework for accommodating the eGovernment needs. Greece's score was 65 points in 2018, 20 points below the EU average.[31]

EU Countries support the digitisation of their Industries through a wide initiatives agenda. Greece has only performed thus far inaugural steps towards its Industry's rotation towards Industry 4.0

[22] EU's DESI Report 2019, „Human Capital - Digital Inclusion and Skills", https://ec.europa.eu/digital-single-market/en/desi
[23] Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php/Tertiary_education_statistics
[24] Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=ICT_education_-_a_statistical_overview&oldid=454538
[25] Eurostat, https://ec.europa.eu/eurostat/web/products-datasets/product?code=educ_uoe_grad04
[26] Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php/ICT_specialists_in_employment
[27] Eurostat, https://ec.europa.eu/eurostat/en/web/products-datasets/-/ISOC_SKE_ITTN2
[28] Eurostat, https://ec.europa.eu/eurostat/en/web/products-datasets/-/ISOC_SKE_ITTN2
[29] EU's DESI Report 2019, „Digital Public Services", https://ec.europa.eu/digital-single-market/en/desi
[30] EU's DESI Report 2019, „Digital Public Services", https://ec.europa.eu/digital-single-market/en/desi
[31] EU's DESI Report 2019, „Digital Public Services", https://ec.europa.eu/digital-single-market/en/desi

To support and accelerate the digitisation of their Industries, Governments all over Europe have architected national Industry 4.0 strategies and adopted relevant initiatives. In this context, we have collected, reviewed and analysed sixteen national strategies & initiatives across different dimensions. Although, every country's plan differs significantly with regards to its strategic focus, key audience, policy design, implementation approach, and funding approaches, there are some common traits and characteristics with regards to how these 16 countries have architected their Industry 4.0 strategies.

1. With regards to countries' Industry 4.0 vision, almost all countries aim to strengthen the country's industrial competitiveness and accelerate its digitisation. Nevertheless, besides their common vision, each country appears to have followed a different approach in architecting, implementing and funding their Industry 4.0 strategies and have avoided the single country imitation.
2. The focus of the designed national Industry 4.0 strategies also varies significantly. In terms of sectoral focus, almost none of the national strategies focuses on specific sectors of their economy for their digitisation. Nevertheless, the concept of enhancing wider areas of economic activity and relevant value chains is highlighted in some of those (i.e. the Portuguese Industry 4.0 strategy).
3. A set of strategies focus their efforts on the implementation and integration of specific Industry 4.0 technologies (i.e. Internet of Things, analytics, etc.)
4. In terms of the audience to which national Industry 4.0 strategies refer to, it is worth mentioning that all countries have designed dedicated incentives for the digitisation of their SMEs.
5. The facilitation of collaboration between industry, research, and public authorities is another major theme met within different Industry 4.0 approaches.
6. While all EU member Industry 4.0 strategies give a clear priority to the deployment and application of Industry 4.0 technologies, there are few strategies that also focus on the R&D enhancement for the development of new technologies (i.e. Italian Industry 4.0 strategy). In addition, Industry 4.0 strategies tend to focus equivalently on the design of digital infrastructure and the implementation of digital technologies as well as on digital upskilling and reskilling.
7. In terms of governance and implementation of their designed Industry 4.0 strategies most countries adopt a top-down approach, with national governments being positioned clearly in the driver's seat.
8. While the major national Industry 4.0 strategies significantly rely on public funding, complementary private investments are also important with the leverage effect being considerable.
9. Most of the Industry 4.0 strategies have been designed recently, therefore limited measurable outcomes have been provided yet, with regards to the progress of their implementation and the enhancement of innovation and integration of Industry 4.0 technologies.

In parallel with national Industry 4.0 initiatives, the European Commission acknowledged the new, tremendous opportunities that Industry 4.0 can bring to the European industry. In this context, it launched the Digitising European Industry initiative (DEI) in April 2016. The DEI initiative introduces a framework for the effective coordination between national and EU-level initiatives and promotes relevant policy actions including investments in digital innovation capabilities. In addition, it focuses on the development of ICT standards, explores the creation of favourable regulatory conditions and promotes specific initiatives for the upskilling and reskilling of the human capital.

Focusing on the third area of observations, it is again highlighted that Greece has taken sporadic, nascent steps regarding its Industry's digitisation. Nevertheless, the new Greek Government has reinvigorated interest in digital and actively supports the digitisation of the Greek Industry.

- With regards to DEI Pillar 1 "The European Platform of national initiatives on digitising Industry ", Greece has not designed yet a national initiative, dedicated to the digitisation of industry. However, the new Ministry of Digital Governance currently works on the revamping of Greece's national digital strategy.[32] The "Bible of Digital Transformation", expected to be published in the spring of 2020 will include a clear national digital vision as well as the guiding principles that should underpin all national digital initiatives and will align the national strategy with the EU requirements and guidelines, the introduction of a set of strategic pillars accompanied by structured digital initiatives that will aim at operationalizing the Greek digital vision and the definition of a clear Governance Model. This model will require Government representation at the highest level. It will introduce robust accountabilities and clear segregation of duties. This will ensure clarity on execution and an uninterrupted flow of information across the Governance structure.
- With regards to DEI Pillar 2 "Digital innovations for all: Digital Innovation Hubs", Greece demonstrates both areas of strengths and areas of developments. To start with, Greece is currently home to a burgeoning start-up scene. From 2012 to 2016, investment in Greek Start-ups grew by a factor of 18, from 5 to 90 million Euros in annual start-up funding per year in 2012 and 2016 respectively, totalling 250 million in the span of five years.[33] Greece is also home to 14 Digital Innovation Hubs (9 fully operational and 5 in preparation status**Error! Bookmark not defined.**) which cover various market domains within manufacturing such as food processing, basic metals, and textiles, and in other sectoral groups, such as agriculture, fishing and construction. Greece's relatively high number of DIHs is a positive indicator of the country's potential and promising track record with regards to efforts at fostering innovation in its industry.[34]

  Nevertheless, our analysis surfaced also a set of alarming findings. In more detail, with regards to Research & Development (R&D) intensity, defined as the gross domestic spending on R&D as a percentage of GDP, Greece ranks significantly below its EU peers, at 1,18% in 2018, compared to an EU average of 2,12% in the same year.[35] The overall technological development remains also low, as this is reflected in the very low number of Greek patents compared with other countries. While the EU-28 average was 107 patents per million inhabitants in 2017, Greece reported 8 patent applications, 97% less patents than Sweden, the European leader (283 patents).[36]

  The most alarming finding in the innovation field, was the fact that the current Greek R&D investments appear disassociated to applied research and industrial implementation. This is evident from the distribution of the Greek R&D personnel across the different sectors of the economy. Namely, contrary to the EU average, where the business sector appears highly involved in R&D (58% FTE), the Greek R&D is mainly dominated by the higher education sector (46% FTE). This highlights that Greek organisations appear hesitant to invest in research of new technologies,

[32] As per the interview that the project team held with the Ministry of Digital Governance on Monday, 13 January 2020
[33] BCG, The Greek startup Ecosystem - http://www.sev.org.gr/Uploads/Documents/50906/BCG_Greeces_Startup_Ecosystem_Apr_2018.pdf
[34] Information provided by the Ministry of Development and Investments on the Digital Innovation Hubs on 21/02/2020 via e-mail
[35] OECD Data - https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm
[36] EPO Data - https://ec.europa.eu/eurostat/web/products-datasets/product?code=sdg_09_40

as well as in active experimentation of how these could be implemented to drive new sources of revenues.[37]

- With regards to DEI Pillar 3 "Strengthening leadership through partnership & industrial platforms", Greece appears to have performed limited steps until now. In Greece, research networks are rare and cooperation between the public research, academia and industry has been initiated but remains weak. The same picture holds for Greek clusters. According to the European Cluster Collaboration Platform[38], currently in Greece there are only three clusters. Although no assessment is currently available regarding their effectiveness and key outcomes, judging from the total number of enterprises that participate in these and their percentage of SMEs (both are numbers are very small), it is evident that these clusters currently have limited scale.

- With regards to DEI Pillar 4 "Preparing Europeans for the digital future", the Greek Government has undertaken some key initiatives for the digital upskilling and reskilling of the Greek human capital. In June 2018, the Greek National Coalition for Digital Skills and Jobs was launched.[39] The Greek Coalition was led by the Ministry of Administrative Reconstruction and included Central Government agencies, Local Government agencies, businesses, social partners and NGOs as its members. In addition, in 2017 the "Alliance for Digital Employability (AFDEmp)" initiative[40] provided a 12 or 24- week intensive training course to previously unemployed candidates with no ICT background, in order to reskill and certify them as full stack developers in different programming languages.

  Although the abovementioned initiatives are considered positive steps, the digital skills gap appears to be a key structural inhibitor for the Greek industry. This is explained by the fact that all initiatives undertaken by the Public Administration, academia, federations and private businesses were fragmented, dispersed and were not underpinned by any common digital skills vision and strategic guidelines. In addition, it appears that there is no structured mechanism in place to measure the effectiveness of the undertaken digital skills initiatives. This leads to lack of and/or wrong information with regards to the real level of digital skills across the Greek society and workforce.

  To address these issues, the Ministry of Digital Governance aims to design a new digital skills initiative, the "Digital Academy". Digital Academy will act as the platform that will interconnect all digital skills initiatives, will enable collaboration between the various bodies that provide ICT training and certification, will eliminate overlaps and replications, will provide global expertise and best practices and will enable international collaboration.[41]

  With regards to DEI Pillar 5 "A regulatory framework fit for the digital age ", in the previous years the Greek authorities have undertaken a limited number of initiatives to transform Greece's regulatory environment and facilitate the Greek digital economy. These initiatives included the

[37] Eurostat Data – Total Research by sector of performance – Full Time Equivalent - https://ec.europa.eu/eurostat/web/products-datasets/product?code=tsc00004
[38] https://www.clustercollaboration.eu/
[39] http://www.nationalcoalition.gov.gr/
[40] https://www.afdemp.org/
[41] As per interview with the Ministry of Digital Governance held on Monday, 13 January 2020.

Directive (EU) 2016/1148 for Cybersecurity[42] and the national cloud policy.[43] In the latest months, two initiatives have been taken up by the Greek government in order to simplify and promote the regulatory environment of the country: Law 4622/2019 and the new multibill that seeks to address the growth of the economy and the country at multiple levels.

In addition, during the recent years a set of horizontal efforts have been implemented in order to boost and assist the business environment of Greece. More specifically laws L. 4442/2016 & 4512/2018, have been pursued. Furthermore, in 2019, law L.4442/2016 was supplemented and extended by law 4635/2019, introducing simplification of the standardisation, licensing and supervision processes as well as by Law 4512/2018, which establishes a new framework for the supervision of economic activities and the product markets.

Also, since early 2018, the "Better Regulation Delivery Directorate" of the General Secretariat for Industry has been established in order to act towards the successful implementation of the aforementioned laws. Further to that, since June 2017, the electronic licensing platform "Notify business – notifybusiness.gov.gr" was established. Lastly, in a significant effort to reduce the administrative burdens of enterprises, the new law for electronic one-stop shops (e-OSS) was developed (Law 4441/2016 and MD 63577/2018). All of the above are a positive indication of the willingness of Greek lawmakers to create a regulatory landscape that will encourage organisations to embrace the newly emerging industrial paradigm.[44]

With regards to the circular economy, the Ministry of Environment and Energy of Greece published in 2018 the Circular Economy Strategy outlining previous efforts on Circular economy until now, the basic strategies and policy axes to be undertaken and 8 main goals to be achieved until 2030. This policy axes included the "effective implementation of prioritisation of waste management, promoting the prevention of creating waste and encouraging re-usage and recycling" and the "promotion of innovative forms of consumptions, such as the use of services instead of purchasing products or the use of electronic computers and digital platforms".[45]

Despite being at the start of its digitisation, Greece has already implemented a set of measures, policies and mechanisms, to support the digital transformation of the Greek Industry

Greece is only at the beginning of a long and demanding effort, in order to achieve Digital Transformation in the Industry sector. Up until today, there has been no official policy or action in the form of a strategy/ initiative etc. from the side of the Greek state in order to support the transition of the Greek industry to the new digital era, i.e. towards Industry 4.0. Nevertheless, a set of measures have already been taken towards the right direction.

- The establishment of the Ministry of Digital Policy, Telecommunications and Media in 2016 was a first positive step towards assisting the digitalisation of the country and the economy overall. On the 8th of July 2019, the Ministry of Digital Governance was established in the place of the former

[42] https://eur-lex.europa.eu/legal-content/EL/TXT/PDF/?uri=CELEX:32016L1148&from=EN
[43] https://www.gsis.gr/dimosia-dioikisi/G-Cloud
[44] Abstract from documents used for the OECD ECONOMIC SURVEY OF GREECE 2018-2020, provided by the Ministry of Development and Investments on February 21, 2020 via mail.
[45] Ministry of Environment and Energy of Greece, http://www.ypeka.gr/LinkClick.aspx?fileticket=pYSLQXgjjOU%3D&tabid=37&language=en-US

Ministry of Digital Policy, Telecommunications and Media. The new Ministry currently updates the National Digital Strategy 2016-2021, in order to produce an enhanced and improved version, namely the Digital Bible, that will be officially published within the first half of 2020.

- At the same time, an important step has also been taken by the signing of a memorandum of cooperation (in May 2019) regarding the setup of a digital Industry 4.0 platform, between the General Secretariat for Industry and the Ministry of Digital Governance.

Besides the aforementioned, in the latest months, two initiatives have been taken up by the Greek government in order to simplify and promote the regulatory environment of the country:

- Law 4622/2019, that seeks to re-organize the way the country's public administration is conducted, by simplifying the process of decision making (which from now on will be operated centrally from the Government).
- Law 4635/2019 (multibill) that seeks to address the growth of the economy and the country at multiple levels. With respect to the Greek Industry, the multibill seeks to simplify the issuing of licenses for businesses in the Industry sector as well as offer financial incentives to businesses that seek to operate in the context of business clusters.

Besides political actions and initiatives, other non-public sector stakeholders promote and stress out the importance of a digital industry, state and economy in general. One of the main supporters of Industry 4.0 and its strategic importance for the competitiveness of the country and Greek enterprises in the future is the Federation of Enterprises (SEV) of Greece.

- SEV, since February 2019, established the Observatory of Digital Transformation for the country. In the lines of this venture, the Digital Manufacturing Index (DMI) has been developed in order to monitor the digital results of the country as a whole, compared to its EU counterparts within the EU-28.

Currently the Government's policies for the digitisation of the enterprises in the industrial sector are supported through two main funding streams, the Operational Program "Competitiveness, Entrepreneurship & Innovation" (EPAnEK) and the Hellenic Development Bank (former ETEAN).

The operational programme EPAnEK constitutes one of the seven sectoral Operational Programmes of the Partnership and Cooperation Agreement (former NSRF) for the period 2014-2020. The pivotal strategic objective of EPAnEK is to enhance the competitiveness and extroversion of enterprises, to facilitate transition to quality entrepreneurship with innovation and the growth of domestic added value as the cutting edge. The total public expenditure for EPAnEK is set at €4,66 billion.

EPAnEK funds the support measure " Research – Create – Innovate " (total of €542,5 million) and also provisions the use of financial instruments (loans, guarantees, microfinance and equity financing) that could support its purposes. The measure "Research – Create – Innovate"[46] is managed by the General Secretariat for Research and Technology and aims to support:

- research and innovation

[46] Source: http://www.antagonistikotita.gr/epanek_en/news.asp?id=7

- technological development and demonstration at operating enterprises for the development of new or improved products
- the development of synergies among enterprises
- research and development centres and higher education sector as well as to support
- the patentability of research results and industrial property.

EPAnEK has also published two actions that promote the digital transformation of enterprises and organisations., the "Digital Step" that aims at the digital upgrading of very small, small and medium sized enterprises with business plans from €5.000 to €50.000 and the "Digital Jump", that aims at the digital transformation of very small, small and medium sized enterprises with business plans from €55.000 to €400.000. The funding scheme was co-financed by Greece and the European Union – European Regional Development Fund with a budget of €51,6 million.

The Hellenic Development Bank (HDB) aims to support the design, implementation and management of specialized financial actions, delivered by financial institutions to small and medium sized enterprises. The Hellenic Development Bank created two funding schemes that aim to support digital development of enterprises, the programme "Business Innovation Greece" and the programme "4th Industrial Revolution".

- The programme "Business Innovation Greece", aims to support the general objectives of European Economic Area and Norway Grants 2014-2021. The programme targets to increase value creation and sustainable growth in the Greek business sector and to allocate 75% of the funding to SMEs. The total budget of the programme for the ICT sector is €3 million and it is divided in two grant schemes, the "Individual Project Scheme" concerning SMEs and large enterprises with no more than 25% public ownership, and the "Small Grants Scheme 1" concerning SMEs.
- The Investment Scheme "4th Industrial Revolution", aims to invest in new or existing SMEs that retain an establishment in the Greek territory at the time of the investment and are active in the field of the 4th Industrial Revolution. The budget of "4th Industrial Revolution" is set at €50 million from public funding and €15 million from private equity.

Besides the abovementioned funding sources and initiatives, there are additional funding sources that are used to support enterprises towards digital transformation:

- EquiFund[47]: An initiative created by the Hellenic Republic in cooperation with the European Investment Fund (EIF) that supports research projects of SMEs and start-ups.
- COSME[48]: The EU program for the Competitiveness of Enterprises and SMEs, running from 2014 to 2020, with a budget of €2.3 billion.
- InnovFin[49]: With InnovFin – EU Finance for Innovators, the EIB Group (the European Investment Bank and the European Investment Fund) can provide financing starting at €25.000 for investments in research and innovation to companies and other entities of all sizes and age. InnovFin supports start-ups, SMEs, mid-caps, larger private companies, research institutes/ organisations and universities or R&I-driven entities.

[47] EquiFund Brochure (https://equifund.gr/wp-content/uploads/2018/02/EquiFund-Brochure.pdf)
[48] COSME – Leaflet (https://ec.europa.eu/docsroom/documents/9783)
[49] InnovFin (https://www.eib.org/en/products/blending/innovfin/products/index.htm)

- EIB[50]: Offers loans, guarantees, equity investments and advisory services. The most suitable tool will depend on the objectives of the project and on various other factors.
- Tax incentives for investment[51]: General Secretariat of Research and Technology provides certifications of scientific and technological research expenditure and deduction of 30% surcharge.

<u>Greek executives acknowledge the significant of Industry 4.0 and claim to have initiated their organisations' digitisation albeit at a variable degree</u>

In order to capture the perception of the Greek Industry with regards to their Industry 4.0 capabilities, we performed the Industry 4.0 survey.[52] The outcomes of the survey enabled us to capture the pulse of the Greek industrial enterprises and to overlay the executives' opinions against "hard data", in order to extract an additional layer of insight.

The surveyed Greek executives recognize the significance of Industry 4.0 and the changing of the industrial paradigm – 1 out of 2 of the surveyed executives recognize that their respective organisations have understood the significance of Industry 4.0 and acknowledge the fact that this will disrupt their industries in the next years. Adding to the above, in terms of new opportunities that will arise from the introduction of Industry 4.0 technologies, most of the respondents expect Industry 4.0 to pave the way for "New Services", "New Business Models" and "New Markets".

Greek executives perceive their organisations' increased productivity as the most important direct benefit from implementing Industry 4.0 technologies: Business leaders currently direct their Industry 4.0 attention in areas where they expect to see wider benefits. 2 out of the 3 the respondents perceive that, primarily, Industry 4.0 will increase productivity, while 1 out of 2 believe that Industry 4.0 will improve decision making and decrease operational costs. This indicates that Greek executives appear to primarily use Industry 4.0 technologies within their organisations to "become digital", optimize their internal operations and reap direct benefits. The use of digital technologies to create new, smart, connected products currently comes as a second priority.

Greek organisations appear to have initiated their Industry 4.0 transformation, albeit at a variable degree: The majority of the surveyed organisations appear to have initiated their digital transformation across specific functions of their organisations. In fact, 7 out of 10 participants cited that their support functions demonstrate the highest level of digitisation, while Warehouse & Logistics and Marketing & Sales also demonstrate a relatively high degree of digital maturity. This verifies the abovementioned finding, that organisations primarily focus on internal efficiencies instead of aiming at the "smartification" of their products and services. In fact, according to the survey, the percentage of the surveyed organisations that produce "smart" products is still very low. Currently 1 out of 2 of them cite that their products have no interface or ability to communicate with any other machine, or that they can just send or receive only basic input/output signals (one-way communication).

[50] EIB (https://www.eib.org/en/products/index.htm)
[51] Source: General Secretariat for Research and Technology
[52] The performed analysis and the respective conclusions were based on data recorded through the "Industry 4.0" survey ran by the Ministry of Development and Investments, PwC and Accenture, with 152 Greek executives across the following sectors: B. Mining & Quarring, C: Manufacturing, E: Water supply; sewage, waste management and remediation activities, F: Constuction, H: Transportation, J: Information & Communication, which was launched on November 2019 and closed in February 2020.

Out of the total set of technologies that underpin the concept of Industry 4.0, Greek organisations appear to currently focus their attention to cloud, cybersecurity, big data analytics and manufacturing-dedicated systems, i.e. SCADA and MES: In terms of the Industry 4.0 technologies that Greek organisations implement, our survey indicates that during the last years, our respondents have focused their attention on the cloud, cybersecurity, big data analytics and SCADA and MES systems.

Evidence also indicates that organisations intend to invest intensively in Industry 4.0 initiatives over the next 5 years. Respondents cited that in the near future they plan to continue their investments in Cloud, Cybersecurity and big data analytics, while they also aim at actively experimenting with IIoT, industrial robots and AI. These investments in the latter technologies are expected to further increase Greece's ranking across the respective indexes (i.e. % of Greek enterprises/ manufacturers implementing industrial robots).

At the same time, a quite alarming finding is surfaced. 20% of the respondents appear not to have implemented any Industry 4.0 technology in their organisations.

Participants' production lines demonstrate a variable degree of digitisation, although the majority of the respondents claim to have revamped their production equipment during the last two years: With regards to the digitisation of the surveyed organisations' production lines, an interesting finding emerges. Almost 4 out of 10 of the participants indicated that their organisations' production lines demonstrate a very low degree of digitisation. Nevertheless, at the same time 7 out 10 of the same sample claim that they have modernised their production lines within the last two years.

The Greek surveyed executives face multiple challenges during their rotation to Industry 4.0: Our survey results suggest that the lack of digital skills for implementing and using Industry 4.0, the limited time to experiment, test and implement new Industry 4.0 technologies, the low level of clients' readiness with regards to Industry 4.0 practices and the lack of technical knowhow in implementing and using Industry 4.0 capabilities are being identified as the four top-of-mind challenges. These challenges confirm Greece's low position, both across the integration of digital technologies (DESI Index's 4th pillar) and across the digital skills of the Greek Human Capital (DESI Index's 2nd pillar).

Greek surveyed executives verify the limited digital skills currently existing in the Greek market: Only 17% of the Greek executives believe that their workforce is currently digitally adept, with major upskilling required mainly on new technologies, complex problem-solving and soft skills. In addition, the majority of Greek executives perceive that "Expertise in new technologies" will be the most sought-after skill when hiring employees for Industry 4.0 activities over the next 5 years, while "Soft skills" and "Problem solving skills" appear to also be important for about half of them.

Greek executives welcome the support of the Greek Government to further enable their organisations' digitisation: Greek organisations also cited that the Greek Government has an important role to play in abolishing the abovementioned structural inhibitors and accelerate Industry 4.0 adoption within the Greek industry, through the provision of relevant financial and non-financial incentives. To start with, almost 9 out of 10 Greek executives believe that the provision of a modern technological infrastructure (e.g. 5G, integrated national fibre optic broadband and wireless networks) could catalyse the implementation of Industry 4.0 initiatives within Greek organisations. In addition, 8 out of 10 of the respondents perceive the provision of relevant tax incentives as an important motive for organisations' digital transformation. Next to tax incentives, the provision of technical expertise for the design and implementation of Industry 4.0 initiatives and for tackling cybersecurity issues feature high on the agenda of 8 out of 10 respondents. These results suggest that the breadth and depth of the digital interventions required to be implemented by the Greek Government shall be significantly deep and wide, to ensure the setup of a holistic support mechanism for the Industry's rotation to Industry 4.0.

3 The role of the Industry & manufacturing in the global, European and Greek economy

3.1 Chapter's Summary

Industry is a central pillar to the development of national economies and to the acceleration of economic growth. Historically, manufacturing has been "the driver of economic growth, structural change, and catch-up".[53] World Economic Forum highlights that manufacturing is significantly important to the prosperity of nations "with over 70% of the income variations of 128 nations explained by differences in manufactured product export data alone".[54] Industry indeed matters for countries' economic performance and manufacturing proves to be directly linked to national competitiveness.[55] According to the World Bank, Industry in 2017 contributed 25,4% of the world's total GDP, while the employment in the industry sector reached 23,08% of the worldwide employment.[56] At the same time, exports of goods, which is the key output of Industry, reached the $17,52 trillion.[57]

Industry consists the backbone of the European economy. Europe's global competitive advantage on the production of industrial products translated to 25% of the EU's total value-added in 2018[58], while EU Industry's employment accounted for 27% of total employment in the EU for 2018.[59] The EU is also one of the world's largest players in global trade being the second largest exporter and importer of goods in the world, with only China exporting more goods and the United States importing more. In 2018, trade in goods represented 70% of total EU trade in goods and services.[60] In this context, competitiveness is at the heart of the Commission's agenda and, as we stand on the brink of a new industrial revolution, the Commission is committed to supporting the digital and green transformation of EU Industry.

Zooming into Greece, Industry also plays an important role in the overall Greek economy, as it generated 24,2% of the total Gross value added in 2017[61] and employed 19% of the total Greek workforce in the same year.[62] In addition, looking at the development of the Greek industrial production from 2013 – 2018 and its projections for 2019 and 2020, a continuous increase is noted since 2015. Projections estimate that the industrial production will continue to grow in 2019 (by 0,9%) and in 2020 (by 3%).[63]

[53] Naudé W., Szirmai, A. The importance of manufacturing in economic development: Past, present and future perspectives. UNU-MERIT Working Papers , 2012-041, 2012
[54] World Economic Forum (WEF). The Future of Manufacturing Opportunities to drive economic growth. A World Economic Forum Report in collaboration with Deloitte Touche Tohmatsu Limited, April 2012
[55] Pitelis, Christos & Antonakis, Nicholas. (2003). Manufacturing and competitiveness: The case of Greece. Journal of Economic Studies. 30. 535-547. 10.1108/01443580310492826.
[56] World Bank, https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?view=chart, https://data.worldbank.org/indicator/SL.IND.EMPL.ZS
[57] World Bank, https://data.worldbank.org/indicator/BX.GSR.MRCH.CD
[58] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64&lang=en
[59] Eurostat, National accounts employment data by industry (up to NACE A*64), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64_e&lang=en
[60] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[61] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64&lang=en, Data 2018 not available for Greece
[62] Eurostat, National accounts employment data by industry (up to NACE A*64), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64_e&lang=en
[63] Eurostat, Stochasis Macroeconomic Trends -SectoralForecasts, December 2019. Forecasts have been provided by Stochasis

Nevertheless, the comparison of the Greek Industry to the German, French and Portuguese ones, highlights that despite Industry's key role across all countries, each country is unique in terms of the structure of its economy. In fact, Industry contributes the highest to the German economy (amongst the countries we referred to) with a 35% share on the country's total Gross Value Added and a 29% share on the country's overall employment in 2018.

At the same time, looking at the Industries' GVA and employment growth, Portugal demonstrated the highest Industry GVA growth rate (21% growth) between 2013 – 2018. At the same time, the Portuguese Industry employment also increased by 12% during the same time-period. This combined with the significant increase of 48% in Gross Capital Formation, signifies the great focus and efforts that Portugal has demonstrated during the last years to recover from its recent financial crisis, boost its industry and enhance its productivity and competitiveness. Zooming into the exporting capacity of goods for each country, Greece demonstrated the highest increase in exporting goods during the last years (24%). However, it still held the lowest percentage of exports of goods as % of GDP in 2018 with 18%. In terms of high-tech exports as a percentage of the country's overall exports, France came first in 2018 with 20,5%, contrary to Greece and Portugal, where high-tech products only hold 4,5% and 4% of their overall exports.

Countries' unique characteristics and focus across different areas of their Industries, indicate that moving forward their national Industry 4.0 strategies shall also be tailored to their Industries' specific needs and strengths.

3.2 The central importance of Industry & Manufacturing in the global economy

Industry is a central pillar to the development of national economies and to the acceleration of economic growth. In fact, there is evidence that countries with strong industrial sector have shown more economic growth, had improved national income, promoted living standard of people and decreased unemployment. According to the World Bank, Industry in 2017 contributed 25,4% of the world's total GDP, while the employment in the industry sector reached 23,08% of the worldwide employment.[64] At the same time, exports of goods, which is the key output of Industry, reached the $17,52 trillion.[65]

Apart from its economic contribution, a strong Industry guarantees higher levels of economic diversification[66], minimizing risks of associating economic reliance on a single sector or commodity. Furthermore, a growing Industry creates increased demand for high-skilled labour and technology research, which in turn leads to higher availability and funding of relevant academic and research programs, thus creating positive feedback loop that affects the overall know-how and education level of the population. Moreover, Industry growth can also lead to incentivisation for the design of a legal system which promotes innovations and transmission of high-tech know-how, while encouraging entrepreneurship and manufacturing investments.

Zooming into Manufacturing, which is the largest sector included within the remits of Industry, it is evident that its contribution and significance to the global economy is also central, with 15,6% of the world's total

[64] World Bank, Industry (including construction), value added (% of GDP), https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?view=chart, Employment in industry (% of total employment) (modeled ILO estimate), https://data.worldbank.org/indicator/SL.IND.EMPL.ZS
[65] World Bank, Goods exports (BoP, current US$), https://data.worldbank.org/indicator/BX.GSR.MRCH.CD
[66] OECD, AID FOR TRADE AT A GLANCE 2019 ECONOMIC DIVERSIFICATION AND EMPOWERMENT, https://www.oecd-ilibrary.org/docserver/785f021c-en.pdf?expires=1582713719&id=id&accname=guest&checksum=BAC4C882B6158655CD5E4CD9C7AA3214

GDP coming from this sector in 2017.[67] In fact, according to economist Nicholas Kaldor, GDP growth is closely tied to growth in the manufacturing sector. This relationship, known as Kaldor's First Law, is justified by three key attributes which characterize the manufacturing sector. Firstly, manufacturing can facilitate increasing returns to scale. Secondly, as will be demonstrated in our discussion of exports, manufacturing has historically been the largest component of exports, thereby enabling export led growth. Third, an increasingly large majority of services in modern economies depend primarily on manufactured goods[68].

Industry and the manufacturing sectors are central pillars of national economies and their growth can have significantly positive spill over effects to other sectors and to the worldwide economy and society. Historically, manufacturing has been "the driver of economic growth, structural change, and catch-up".[69] World Economic Forum highlights that manufacturing is significantly important to the prosperity of nations "with over 70% of the income variations of 128 nations explained by differences in manufactured product export data alone".[70] McKinsey Global Institute points out that the role of manufacturing in the economy changes over time and it differs according to the economic development stage of the country. In developed economies manufacturing has the ability to drive productivity growth, competitiveness, innovation and trade.[71] Industry indeed matters for countries' economic performance and manufacturing proves to be directly linked to national competitiveness.[72]

At the same time, Industry and manufacturing demonstrate the largest malleability to the underlying technological framework of each time period. Unlike sectors that involve fixed components such as resources, land, and livestock, Industry and manufacturing involve processes which are defined almost completely by the underlying technological conditions of the time period analysed. As such, while Industry 4.0 will undoubtedly transform economic activity across all sectors, Industry and manufacturing are most likely to become the most rigorously transformed, as well as the drivers and enablers of the 'wave' of Industry 4.0 that will, in turn, be diffused across all other sectors in the economy. More details on how Industry 4.0 disrupts the Industrial paradigm are presented in chapter 5.

Before we move into the analysis of the European and Greek Industry, it is important to define the perimeter of the term "Industry" that we will use throughout this Deliverable. According to EU's definition and Eurostat's data classification, the term "Industry" includes the following sectors of economic activities according to NACE classification: B) Mining and Quarrying, (C) Manufacturing, (D) Electricity, Gas Steam and Air Conditioning supply, (E) Water Supply, Sewerage, (F) Construction. For the purpose of our engagement, the "term" Industry shall also include sector (H) Transportation and Storage.

[67] World Bank, Manufacturing, value added (% of GDP), https://data.worldbank.org/indicator/NV.IND.MANF.ZS?view=chart
[68] J.S.L. McCombie, A Kaldorian Theory of Economic Growth: The importance of the Open Economy, University of Cambridge, https://www.boeckler.de/pdf/v_2013_07_31_mccombie.pdf
[69] Naudé W., Szirmai, A. The importance of manufacturing in economic development: Past, present and future perspectives. UNU-MERIT Working Papers , 2012-041, 2012
[70] World Economic Forum (WEF). The Future of Manufacturing Opportunities to drive economic growth. A World Economic Forum Report in collaboration with Deloitte Touche Tohmatsu Limited, April 2012
[71] McKinsey. Manufacturing the future: the next era of global growth and Innovation, McKinsey Global Institute Report, 2012. [Online] Available:www.mckinsey.com/insights/ manufacturing/the_future_of_manufacturing
[72] Pitelis, Christos & Antonakis, Nicholas. (2003). Manufacturing and competitiveness: The case of Greece. Journal of Economic Studies. 30. 535-547. 10.1108/01443580310492826.

3.3 The European Industry Overview

The following paragraph aims to provide some key figures on the European Industry and its contribution to the overall European economy. For this reason, we will review at a high level the following dimensions for the European Industry: EU Industry's value added to the overall EU economy, EU Industry's employment, the significance of EU Industry in the global trade with an emphasis on high technology products and the overall EU industrial production index that measures changes in the overall output of the EU industry. Finally, we will review the productivity of the EU Industry (and its sectors) as well as its labour cost index.

This paragraph is purely descriptive, non-exhaustive and highlights through the provision of relevant figures the importance of the EU Industry for the EU economy.

Industry is the backbone of the European economy. On aggregate, industrial enterprises contributed 29% of the EU's total Gross Value-Added in 2018 (see Figure 1)[73], while in the same year they were also responsible for employing 27% of Europeans (compared with 31% in 2000) (see Figure 2)[74].

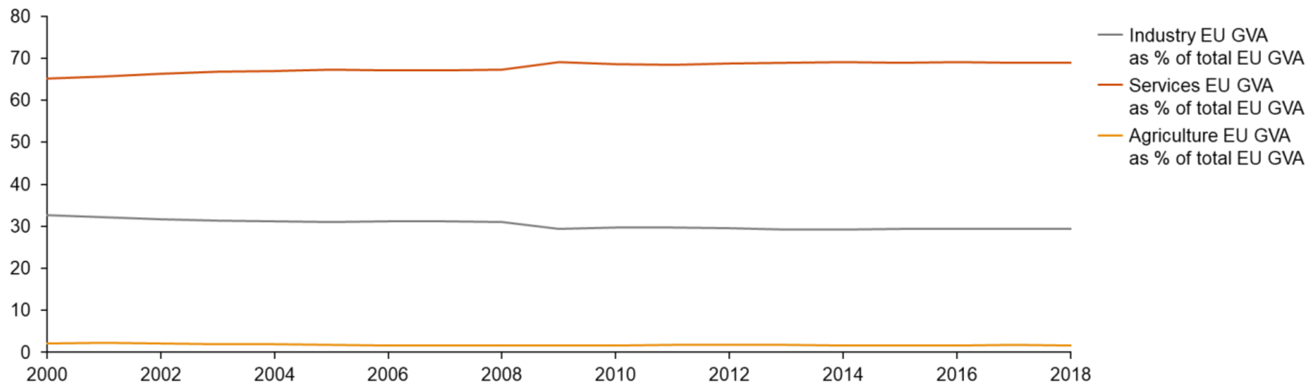

*Figure 1: Industry, Services & Agriculture Gross Value Added as % of total Gross Value Added (%) – Source: Eurostat, National accounts aggregates by industry (up to NACE A*64)*

[73] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64&lang=en
[74] Eurostat, National accounts employment data by industry (up to NACE A*64), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64_e&lang=en

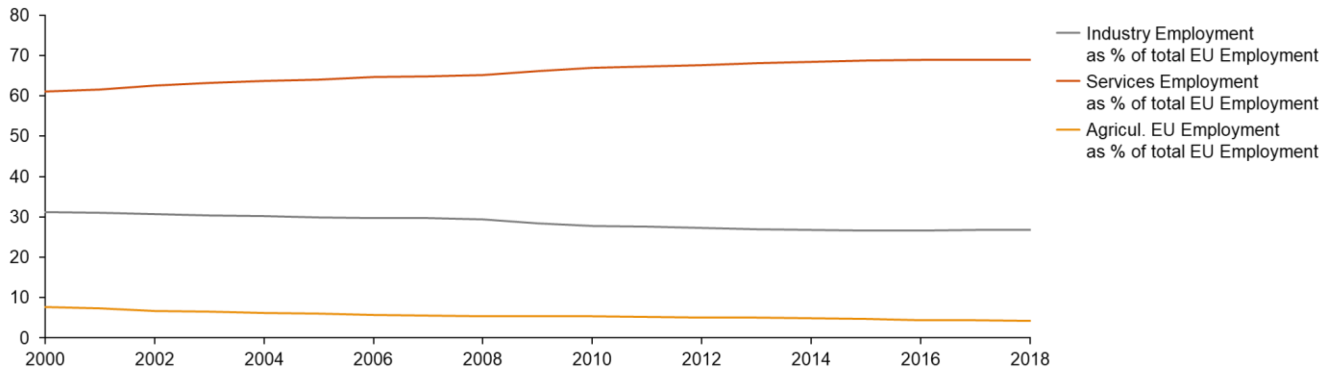

*Figure 2: Industry, Services & Agriculture Employment as % of total Employment (%) – Source: Eurostat, National accounts employment data by industry (up to NACE A*64)*

With regards to global trade, the EU is one of the world's largest players in trade being the second largest exporter and importer of goods in the world, with only China exporting more goods and the United States importing more. In 2018, trade in goods represented 70% of total EU trade in goods and services. Looking separately at goods and services, both have recorded similar trends, with values more than doubling between 2000 and 2017 (see Figure 3).[75,76]

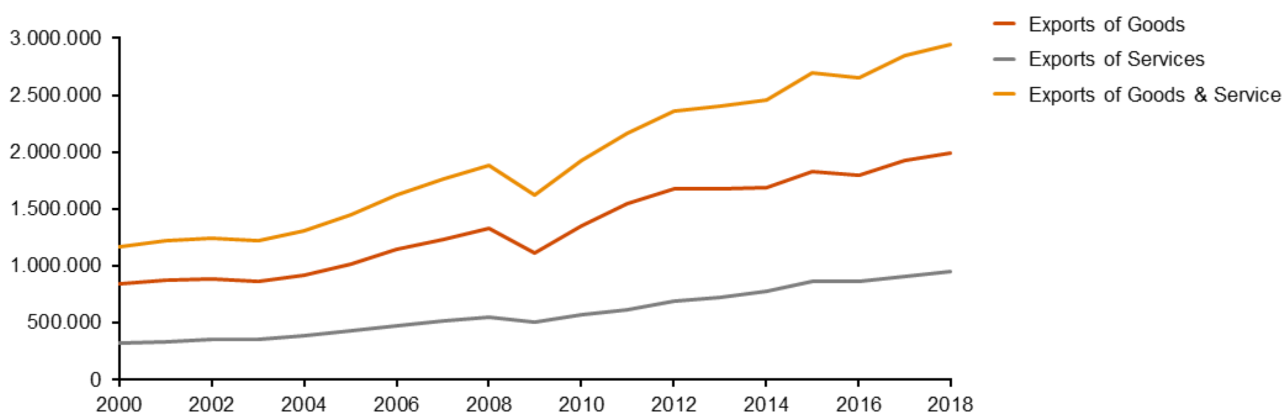

Figure 3: Exports of Goods & Services (Mn. Eur) – Source: Eurostat, European Union and euro area balance of payments - quarterly data (BPM6)

[75] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[76] The European economy since the start of the millennium – A statistical portrait, 2019 edition, https://ec.europa.eu/eurostat/cache/digpub/european_economy/index.html?lang=en

Regarding the EU trade in goods balance, the EU underwent two key phases: a continuous deficit between 2000 and 2012, followed by an increasing surplus, which reached EUR 146 billion in 2016 and then decreased to 122 billion in 2017 and further to 61 billion in 2018 (see Figure 4).[77]

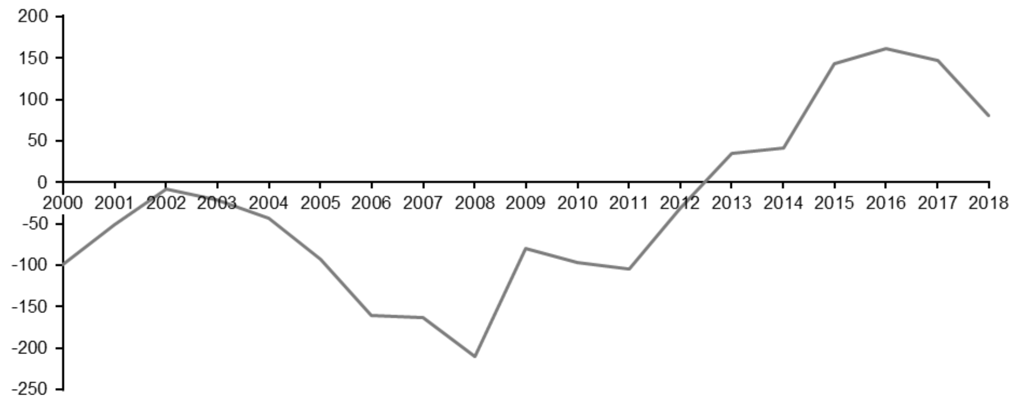

Figure 4: Trade balance of goods (Bn. Euros) – Source: Eurostat, European Union and euro area balance of payments - quarterly data (BPM6)

In 2018, the highest surpluses for trade in goods (including within the EU and outside the EU) were recorded in Germany (EUR +222 billion), Ireland (EUR +108 billion in 2017), the Netherlands (EUR +68 billion), Italy (EUR +47 billion) and Denmark (EUR +15 billion), and the largest deficits in the United Kingdom (EUR -156 billion), France (EUR -48 billion), Spain (EUR -31 billion) and Greece (EUR -23 billion).[78]

Zooming into the European share of exports of high technology products[79] (out of the total exports), this took a severe hit after the financial crisis, dropping from 17,1% in 2009 to 15,3% in 2013. Since then it started recovering, stabilizing around 17,8% since 2016 and being 17,9 in 2018, 0,8% higher than the pre-crisis period (see Figure 5).[80]

[77] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[78] The European economy since the start of the millennium – A statistical portrait, 2019 edition, https://ec.europa.eu/eurostat/cache/digpub/european_economy/index.html?lang=en
[79] High technology products are defined according to SITC Rev.4 as the sum of the following products: Aerospace, Computers-office machines, Electronics-telecommunications, Pharmacy, Scientific instruments, Electrical machinery, Chemistry, Non-electrical machinery, Armament. The total exports for the EU do not include the intra-EU trade
[80] Eurostat, High-tech exports - Exports of high technology products as a share of total exports (from 2007, SITC Rev. 4), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=htec_si_exp4&lang=en

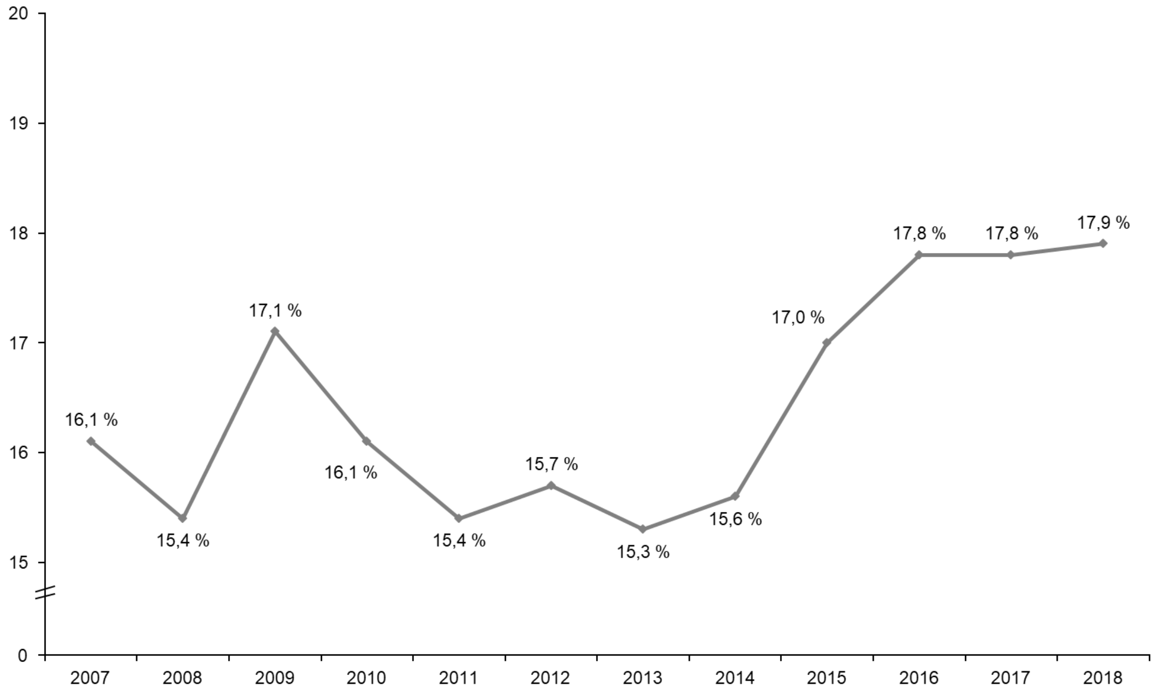

Figure 5: Exports of high technology products as a share of total exports (%) – Source: Eurostat, High-tech exports - Exports of high technology products as a share of total exports (from 2007, SITC Rev. 4)

EU also demonstrates a strong **industrial production**. After the economic crisis in 2008, the value generated by EU industrial production[81] was reduced dramatically in 2009, with a sharp decrease of 18 %. However, there was a turn-around between 2009 and 2011 when the value of sold production increased by 15 % and remained stable in the following three years. The results of 2018 show the consolidation of the growth in production, after the full recovery and surpassing the 2008 level. This upwards trend of the EU's industrial production was continued in 2018 and was mainly due to the manufacturing of motor vehicles, trailers & semi-trailers, other transport equipment and machinery & equipment (see Figure 6).[82]

[81] Eurostat, Production in industry - annual data - https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sts_inpr_a&lang=en The industrial production index shows the output and activity of the industry sector. It measures changes in the volume of output on a monthly basis. Data are compiled according to the Statistical classification of economic activities in the European Community, (NACE Rev. 2, Eurostat). Data and weights are available for the following NACE categories: B) Mining and Quarrying, (C) Manufacturing, (D) Electricity, Gas Steam and Air Conditioning supply, (E36) Water Supply and collection
[82] Eurostat, Industrial production statistics, https://ec.europa.eu/eurostat/statistics-explained/index.php/Industrial_production_statistics#Overview

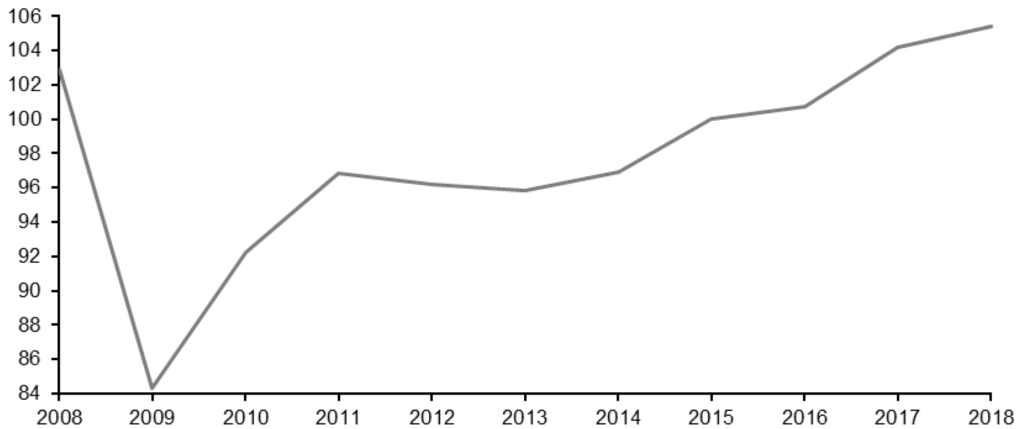

Figure 6: Evolution of EU-28's industrial production index, 2008 - 2018 (2015=100) – Source: Eurostat, Production in industry - annual data

Through this short analysis it is evident that the EU Industry and Manufacturing are of vital importance for the EU economy. In this context, competitiveness is at the heart of the Commission's agenda and, as we stand on the brink of a new industrial revolution, the Commission is committed to supporting the digital and green transformation of EU Industry.[83]

Zooming into different the sectors of the Industry, in terms of Gross Value Added, manufacturing represents the lion's share of value creation within Europe's industry, accounting for 16% of the EU's total value-added in 2018. Among the remaining NACE categories in our sample, construction is the second largest sector in terms of value creation, corresponding to 5,48% of Europe's total value-added, followed by transportation & storage with 4,85% of EU's total value-added. Other industry categories, such as mining and quarrying, energy (electricity and gas), and water supply and sewerage correspond to less than 2% of the EU's value-added (See Figure 7). Notably, the evolution of Gross Value Added across EU's industrial sectors has been relatively stable in terms of Gross Value added, with minimal shifts in the relative makeup of each sector's over the 2010-2018 period. [84, 85]

[83] Please refer to Chapter 7 for detailed EU policies and strategies relevant to the digitisation and the green transformation of the EU Industry
[84] Although according to EU's definition, Industry includes the following NACE categories: B) Mining and Quarrying, (C) Manufacturing, (D) Electricity, Gas Steam and Air Conditioning supply, (E) Water Supply, Sewerage, (F) Construction, for the purpose of our engagement, we have also included in our analysis the (H) Transportation and Storage sector. For this reason, Industry-related numbers at an aggregate level may slightly vary from the sum of its sector-related numbers.
[85] Eurostat, Gross value added and income by A*10 industry breakdowns
https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a10&lang=en

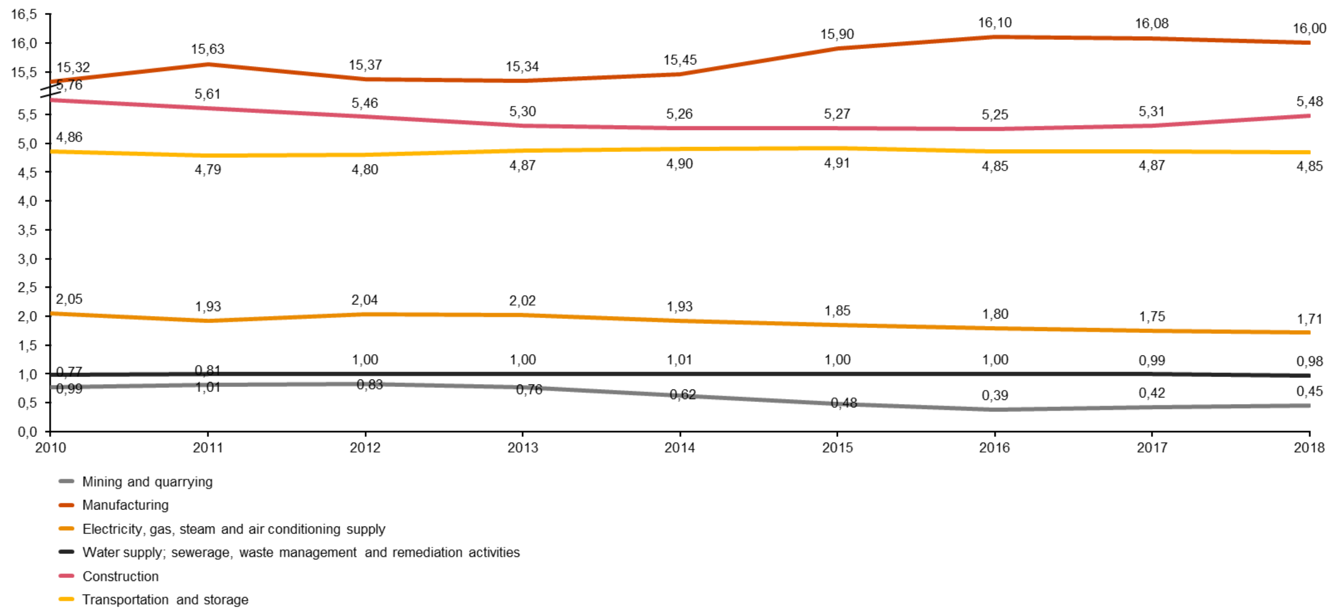

*Figure 7: Industrial sectors' Gross Value-Added contribution to the total EU Gross Value Added (%) – Source: Eurostat, National accounts aggregates by industry (up to NACE A*64)*

In terms of employment, the Manufacturing sector employs the majority of EU industry employees, amounting to 14,4% of all European jobs. Construction is the second largest industrial employer in Europe, amounting to 7,1% of employees, followed closely by Transportation and Storage with 4,7%. Energy, Water Supply and Mining and Quarrying employ the lowest numbers of employees, with each of these subsectors amounting to less than 1%. With regards to the analysis of employment trends across industrial

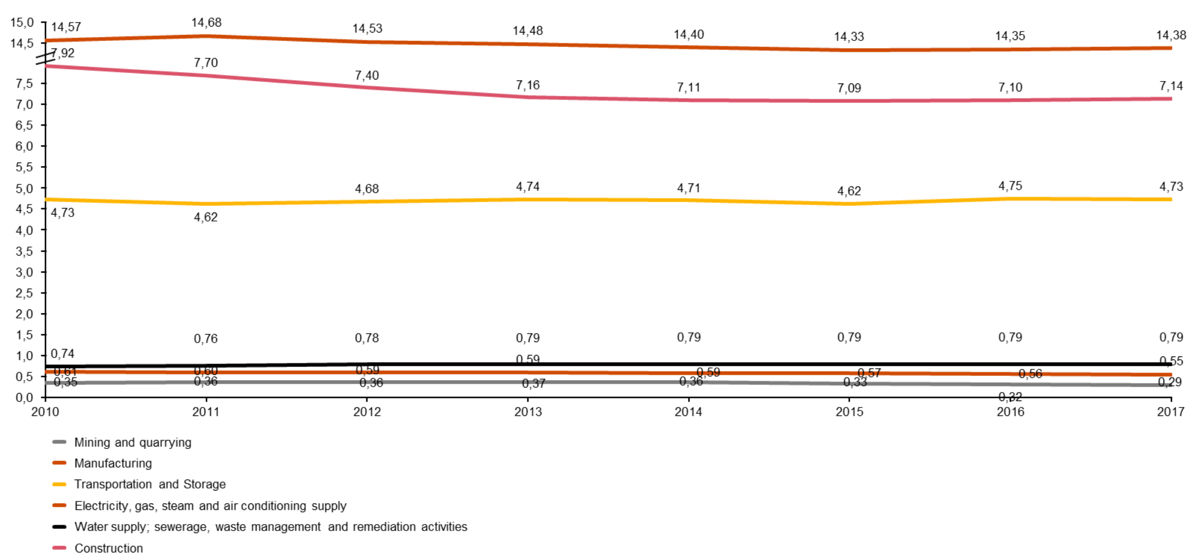

*Figure 8: Industrial sectors' Employment contribution to the total EU Employment (%) – Source: Eurostat, National accounts employment data by industry (up to NACE A*64)*

sectors since 2010, there was very little variability in the employment levels, with all sectors moving within a 2 percentage-point range of their 2010 share of employment (see Figure 8).[86]

With regards to EU's **exporting activity** in 2017, Manufacturing made up the highest percentage of all European exports, representing a 55% share of all EU exports. Following closely after, we find Mining and Quarrying, Energy and Water Supply, all of which accounted for around 14% to 19% of EU exports. Construction and Transportation and Storage account for 8% and 2% of EU exports respectively, representing the less export-oriented industrial sectors (see Figure 9). The evolution of EU exports at an industry level reveals that the fastest growing industrial export sector is manufacturing, which grew from 48% to 55% over the years 2012-2017. Mixed trajectories are observed among the different subsectors. While construction and transportation and storage have stayed stable throughout the years 2012-2017, the most significant drop was recorded by mining and quarrying, which accounted for 24% of exports in 2012. Nonetheless, since 2015, the sector has been growing its exports, a trend also echoed by the Energy and Water Supply sectors. [87]

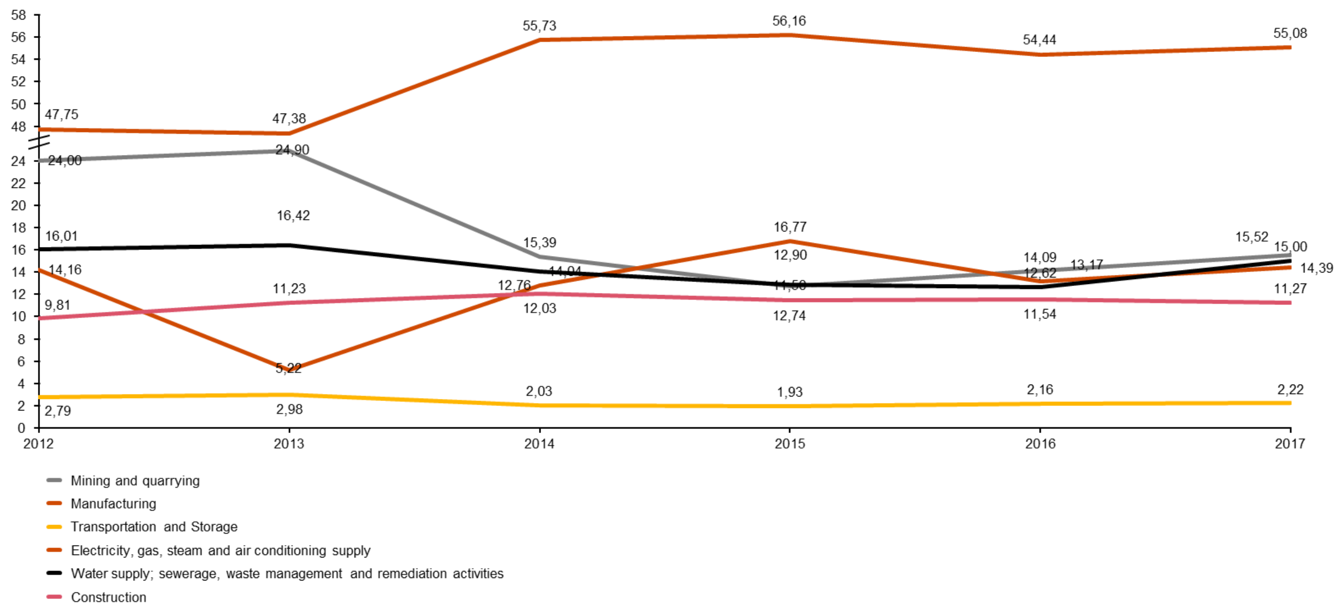

Figure 9: Industrial sectors' Exports contribution to the total EU Exports (%) – Source: Eurostat, Trade by NACE Rev. 2 activity and enterprise size class

[86] Eurostat, National accounts employment data by industry (up to NACE A*64), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64_e&lang=en
[87] Eurostat, Trade by NACE Rev. 2 activity and enterprise size class, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ext_tec01&lang=en

Looking at the labour productivity of the EU Industry and its sectors is its evident that from 2010 to 2018, the electricity, gas, steam and air conditioning supply maintained the first place, while the mining and quarrying sector was severely hit in 2016 with a decrease of 15% from 2015. Since then it recovers, however it has yet to reach the 2014 productivity levels. Manufacturing holds one of the last three positions in terms of labour productivity in this time period (see Figure 10).[88, 89]

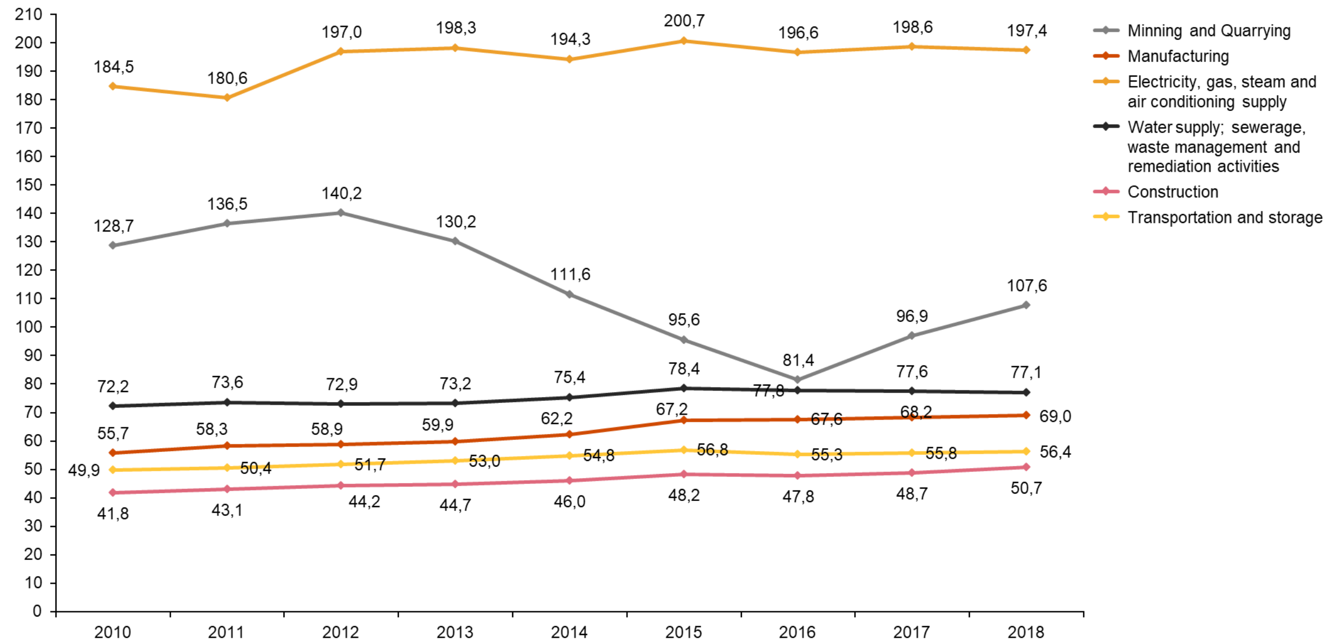

*Figure 10: GVA per employee (Thousand Euros per person) – Source: Eurostat, National accounts aggregates by industry (up to NACE A*64) & National accounts employment data by industry (up to NACE A*64)*

Finally, zooming into the labour cost of the Industrial Sectors in EU, it is evident that all sectors have increased their labour cost per hour during the last eight years (from 2010 to 2018). In more detail, the Electricity, gas steam and air conditioning supply sector appears to have the highest hourly labour cost (compensation plus taxes minus subsidies) at 39,1€ per hour in 2018 followed by the Mining and quarrying and the Manufacturing sectors at 29,8€ per hour and 28€ per hour respectively. The smallest value is observed for the Water supply sector, at 23,3€ per hour in 2018 (see Figure 11).[90]

[88] : Eurostat, National accounts aggregates by industry (up to NACE A*64), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64&lang=en
[89] Eurostat, National accounts employment data by industry (up to NACE A*64), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64_e&lang=en
[90] Eurostat, Labour cost levels by NACE Rev. 2 activity, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lc_lci_lev&lang=en

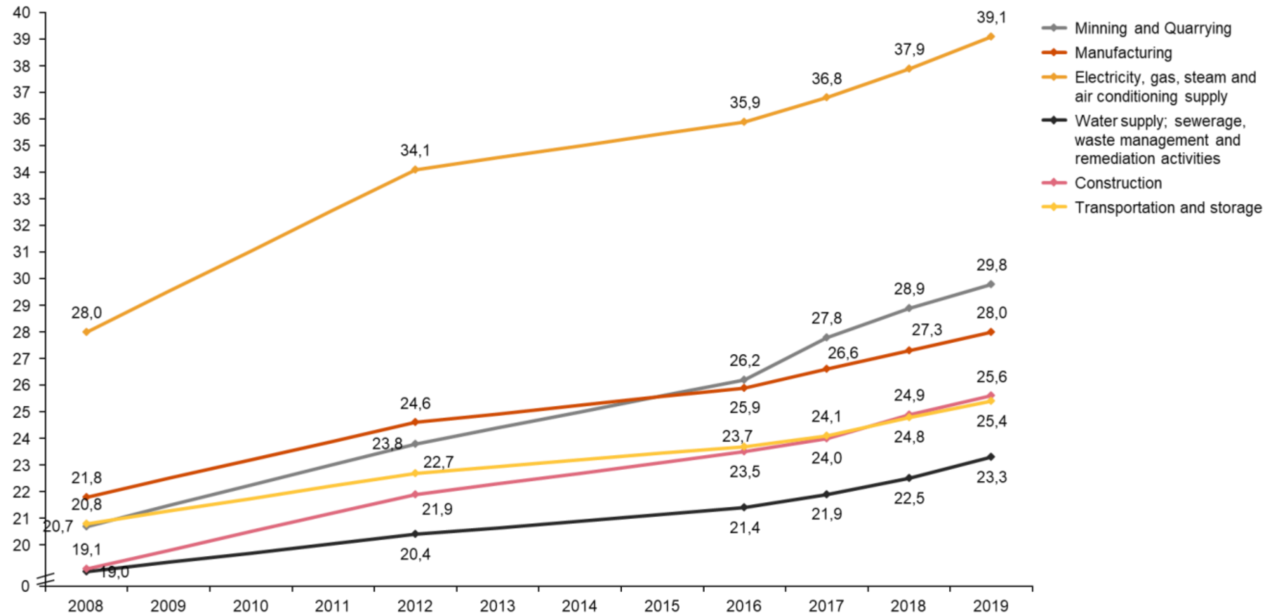

Figure 11: Labour Cost – Compensation of employees plus taxes minus subsidies (Euros per hour) – Source: Eurostat, Labour cost levels by NACE Rev. 2 activity

3.4 The European Manufacturing Overview

Since the manufacturing industry contributes the highest to the overall EU industry both in terms of value added, employment and exporting capacity, while at the same time it is the most diversified sector in terms of areas of economic activity included in it, this paragraph aims at providing more granular information on the set of sub-sectors that constitute manufacturing and at gaining a better understanding of their particular characteristics.

In 2017, the four largest manufacturing sectors contributing to the EU's Manufacturing Gross Value-added were the manufacturing of motor vehicles (14% of Manufacturing), food products, beverages and tobacco products (12% of Manufacturing), manufacturing of basic metals (12% of Manufacturing), and manufacturing of machinery and equipment (11% of Manufacturing). On the other hand, the subsectors that contribute the least to Europe's Gross Value-added are the manufacture of textiles and the manufacture of coke and petroleum products, whose GVA represents 3% and 2% of the Manufacturing Gross Value-added respectively (see Figure 12).[91]

[91] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64&lang=en

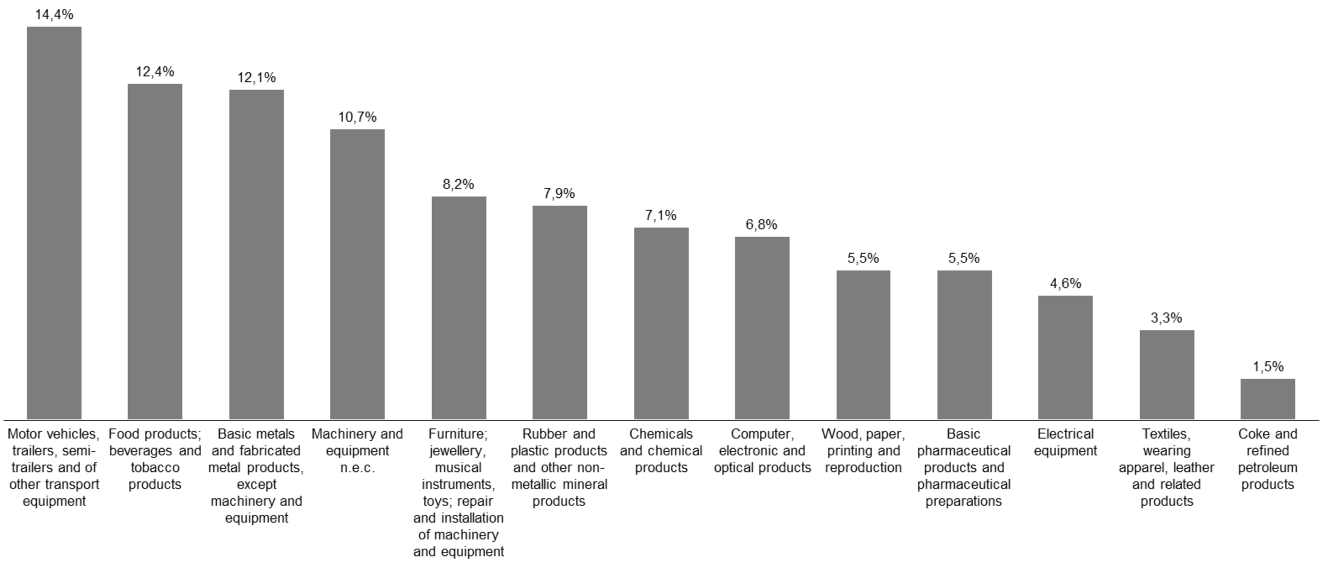

*Figure 12: Gross Value-added contribution to EU Manufacturing's Gross Value Added, 2017 – Source: Eurostat, National accounts aggregates by industry (up to NACE A*64)*

Moving on to the analysis of employment trends within the European manufacturing landscape, the manufacture of food products, beverages, and tobacco products and the manufacture of basic metals and fabricated metal products employ the greatest number of employees, representing 15% of the European workforce. On the other hand, the smallest manufacturing subsectors in terms of persons employed are the manufacture of basic pharmaceutical products and the manufacture of coke and refined petroleum products, both of which correspond to less than 2% of the European workforce (See Figure 13).[92]

[92] Eurostat, National accounts employment data by industry (up to NACE A*64), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64_e&lang=en

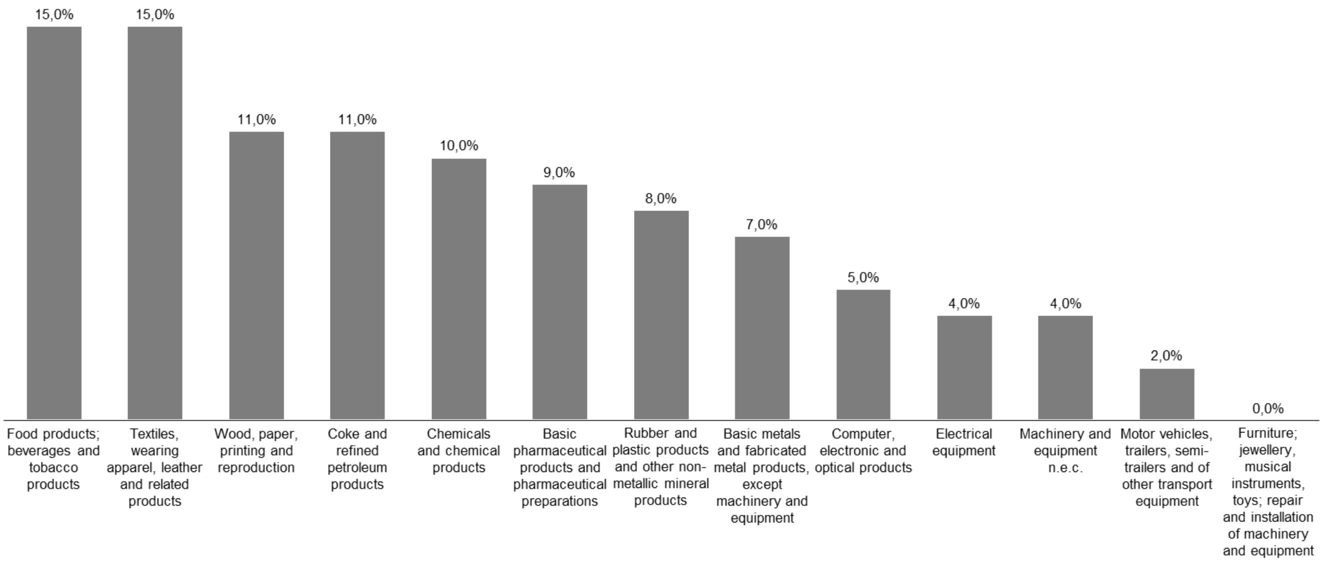

*Figure 13: Breakdown of Employment in EU Manufacturing, 2017 – Source: Eurostat, National accounts employment data by industry (up to NACE A*64)*

A breakdown of **EU export data** for the manufacturing subsectors reveals significant insights with respect to the export potential and export trends of Europe's manufacturing sector. The Manufacture of motor vehicles subsector has a clear lead in terms of exports, accounting for 25,4% of all manufacturing exports in 2017. Ranked 12% lower, the Manufacture of machinery and equipment (13%) subsector represents the second largest EU exporter of manufacturing goods and services. At the tail end of the manufacturing subsectors, furniture, jewellery, and musical instruments and the repair and installation of machinery and equipment represent the smallest share of exports at below 1% of EU manufacturing trade outflows (See Figure 14)[93].

[93] Eurostat, Trade by NACE Rev. 2 activity and enterprise size class https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ext_tec01&lang=en

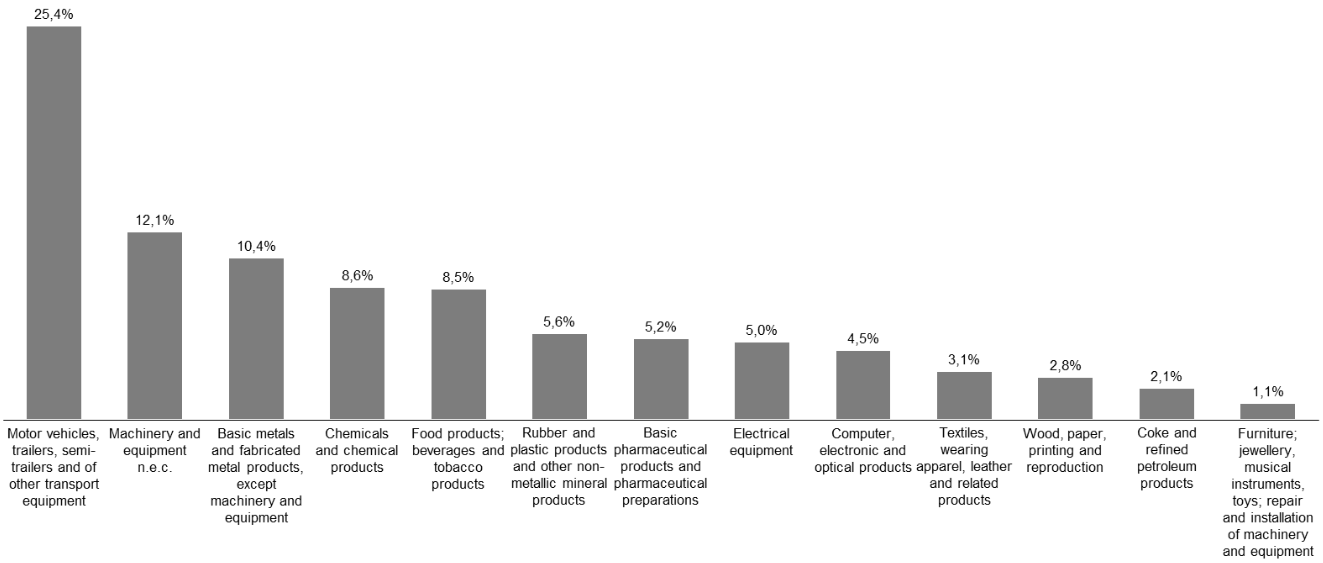

Figure 14: Breakdown of Exports in EU Manufacturing, 2017 – Source: Eurostat, Trade by NACE Rev. 2 activity and enterprise size class

3.5 The Greek Industry Overview

Focusing on Greece, a brief overview of the aforementioned indicators on the domestic level will help shed light on the particular state of Greek industry and manufacturing. During the last years, the Greek fiscal derailment and the national Government (GG) Debt crisis severely hit the Greek economy and the all its economic activities. This is evident from the declining contribution of the Greek Industry to the overall

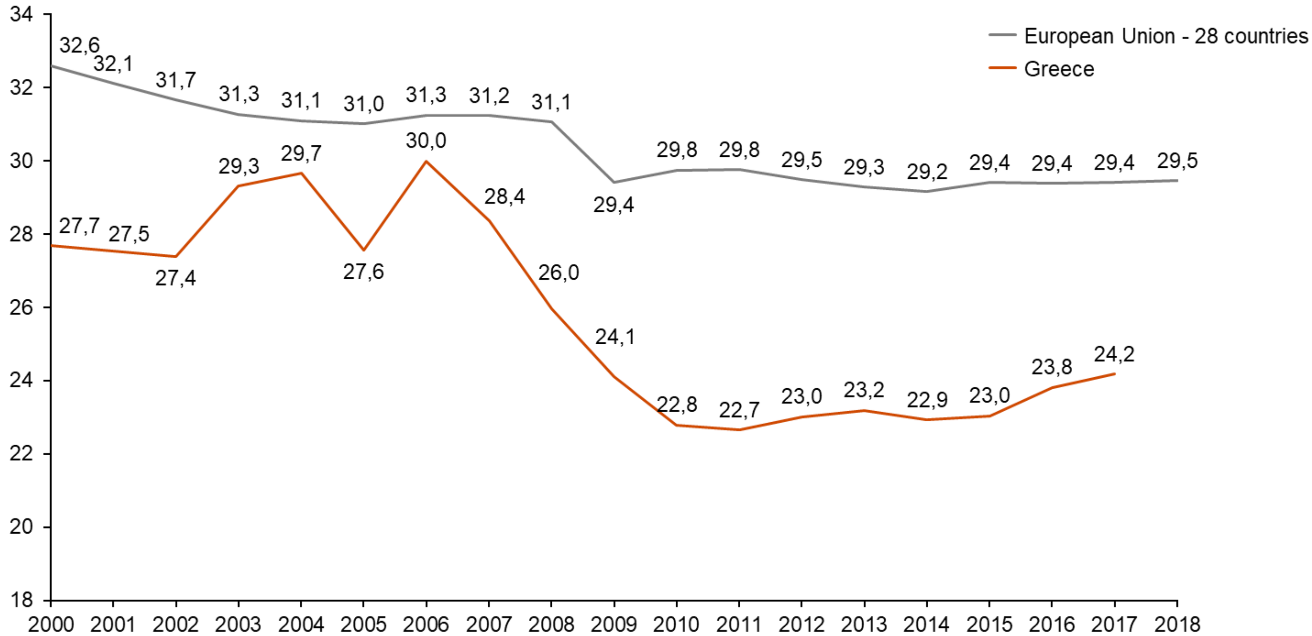

*Figure 15: EU & Greek Industry Gross Value Added as % of total EU & Greece's Gross Value Added (%) – Source: Eurostat, National accounts aggregates by industry (up to NACE A*64)*

Greek economy both in terms of Gross Value Added and in terms of employment. Nevertheless, despite this severe hit the Greek Industry continues to play an important role in the overall Greek economy, as it generated 24,2% of the total Gross value added in 2017 (contrary to 29,4% of the EU average) (see Figure 15).[94, 95] In the same year, employment in the Greek Industry contributed to 19% of the total Greek employment (see Figure 16).[96, 97]

[94] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64&lang=en
[95] Data 2018 not available for Greece
[96] Eurostat, National accounts employment data by industry (up to NACE A*64), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64_e&lang=en
[97] 2018 Data not available for Greece

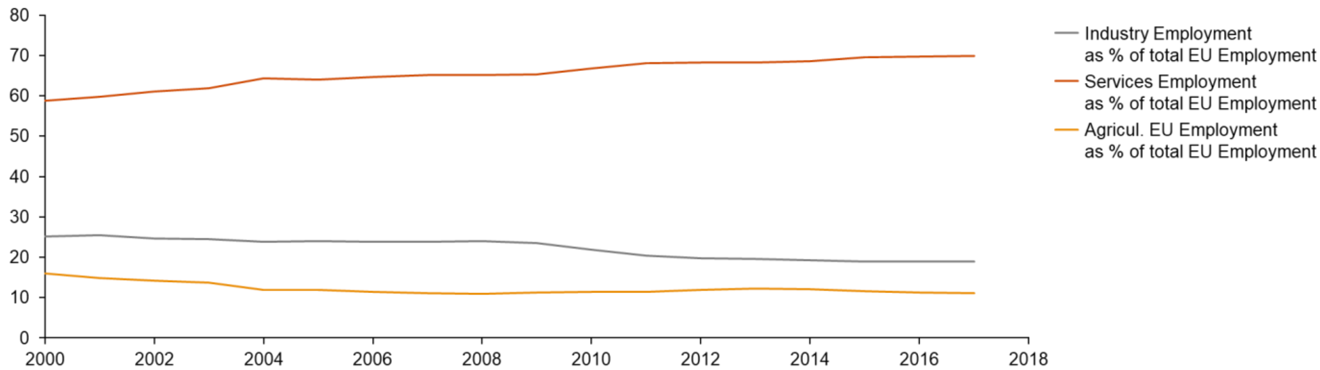

*Figure 16: Greece's Industry, Services & Agriculture Employment as % of total Greece's Employment (%) – Source: Eurostat, National accounts employment data by industry (up to NACE A*64)*

The severe Greek financial crisis has taken also a significant hit on fixed capital investments across all sectors of the Greek economy. The, mainly Government controlled, investments in other construction and in transport equipment fell by- 22,9% and -43,5% respectively in 2018. In 2019 the recovery investment in transport equipment was notable (+30,5%) but the recovery of investment in other construction was much lower than expected (+3,1%). Also, investment in Fixed Capital (FC) excluding investment in other construction and transportation equipment (an indicator that includes and refers to investments in technology equipment) was severely hit from 2015 to 2017, but ware up by an expected +4,9% in 2019 (see Figure 17).[98, 99] Although there is no specific data available for fixed capital investments for the Greek Industry, it is fair to assume that the overall hit in fixed capital investments relates also to decelerated investments within the Greek Industry with regards to their technology equipment and Industry 4.0 technologies and applications.

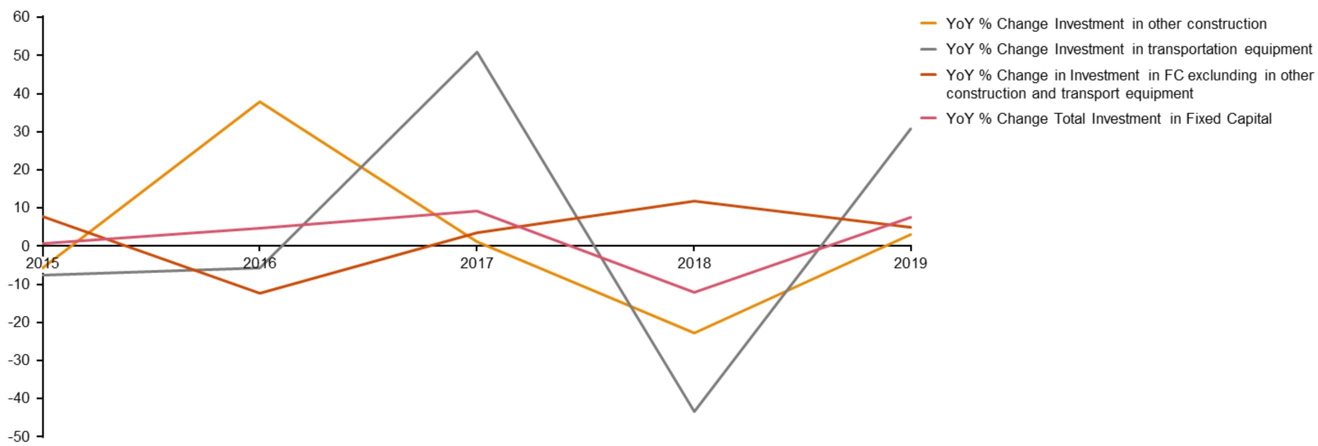

Figure 17: YoY % Change in different types of Investments of Fixed Capital, 2015 - 2019, (%) – Source: Hellenic Statistical Authority, Gross Capital Formation (Flash Estimates), Stochasis Macroeconomic Trends -Sectoral Forecasts, December 2019. Forecasts have been provided by Stochasis

[98] Hellenic Statistical Authority, Gross Capital Formation (Flash Estimates), https://www.statistics.gr/en/statistics/-/publication/SEL18/-
[99] Stochasis report: Stochasis Macroeconomic Trends – Sectoral Forecasts, December 2019

With regards to the Greek trade, exports of Goods registered a substantial increase from 17,7bn. in 2009 to 32,4bn. in 2018 (83% increase) reflecting the fundamental improvement of Greece's international competitiveness. On the contrary, exports of services during the same time period increased by 37%.

Nevertheless, the trade balance of goods for Greece remains constantly negative (for 2018 this was -22,5bn.), contrary to the trade balance of services that has been positive since 2002, totalling at 19,3bn. in 2018. This leads to a negative trade balance for Goods & Services in 2018 of -3,2bn. Euros (see Figures 18, 19).[100]

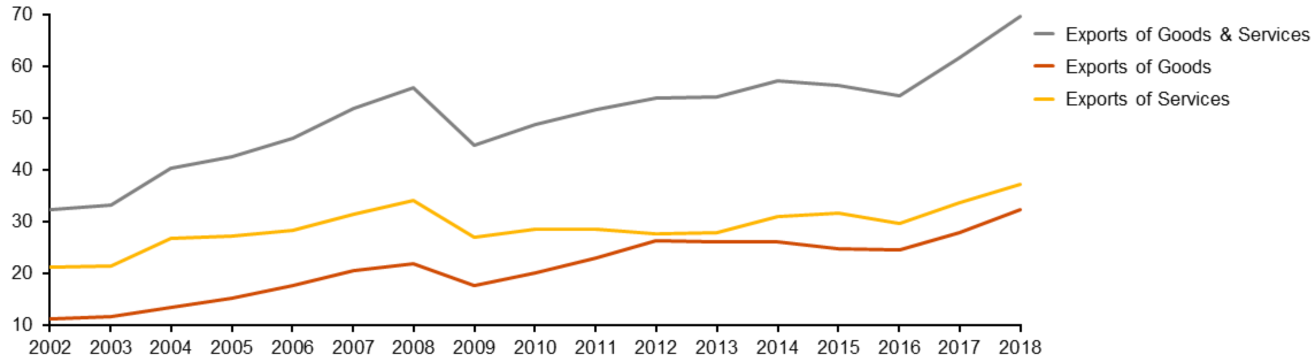

Figure 18: Greek Exports of Goods & Services in fixed 2010 prices (in billion Euros) – Source: Eurostat, European Union and euro area balance of payments - quarterly data (BPM6)

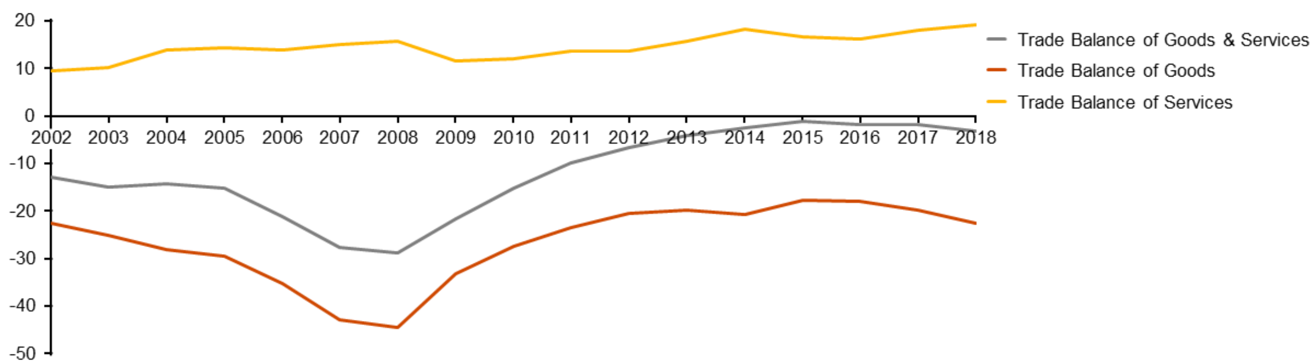

Figure 19: External Balance of Goods and Services in fixed 2010 prices (in billion Euros) - Source: Eurostat, Balance of payments by country - annual data (BPM6)

With regards to the percentage of exports of high technology products[101] (over Greece's total exports), the situation is much worse than the EU average. Greece remains significantly behind the EU average with regards to high tech exports. In more detail, after 2009, when the share of the high-tech exports was at its peak in Greece with 7,7% of the total Greek exports, it dropped by 5% during a 4-year period, reaching an 11-year low of 2,7% in 2013. Since then it has slightly increased, but not enough to overcome the pre-

[100] Eurostat, Balance of payments by country - annual data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_c6_a&lang=en

[101] High technology products are defined according to SITC Rev.4 as the sum of the following products: Aerospace, Computers-office machines, Electronics-telecommunications, Pharmacy, Scientific instruments, Electrical machinery, Chemistry, Non-electrical machinery, Armament. The total exports for the EU do not include the intra-EU trade

crisis value, being at 4,5% in 2018. This percentage is significantly lower than the EU average (more than 13%) (see Figure 20).[102] This indicates that although the Greek economy has increased its exporting activity during the last years in terms of goods, its exports are products of limited value added.

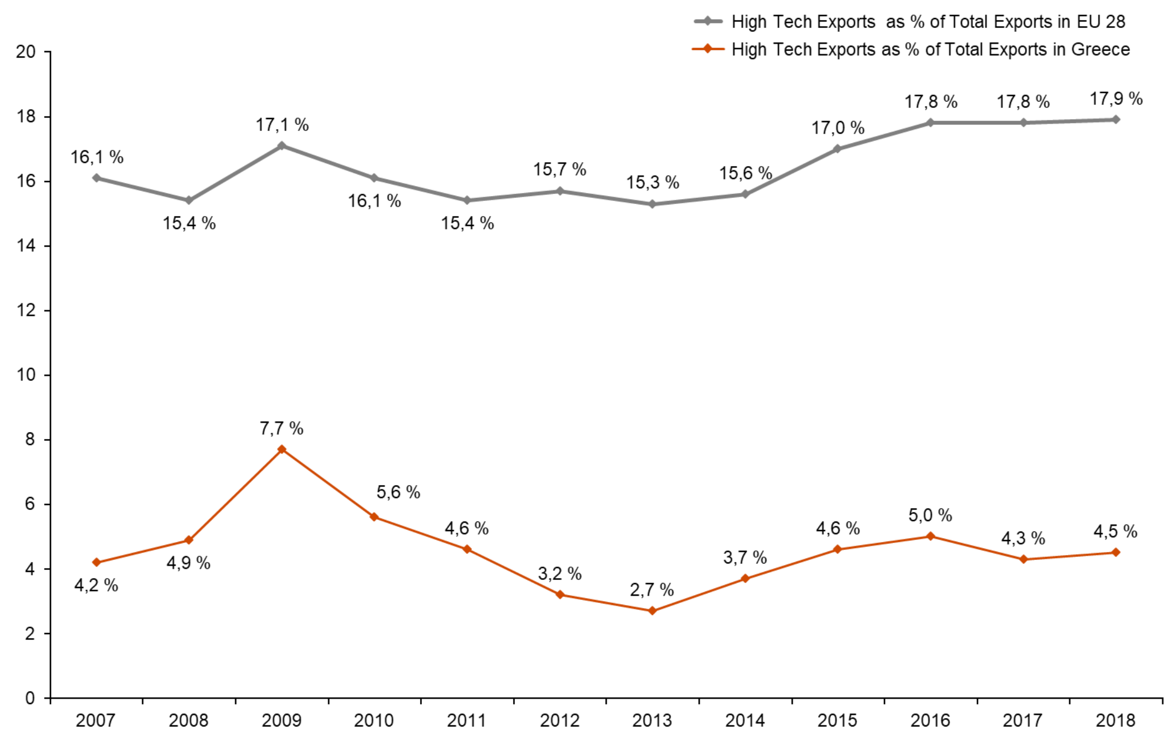

Figure 20: Exports of high technology products as a share of total exports, EU & Greece, (%) – Source: Eurostat, High-tech exports – Exports of high technology products as a share of total exports (from 2007, SITC Rev. 4)

Looking at the development of the **Greek industrial production** from 2013 – 2018 and its projections for 2019 and 2020, we observe that continuously increases since 2015. In fact, in 2017, the industrial production demonstrated its highest growth (by 3,9%). Projections estimate that the industrial production will continue to grow in 2019 (by 0,9%) and in 2020 (by 3%) (see Figure 21).[103, 104]

[102] Eurostat, High-tech exports – Exports of high technology products as a share of total exports (from 2007, SITC Rev. 4), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=htec_si_exp4&lang=en
[103] Eurostat, Production in industry - annual data, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sts_inpr_a&lang=en
Data are compiled according to the Statistical classification of economic activities in the European Community, (NACE Rev. 2, Eurostat). Data and weights are available for the following NACE categories: B) Mining and Quarrying, (C) Manufacturing, (D) Electricity, Gas Steam and Air Conditioning supply, (E36) Water Supply and collection
[104] Stochasis report: Stochasis Macroeconomic Trends – Sectoral Forecasts, December 2019

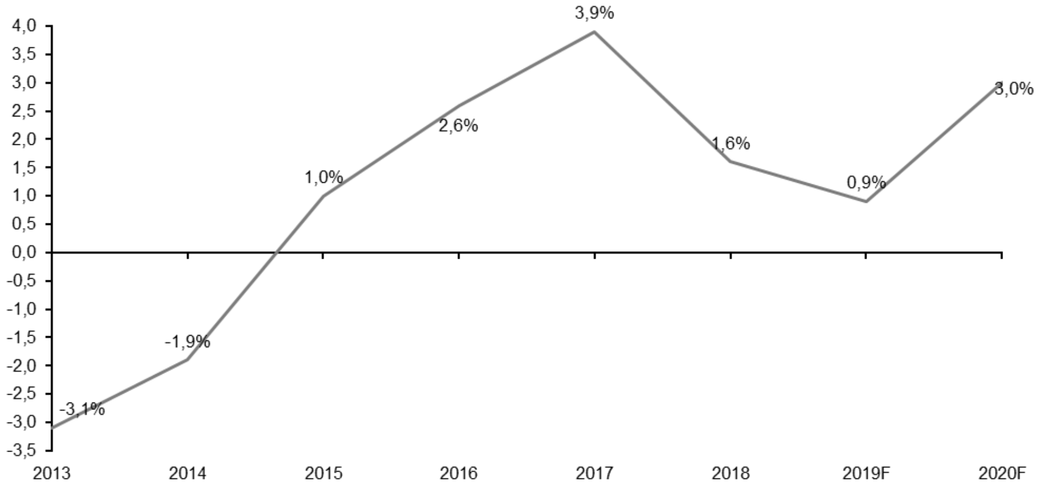

Figure 21: YoY change (%) of Greece's industrial production index, 2013 – 2020F (2015=100) - Source: Eurostat, Production in industry - annual data / Stochasis Macroeconomic Trends -Sectoral Forecasts, December 2019. Forecasts have been provided by Stochasis

If we further zoom-into the different Greek Industry sectors[105], a cross industry analysis of gross value added demonstrates that Greece's Manufacturing sector represents the greatest contribution to Greece's overall Gross Value-added, amounting to 10% in 2017. The transportation and storage sector ranks 2nd with 7% Gross Value-added, while the remaining industrial sectors represent a significantly smaller percentage of the domestic Gross Value-added, with less than 3% each. Water supply and mining and quarrying hold the last positions in this ranking. In terms of growth trends, manufacturing is the fastest growing industrial sector in Greece, with over 3% growth of its Gross Value-Added contribution since 2010. While most of the other industrial sectors have remained relatively stable over the past decade, Greece's construction sector declined by 2% since 2010 (see Figure 22).[106]

[105] Although according to EU's definition, Industry includes the following NACE categories: B) Mining and Quarrying, (C) Manufacturing, (D) Electricity, Gas Steam and Air Conditioning supply, (E) Water Supply, Sewerage, (F) Construction, for the purpose of our engagement, we have also included in our analysis the (H) Transportation and Storage sector. For this reason, Industry-related numbers at an aggregate level may slightly vary from the sum of its sector-related numbers
[106] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64&lang=en

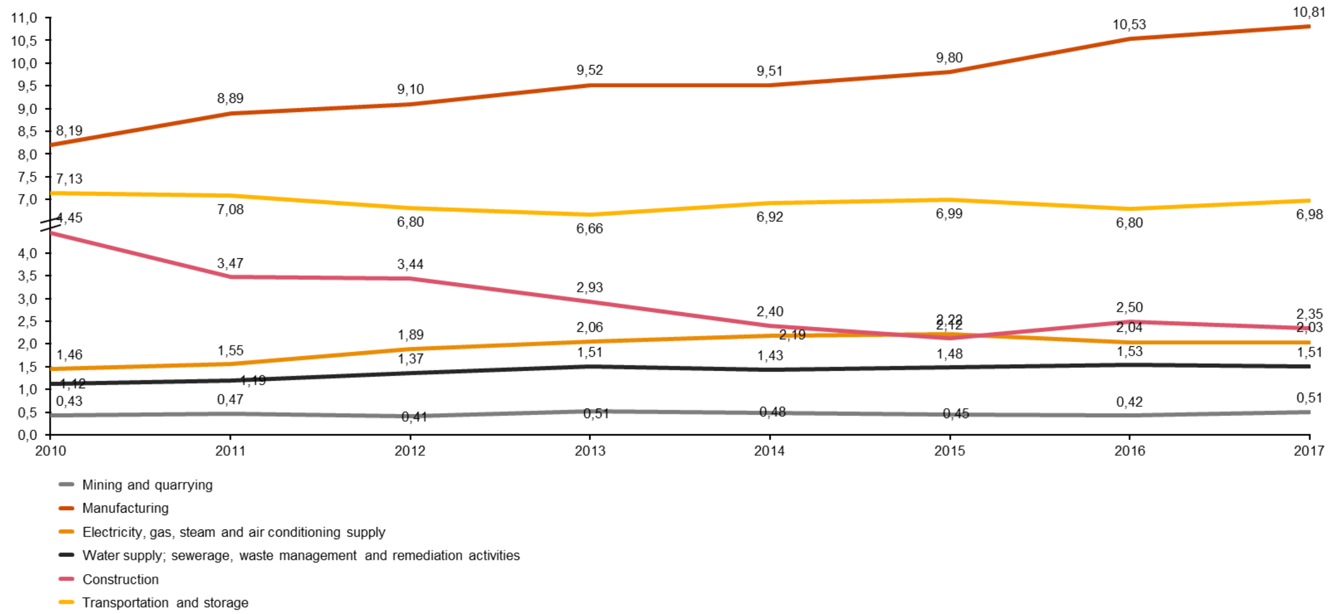

*Figure 22: Industrial sectors' Gross Value-Added contribution to the total Greek Gross Value Added (%) – Source: Eurostat, National accounts aggregates by industry (up to NACE A*64)*

Industry in Greece employed approximately 790.000 people in 2017 - over 330.000 of them were employed in the Manufacturing sector, over 200.000 in the Construction sector and approximately 195.000 in the Transportation and storage sector. As stated, out of the industrial sectors, the largest employer is manufacturing, whose workforce corresponded to 8% of the total Greek workforce in 2017. In the 2nd and 3rd position we find the construction and transportation and storage sectors, each of which represents around 5% of Greece's workforce. The sectors with the smallest percentage of employees in 2017 were the electricity and mining and quarrying sectors. Since 2010, the most significant decline in employment was demonstrated by the construction industry, echoing the aforementioned decreases in gross value added and exports for the same sector (see Figure 23).[107]

[107] Eurostat, National accounts employment data by industry (up to NACE A*64), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64_e&lang=en

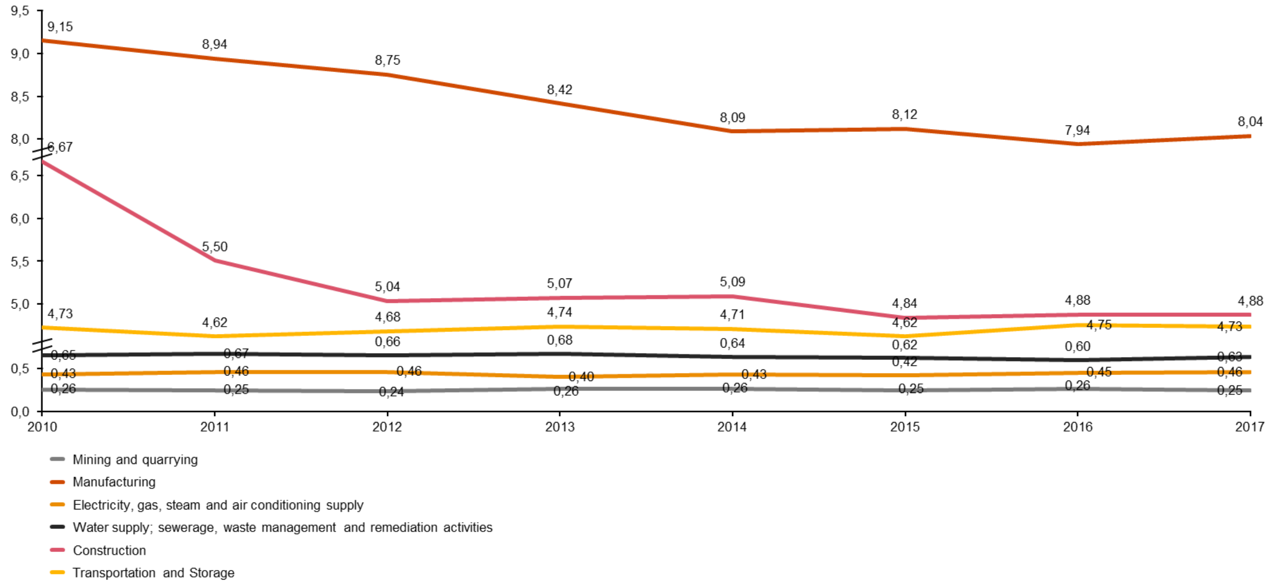

*Figure 23: Greek Industrial sectors' Employment contribution to the total Greek Employment (%) – Source: Eurostat, National accounts employment data by industry (up to NACE A*64)*

Shifting our focus to the **export** of industrial goods from Greece, the manufacturing sector includes almost all Greek industrial exports. While Greek manufacturing exports correspond to 64% of all Greek exports in 2017, the remaining industrial sectors' exports represent 0-2% of the country's outgoing trade (See Figure 24).[108]

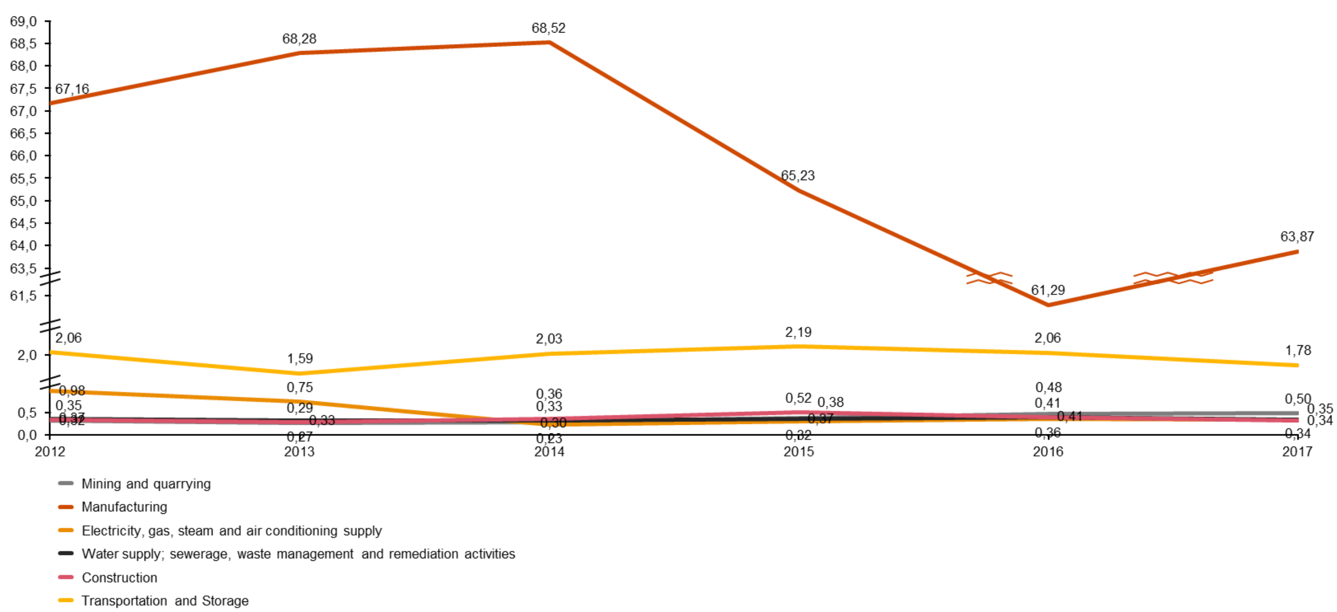

Figure 24: Greek Industrial sectors' Exports contribution to the total Greek Exports (%) – Source: Eurostat, Trade by NACE Rev. 2 activity and enterprise size class

108 Eurostat, Trade by NACE Rev. 2 activity and enterprise size class, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ext_tec01&lang=en

Zooming into labour productivity, the highest values throughout the years are spotted in the Electricity, gas, steam and air conditioning supply sector with a gross value added of approximately 169.000 € per person employed in 2017, 17% lower from the 8-year high of 205.000€ in 2013. Water supply; sewerage, waste management and remediation activities follow with a gross value added of 90.600€ per employee in 2017. The smallest GVA per employee is presented in the Construction sector, with only 18.300€ in 2017 (see Figure 24). [109, 110]

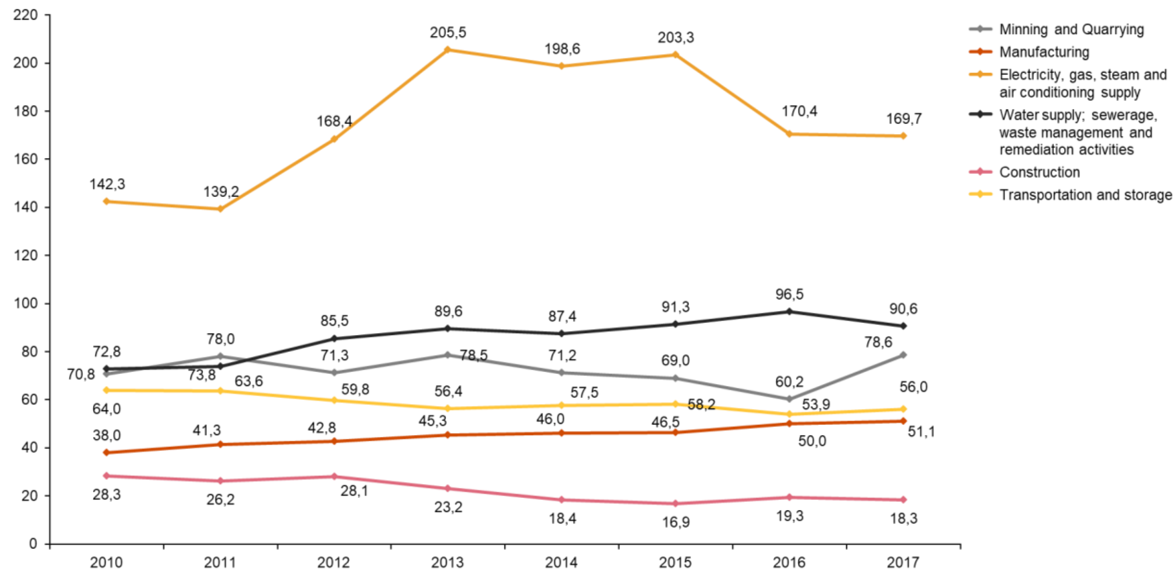

*Figure 25: GVA per employee (Thousand Euros per person) – Source: Eurostat, National accounts aggregates by industry (up to NACE A*64) & National accounts employment data by industry (up to NACE A*64)*

Finally, with regards to the labour cost per hour index in the Industrial Sectors in Greece, the Electricity, gas, steam and air conditioning supply presented the most significant drop since 2008, reducing from 30,8€ per hour to 21€ per hour in 2019, that places it 3rd in the relevant Industrial ranking for 2019. The Transportation and storage sector demonstrates the highest labour cost in 2019, with 25,5€ per hour, followed closely by the Mining and Quarrying sector, at 24,4€ per hour. Water supply and Manufacturing come 4th with 16,2€ per hour and 5th with 16,1€ per hour respectively. The sector with the lowest labour cost is the Construction, with 10,3€ per hour in 2019(see Figure 26). [111]

[109] Source: Eurostat, National accounts aggregates by industry (up to NACE A*64), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64&lang=en
[110] Eurostat, National accounts employment data by industry (up to NACE A*64), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64_e&lang=en
[111] Eurostat, Labour cost levels by NACE Rev. 2 activity, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lc_lci_lev&lang=en

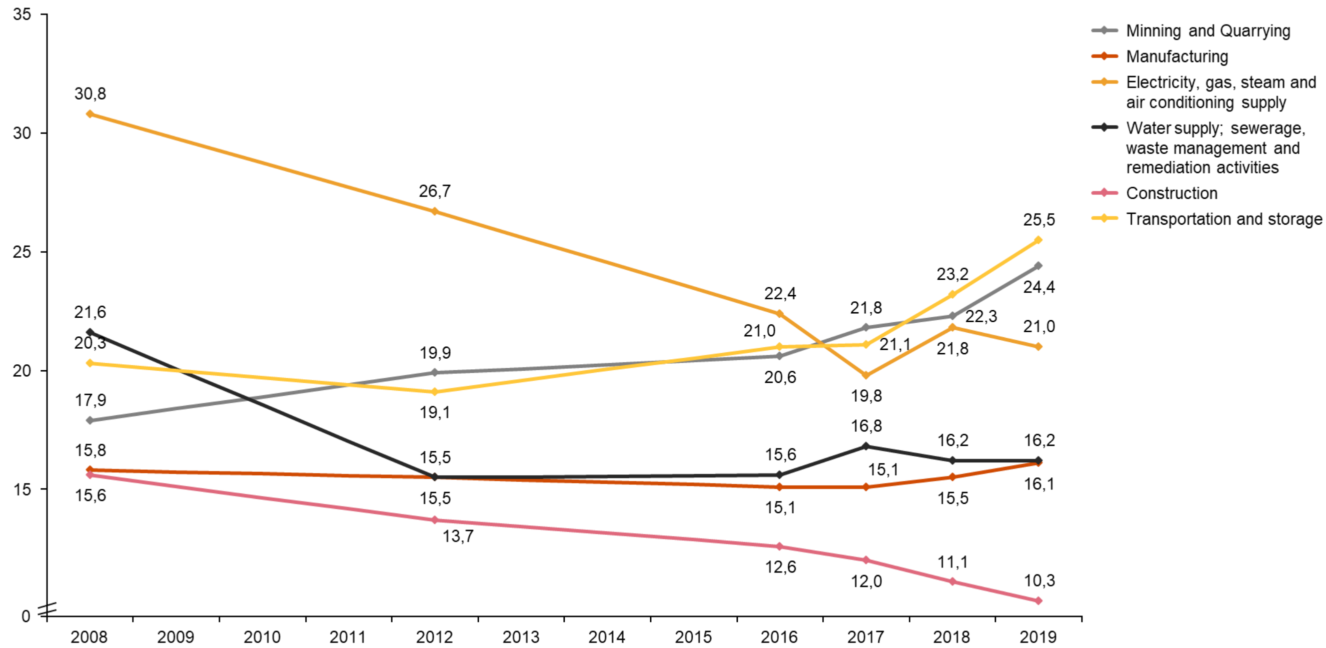

Figure 26: Labour Cost – Compensation of employees plus taxes minus subsidies (Euros per hour) – Source: Eurostat, Labour cost levels by NACE Rev. 2 activity

3.6 The Greek Manufacturing Overview

Zooming into the Greek manufacturing sector, we will now focus our analysis on the relative performance of the different manufacturing subsectors of the Greek economy.

In terms of gross value added, manufacturers of food products beverages and tobacco products lead the way, representing 33% of the total manufacturing Gross Value-added in 2017. Coming in 2nd at 20,3% of manufacturing value added is the manufacture of basic metals and fabricated metal products subsector. The remaining subsectors of Greek manufacturing all report less than 10% of the total manufacturing Gross Value-added, with the manufacture of motor vehicles and the manufacture of computers coming in last in terms of total value added (see Figure 27). [112]

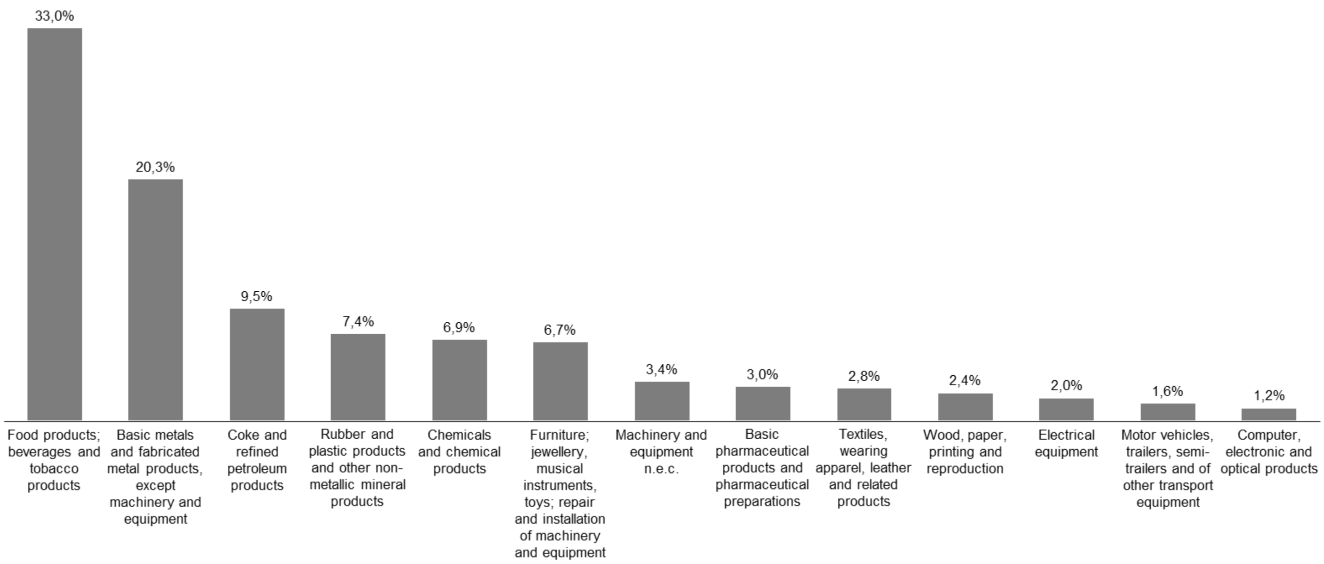

*Figure 27: Gross Value-added contribution to Greek Manufacturing's Gross Value Added, 2017 – Source: Eurostat, National accounts aggregates by industry (up to NACE A*64)*

In terms of employment, Greek manufacturers of food products, beverages and tobacco employed the most people, representing 35% of the Greek manufacturing workforce in 2017. Manufacturers of basic metals follow, with a workforce that corresponds to 14% of Greece's manufacturing workforce. These two aforementioned subsectors are followed by several medium size industries, such as furniture, textile and rubber manufacturing, each of which represents around 10% of the Greek manufacturing workforce. While the remaining manufacturing subsectors all employ less than 4% of the Greek workforce, coke and

[112] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64&lang=en

petroleum product manufacturers represent the smallest subsector, accounting for just 1% of the overall manufacturing workforce in 2017 (see Figure 28). [113]

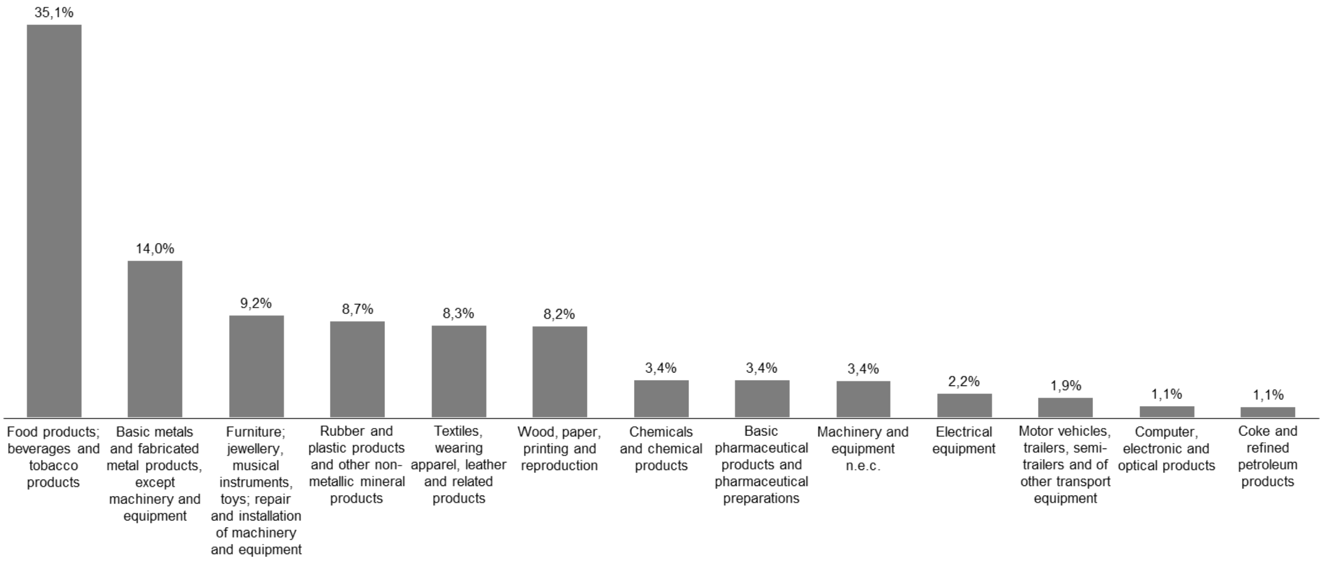

*Figure 28: Breakdown of Employment in Greek Manufacturing, 2017 – Source: Eurostat, National accounts employment data by industry (up to NACE A*64)*

Regarding **exports** of industrial goods, the top Greek manufacturing exporter is the manufacture of coke and refined petroleum products. This subsector is responsible for 39% of Greek manufacturing exports, surpassing the second runner up by more than 20%. The 2nd and 3rd largest export share among Greek manufacturers was reported by the manufacture of basic metals and the manufacture of food products, with the corresponding 14% and 10% share of manufacturing exports in 2017. All other manufacturing subsectors display a significantly lower export rate, with none surpassing 5% of manufacturing exports (See Figure 29).[114]

[113] Eurostat, National accounts employment data by industry (up to NACE A*64), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64_e&lang=en
[114] Eurostat, Trade by NACE Rev. 2 activity and enterprise size class, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ext_tec01&lang=en

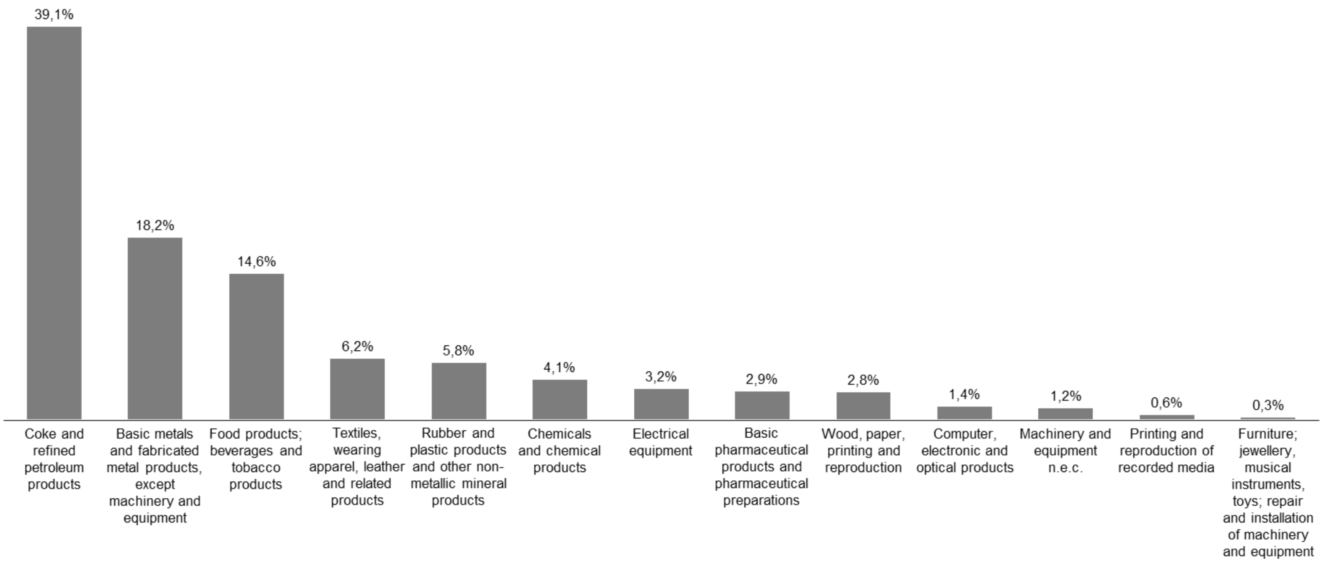

Figure 29: Breakdown of Exports in Greek Manufacturing, 2017 – Source: Eurostat, Trade by NACE Rev. 2 activity and enterprise size class

Finally, if we examine the manufacturing production index and compare it with the overall industrial production index, we observe that the production of manufacturing industry has increased by 2,9% in 2017 and 2,8% in 2018. It is now projected to grow by 2,1% in 2019 and by 3,4% in 2020 (see Figure 30).[115, 116]

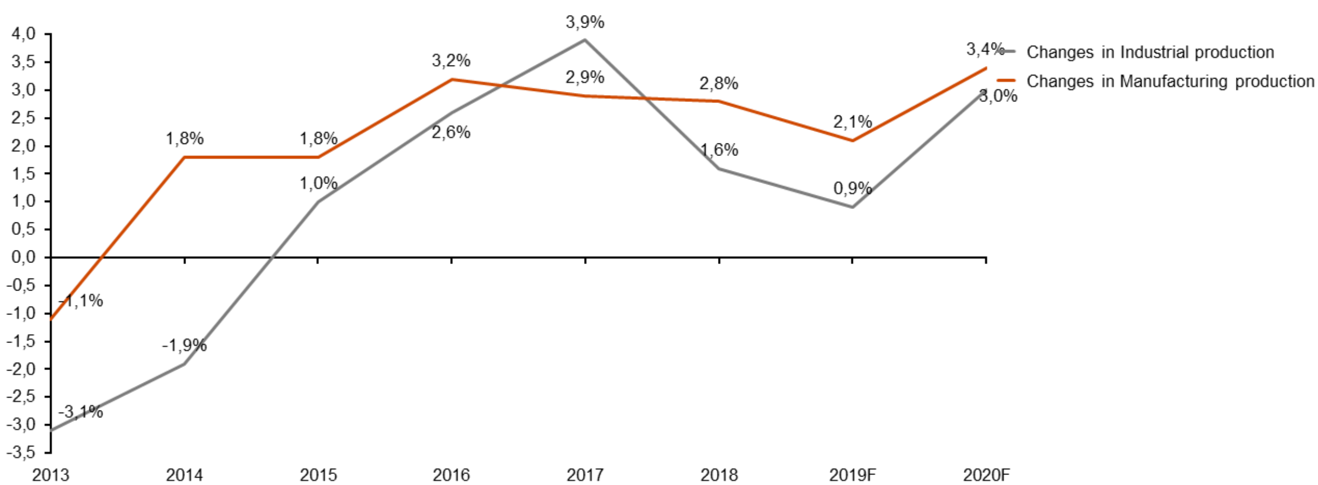

Figure 30: Evolution of Greece's industrial & manufacturing production index, 2013 – 2020F (2015=100) - Source: Eurostat, Production in industry - annual data, Stochasis Macroeconomic Trends -Sectoral Forecasts, December 2019. Forecasts have been provided by Stochasis

[115] Eurostat, Production in industry - annual data, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sts_inpr_a&lang=en
Data and weights are available for the following NACE categories: B) Mining and Quarrying, (C) Manufacturing, (D) Electricity, Gas Steam and Air Conditioning supply, (E36) Water Supply and collection
[116] Stochasis report: Stochasis Macroeconomic Trends – Sectoral Forecasts, December 2019

With regards to developments in the production of the main sub-sectors of Greek manufacturing from 2015 – 2020, a look at the table below indicates that, in general terms, Greek manufacturers have increased their output over the past 5 years, with annual growth rates nearing 3% for the whole sector. That being said, production output trends on a sub-sectoral level vary significantly among different sub-sectors.

The highest increases in production output over the course of 2015-2020 are recorded by the pharmaceutical sector, where output grew at annual rates of 19% and 24% for two consecutive years (2017-2019). The tobacco manufacturing sector also raised its output significantly, recording a 22-percentage point increase in production over the course of 2018, albeit following a slower increase in its output by 8% in 2016.

Closely following the frontrunners in annual production growth rates are the Greek manufacturers of chemicals, rubber and plastic products and basic metals, all of which also demonstrated consistent growth in their output over the past half-decade, above the sectoral average.

In terms of variability, manufacturers of coke and petroleum products display the highest level of output growth variability, displaying above average growth rates until 2017, before recording a decreasing output (-8%) over the course of 2018. Finally, the food manufacturing sector was the most stable in terms of production output levels, nevertheless it did note exceed a growth rate of 2,5% over the 5-year period.[117]

Manufacturing Sub-Sectors – Production index growth rates (2015 – 2020)[118, 119]	2015-2016	2016-2017	2017-2018	2018-2019F	2019-2020F
Food products	0,9%	1,5%	0,0%	1,8%	2,4%
Beverages	-1,0%	-5,5%	5,7%	0,3%	3,3%
Tobacco products	11,9%	-8,0%	-8,1%	22,2%	3,8%
Coke and refined petroleum products	7,4%	4,4%	3,5%	-8,7%	2,0%
Chemicals and chemical products	6,4%	2,2%	7,1%	6,0%	2,8%
Basic pharmaceutical products and. Preparations	8,1%	5,7%	19,1%	24,4%	3,5%
Rubber and plastic products	0,7%	3,2%	2,0%	7,7%	2,4%
Non-metallic mineral products	12,3%	2,9%	1,5%	-5,2%	12,5%
Basic metals	4,9%	17,7%	3,8%	-2,1%	4,2%

[117] Stochasis report: Stochasis Macroeconomic Trends – Sectoral Forecasts, December 2019
[118] Eurostat, Production in industry - annual data, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sts_inpr_a&lang=en
[119] Stochasis report: Stochasis Macroeconomic Trends – Sectoral Forecasts, December 2019

3.7 Comparison of Greece and select EU countries across key indexes

Before we conclude this chapter, we have consolidated and present the key indexes presented above for the EU average and Greece, for three additional countries, Germany, France and Portugal. These countries will be also used as best practices for the design of Greece's Industry 4.0 strategy (as this will be presented in chapter 7).

The depiction of this set of indexes does not aim at explaining the reasons behind each country's and their Industries' current performances. On the contrary, it primarily aims at highlighting that despite Industry's key role across all countries, each country is unique in terms of the structure of its economy. For this reason, their national Industry 4.0 strategies are also tailored to their Industries' specific needs and strengths.

	EU 28	Germany	France	Portugal	Greece
Industry GVA 2018 in million € (%Δ in Industry GVA 2013-2018)[120]	4.184.887,9 (17%)	1.052.060 (21%)	491.617 (6%)	47.800,7 (21%)	38.096 (3%)[121]
Industry GVA as % of total GVA 2018[122]	29%	35%	24%	27%	24%[123]
Industry employment 2018 in thousands (%Δ in Industry employment 2013-2018)[124]	64.130,33 (6%)	13.154 (5%)	6.035 (-2%)	1.318,15 (12%)	786,83 (1%)[125]
Industry employment as % of total employment 2018[126]	27%	29%	21%	27%	19%[127]
Total Gross Capital Formation 2018 (%Δ in Total Gross Capital formation 2013-2018)[128]	N/A	729.029 (29%)	551.926 (17%)	37.031,4 (48%)	22.544,4 (8%)[129]
Industry GVA per employee in 2018 in thousand € (%Δ in GVA per employee 2013-2018)[130,131]	65,26 (11%)	79,98 (15%)	81,46 (8%)	36,26 (8%)	48,42 (2%)[132]

[120] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_a64
[121] Latest data available from year 2017
[122] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_a64
[123] Latest data available from year 2017
[124] Eurostat, National accounts employment data by industry (up to NACE A*64), https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_a64_e
[125] Latest data available from year 2017
[126] Eurostat, National accounts employment data by industry (up to NACE A*64), https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_a64_e
[127] Latest data available from year 2017
[128] Eurostat, Gross capital formation by industry (up to NACE A*64), https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_a64_p5
[129] Latest data available from year 2017
[130] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_a64
[131] Eurostat, National accounts employment data by industry (up to NACE A*64), https://ec.europa.eu/eurostat/web/products-datasets/product?code=nama_10_a64_e
[132] Latest data available from year 2017

	EU 28	Germany	France	Portugal	Greece
Exports of goods 2018 in million € (%Δ in exports of goods 2013-2018)[133, 134]	1.992.500 (19%)	1.292.900 (21%)	517.800 (18%)	56.200 (21%)	32.400 (24%)
Exports of goods as % of GDP 2018[135, 136, 137]	13%	39%	22%	28%	18%
Exports of high technology products as % of total exports 2018[138]	17,9%	15,1%	20,5%	4%	4,5%
Imports of goods 2018 in million € (%Δ in imports of goods 2013-2018)[139, 140]	1.911.700 (16%)	1.066.800 (23%)	567.100 (18%)	72.100 (32%)	54.900 (20%)
Imports of goods as % of GDP 2018[141,142, 143]	12%	32%	24%	35%	30%
Exports of services 2018 in million € (%Δ in imports of goods 2013-2018)[144, 145]	952.800 (32%)	296.200 (42%)	249.400 (24%)	33.300 (51%)	37.200 (33%)
Exports of services as % of GDP 2018[146, 147,148]	6%	9%	11%	16%	20%
Imports of services 2018 in million € (%Δ in imports of services 2013-2018)[149, 150]	751.400 (37%)	315.900 (28%)	225.600 (31%)	16.000 (47%)	17.900 (46%)

[133] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[134] Eurostat, Balance of payments by country - annual data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_c6_a&lang=en
[135] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[136] Eurostat, Balance of payments by country - annual data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_c6_a&lang=en
[137] Eurostat, Gross domestic product at market prices, https://ec.europa.eu/eurostat/databrowser/view/tec00001/default/table?lang=en
[138] Eurostat, High-tech exports - Exports of high technology products as a share of total exports (from 2007, SITC Rev. 4), https://ec.europa.eu/eurostat/web/products-datasets/-/htec_si_exp4
[139] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[140] Eurostat, Balance of payments by country - annual data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_c6_a&lang=en
[141] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[142] Eurostat, Balance of payments by country - annual data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_c6_a&lang=en
[143] Eurostat, Gross domestic product at market prices, https://ec.europa.eu/eurostat/databrowser/view/tec00001/default/table?lang=en
[144] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[145] Eurostat, Balance of payments by country - annual data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_c6_a&lang=en
[146] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[147] Eurostat, Balance of payments by country - annual data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_c6_a&lang=en
[148] Eurostat, Gross domestic product at market prices, https://ec.europa.eu/eurostat/databrowser/view/tec00001/default/table?lang=en
[149] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[150] Eurostat, Balance of payments by country - annual data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_c6_a&lang=en

	EU 28	Germany	France	Portugal	Greece
Imports of services as % of GDP 2018[151, 152,153]	5%	9%	10%	8%	10%
Industrial Production Index 2019, Baseline 2015 = 100[154, 155]	105,1	100,8	103,4	103,6	108,8
Manufacturing Production Index 2019, Baseline 2015 = 100[156]	105,8	100,5	104,2	102,1	110,1
Industry Labour Cost Level 2019 in € per hour (%Δ in Industry Labour Cost Level 2016-2019)[157, 158]	28,2 (8%)	41,2 (7%)	39,1 (6%)	12,1 (9%)	16,9 (6%)

Industry contributes the highest to the German economy with a 35% share on the country's total Gross Value Added and a 29% share on the country's overall employment. The great importance that Industry plays in the German economy, has also been the reason why Germany has been the first country to introduce the term Industry 4.0 and design its national Industry 4.0 strategy in 2011.

With regards to their Industries' GVA and employment growth, it is important to mention that Portugal demonstrates the same Industry GVA growth rate as Germany (21% growth from 2013 – 2018). At the same time, Industry employment has also increased by 12% during the same time-period. This combined with the significant increase of 48% in Gross Capital Formation, signifies the great focus and efforts that Portugal has demonstrated during the last years to recover from its recent financial crisis, boost its industry and enhance its productivity and competitiveness. In fact, the increased productivity of the country is evident by the 8% increase in the Industry GVA per employee, an indicator that is directly linked to labour productivity. At the other end of this set of countries, we find Greece with a very low Industry GVA and employment growth from 2013 to 2018 (3% and 1% respectively), as well as a limited increase in Gross Capital Formation (8%) for the same time period.

Moving to the exporting capacity of goods for each country, we observe that although Greece demonstrates the highest increase in exporting goods during the last years (24%), it still holds the lowest percentage of exports of goods as % of GDP in 2018 with 18%. Germany holds again the first place with its exports of goods consisting almost 40% of its GDP.

The picture slightly changes regarding the export of high-tech products as a percentage of the country's overall exports, where France comes first. In fact, 20,5% of French exports in 2018 were classified as

[151] Eurostat, European Union and euro area balance of payments - quarterly data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_eu6_q&lang=en
[152] Eurostat, Balance of payments by country - annual data (BPM6), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bop_c6_a&lang=en
[153] Eurostat, Gross domestic product at market prices, https://ec.europa.eu/eurostat/databrowser/view/tec00001/default/table?lang=en
[154] OECD, Industrial production, https://data.oecd.org/industry/industrial-production.htm
[155] Industrial Production Index is compiled for the following NACE categories: B) Mining and Quarrying, (C) Manufacturing, (D) Electricity, Gas Steam and Air Conditioning supply, (E36) Water Supply and collection
[156] OECD, Industrial production, https://data.oecd.org/industry/industrial-production.htm
[157] Eurostat, Labour cost levels by NACE Rev. 2 activity, https://ec.europa.eu/eurostat/en/web/products-datasets/-/LC_LCI_LEV
[158] Data available for Industry excl. Construction (F.) and transportation (H.)

high-tech, indicating that France significantly invests in industrial sectors of high value adding, contrary to Greece and Portugal, where high-tech products only hold 4,5% and 4% of their overall exports.

Finally, on a positive note, in 2019 Greece demonstrated signs of recovery from the long financial crisis it went through, as despite their low levels, both its industrial and its manufacturing productions demonstrated the highest increase.

4 Introducing the Industry 4.0 concept

4.1 Chapter's Summary

The concept of "Industry 4.0' is used to describe the fourth industrial revolution, characterized by a fusion of technologies and the use of smart, fully connected devices that blur the lines between the physical, digital, and biological spheres.

Industry 4.0 is "fuelled" by a set of foundational technology trends that radically transform the industrial production and manufacturing. These are the following:

Key Industry 4.0 technology trends		
Additive Manufacturing	Cybersecurity	Manufacturing Execution Systems (MES)
Artificial Intelligence	Distributed Intelligence	New Materials
Augmented Reality	Electronic Components & Systems	Simulation
Big Data Analytics	High Performance Computing	Supervisory Control and Data Acquisition Systems (SCADA)
Blockchain	Industrial Robots	The Industrial Internet of Things (IIoT)
Cloud	Machine-to-Machine (M2M)	Photonics, Automation, Sensors & Applications

4.2 Industry 4.0 Definition

The term "Industry 4.0" is used to describe the fourth industrial revolution, characterized by a fusion of technologies and the use of smart, fully connected smart devices that blur the lines between the physical, digital, and biological spheres. Before Industry 4.0, three industrial revolutions have taken place and have led to major changes in the domain of manufacturing (see Figure 31).

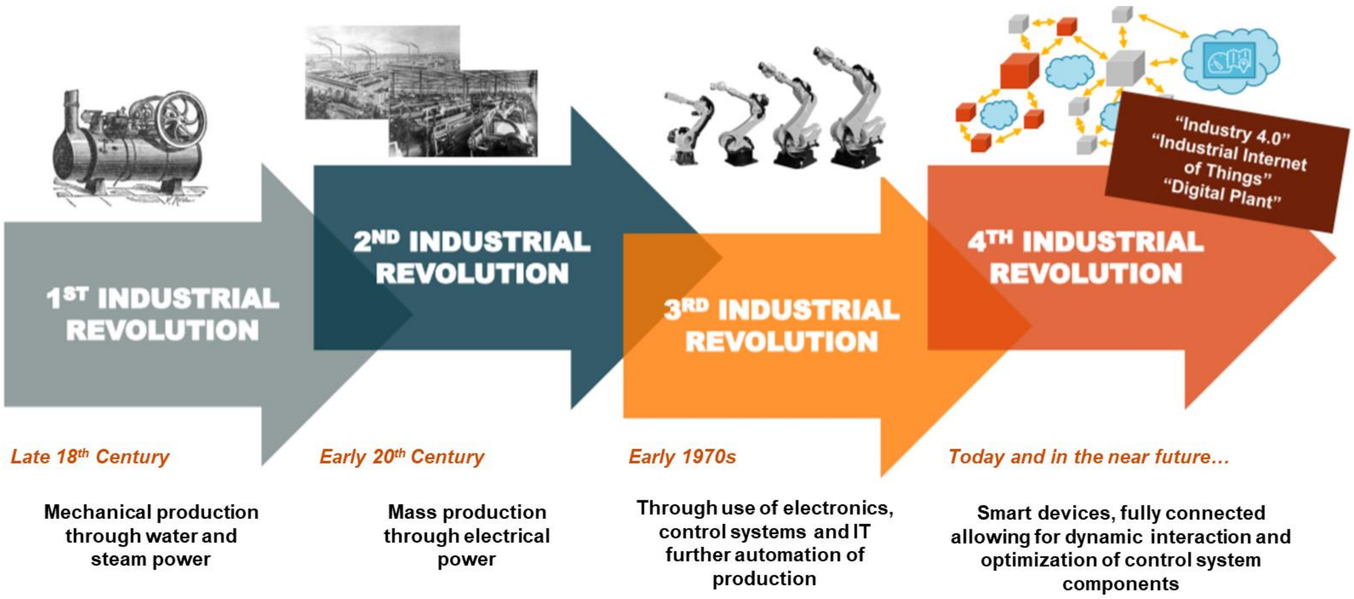

Figure 31: The four industrial revolutions

- Industry 1.0 began in the late 18th century with the introduction of water and steam power which helped in mechanical production and improved the agriculture sector greatly.
- Industry 2.0, in the early 20th century, introduced the mass production as the primary means to production, in general. The mass production of steel enabled the creation of railways, which consequently contributed to mass production at large.
- During the 1970s, Industry 3.0 arose with the advent of the Digital Revolution. Industry 3.0 is directly linked to the use of electronics, control systems and the further automation of IT production.
- In 2011, the German Federal Government firstly introduced the term "Industry 4.0" as an emerging structure, in which manufacturing and logistics systems in the form of Cyber Physical Production Systems (CPPS) intensively use the globally available information and communications network for an extensively automated exchange of information. In fact, Industry 4.0 is being presented as an overall change by digitalisation and automation of every part of the organisation, as well as of the manufacturing process. Nevertheless, there is no consensus on the technologies and/or tools and/or processes necessary to clearly define the boundaries of Industry 4.0.

For this reason, a broad definition is proposed, in order for the concept to include the main aspects of Industry 4.0 and indicate how organisations shall benefit from it.

"INDUSTRY 4.0 is the Digital Reinvention of Industry, where businesses use advanced digital technologies to transform their core value chains, their worker and customer experiences and ultimately their business models.
- New levels of efficiency are achieved in the core of R&D, engineering, production, manufacturing and business support through integrated systems, processes, sensors and new intelligence.
- Worker and customer experiences are reimagined and redesigned through personalisation and advances such as immersive, augmented and virtual reality.
- New business models and revenue streams are unlocked by smart, connected products, services and plants that are enabled by new ecosystems"

Figure 32: Industry 4.0 Definition

There are three reasons why Industry 4.0 does not represent a prolongation of Industry 3.0 but rather a new, distinct revolution. These are: velocity, scope, and systems impact. The speed of current technological breakthroughs is unprecedent, as technology evolves at an exponential rather than a linear pace. Moreover, Industry 4.0 disrupts all industries and blurs their boundaries. Finally, the breadth and depth of these changes herald the transformation of entire systems of production, management, and governance.[159]

[159] Schwab, Klaus. "The Fourth Industrial Revolution". World Economic Forum, Geneva, Switzerland, 2016

4.3 Key Industry 4.0 technology trends

Before discussing how Industry 4.0 changes the global Industrial paradigm, it is important to briefly introduce the foundational technology trends that "fuel" Industry 4.0. These are the following:

Key Industry 4.0 technology trends	Definition
Additive Manufacturing	Additive Manufacturing, also defined as 3D Printing, refers to the prototyping and production of customized, individual goods based on specific customer requirements.
Artificial Intelligence	Artificial Intelligence (AI) consists of a combination of multiple scientific fields, that are supported by technologies that enable machines to sense, comprehend, act and learn.
Augmented Reality	Augmented reality (AR) allows for visualisation of computer graphics placed in the real environment and supports a variety of services, such as the description, planning and real-time operation monitoring, fault diagnostic and recovery, and training related to industrial products and processes
Big Data Analytics	Big Data Analytics is described as the collection and comprehensive evaluation of data from many different sources, from production equipment and systems to enterprise and customer-management systems to support real-time decision making and economically extract value through discovering, capturing and analysing very large volumes of a wide variety of data.
Blockchain	Blockchain is an open distributed ledger of transactions, that securely transmits any type of information without the control of any central authority.
Cloud	The enablement of an on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned with minimal management effort.
Cybersecurity	Within Industry 4.0, all equipment and products across the entire value chain become connected through the internet or amongst themselves and create a fully interconnected industrial networked environment. As a result, secure and reliable communications as well as sophisticated identity and access management of machines and users are essential.
Distributed Intelligence	Distributed intelligence systems are based on the use of cooperative agents, organized in hardware or software components, that independently handle specialized tasks and cooperate to achieve system-level goals and achieve a high degree of flexibility.
Electronic Components & Systems	Electronic Components and Systems (ECS), refer to components which are the hardware and software parts of the systems. The word "systems" is used in this context for the respective highest level of development targeted within the given part of the value chain.
High Performance Computing	High-performance computing (HPC) is the use of parallel processing for running advanced application programs efficiently, reliably and quickly. The term applies especially to systems that function above a teraflop or 1012 floating-point operations per second.
Industrial Robots	Automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications.
Machine-to-Machine (M2M)	Machine-to-machine (M2M) refers to the direct communication between devices using any communications channel, including wired and wireless.

Manufacturing Execution Systems (MES)	Information systems used in manufacturing, to track and document the transformation of raw materials to finished goods. MES provides information that helps manufacturing decision makers understand how current conditions on the plant floor can be optimized to improve production output.
New Materials	The development of new materials and nanostructures (e.g. graphene, composites, PVD, CVD), enable the creation of new components with useful traits such as, durability, shape retention, lightweight, thermo-electric efficiency and re-usability.
Photonics, Automation, Sensors & Applications	New technologies such as Photonics, Automations, Sensors and Applications unlock advanced capabilities for seamless intercommunication throughout the production plant.
Simulation	Simulation techniques focus on the simplification of the design, realisation, tests and running a live operation of manufacturing systems.
Supervisory Control and Data Acquisition Systems (SCADA)	Supervisory control and data acquisition (SCADA) is a system of software and hardware elements that allows industrial organisations to control industrial processes locally or at remote locations, monitor, gather, and process real-time data, directly interact with devices such as sensors, valves, pumps, motors, and more through human-machine interface (HMI) software and record events into a log file.
The Industrial Internet of Things (IIoT)	The Industrial Internet of Things refers to the network of interconnected and uniform addressed objects that communicate via standard protocols. Through the Industrial Internet of Things, more devices and final products will be enriched with embedded computing and will be connected using digital technologies.

Industry 4.0 technologies are currently implemented by all Industrial sectors, nevertheless to a different extent (see Figure 33). This has primarily to do with the current maturity of each Industry 4.0 technology trend, as well as with the range and scope of respective applications developed thus far for each Industrial sector. In the near future, this picture will most likely change, as new, innovative implementations of the Industry 4.0 technology trends will emerge at a global scale across a wider range of industrial sectors.[160]

[160] Accenture analysis. This mapping aims at providing a qualitative depiction of the level of implementation of different Industry 4.0 technology trends across the different Industrial sectors. It is based on professional judgement and is not based on a data analysis exercise.

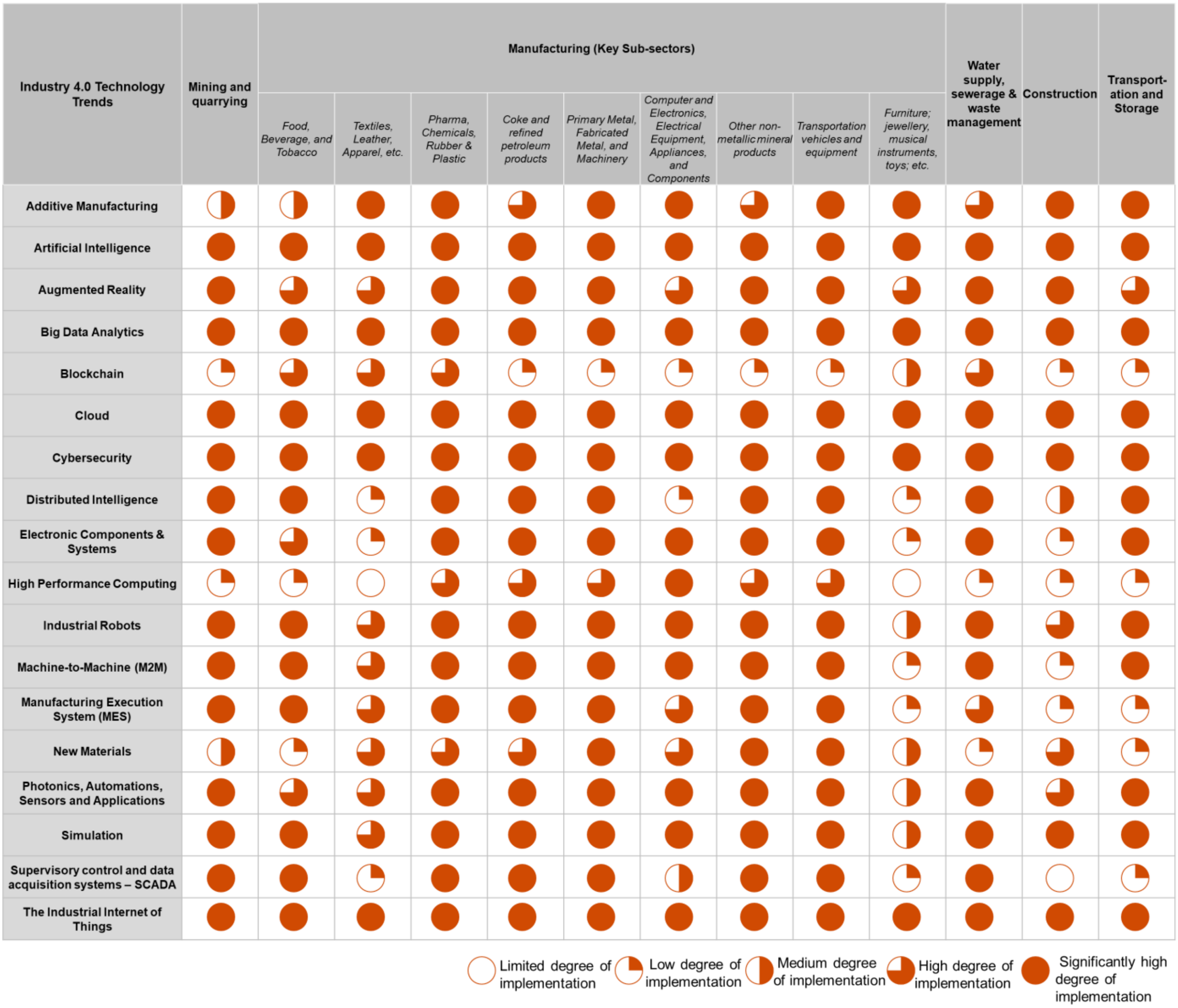

Figure 33: Current degree of implementation of Industry 4.0 technology trends in Industry sectors - Source: Accenture Analysis

Besides the figure above, the following table provides a set of indicative examples regarding the implementation of the Industry 4.0 technologies across different industry sectors.

Key Industry 4.0 technology trends	Indicative Examples from different industry sectors
Additive Manufacturing	Recent advances in the speed, flexibility, and cost of additive manufacturing (AM) have made it accessible to industries previously concerned about the technology's scalability. One such industry is ***textile & apparel manufacturing***, where firms are increasingly looking to 3D printing to quickly and affordably provide customers with customized products. Adidas is leading the way for apparel manufacturers with the launch of its first commercially viable 3D-printed shoe in 2017 and goal to use 3D printing for mass production in the future. Driving the company's adoption of additive manufacturing is its "Creating the New" strategy, which includes goals to dramatically expand product customisation options while reducing production lead times. In fact, in April 2017, Adidas announced the launch of the Futurecraft 4D shoe, the world's first high-performance footwear with a sole crafted through the continuous liquid interface production process (CLIP). CLIP is a revolutionary 3D printing technique, through which designs are pulled out of a vat of polymer resin and fixed into the desire shape using UV light. The shoe was produced in partnership with Carbon, a Silicon Valley-based technology company that is leading the way in this technology.[161,162]
Artificial Intelligence	AI significantly impacts and transforms the Industry, as it can be implemented through different applications across all stages of its value chain. Artificial Intelligence is applicable across all industrial sectors. Key examples can be taken from the ***transportation, vehicle & machine manufacturing, the transportation & storage as well as from the food & beverage sectors.*** In BMW's **automotive assembly plant** in Dingolfing, Germany, workers and robots are collaborating to build a transmission[163], while Budapest-headquartered Waberer's International Nyrt, a European **transportation** leader, deployed an AI solution to automate its truck scheduling function and seamlessly allocate driver team, load and journey schedules in the most efficient way.[164] At the same time, **consumer brands**, i.e. Coca Cola, become increasingly dependent on AI chatbots to represent them in the mass market.[165]
Augmented Reality	Augmented Reality is a technology that is quickly becoming a great tool for many types of sectors. From ***tourism to manufacturing*** and everything in between, Augmented reality is truly changing the way that things work. One sector where AR is particularly relevant and is offering a significant change to the way things are done is the ***mining sector***. More and more mining companies are turning to this technology as a way to improve safety, efficiency, and to drive innovation. For instance, AR can be used to assist with drilling practices, through visual guidance on the usage of the drilling equipment or machine, in order to enhance the accuracy and efficiency of drilling. This application can further be expanded to display the real-time location and orientation of the drill bit below surface or within the rock face, as measured through various tracking technologies. The visualisation of such positioning information of the drill bit and rod would then allow for faster reaction and adjustments by operators to improve drilling accuracy.[166]

161 Adidas, 2017 Annual Report, p. 64-75,
162 The perfect fit: Carbon + Adidas collaborate to upend athletic footwear, from Carbon website, https://www.carbon3d.com/stories/adidas/
163 DPCCars, "BMW Factory Humans & Robots Work Together at Dingolfing Plant" YouTube Video 25:22 minutes, posted March 2, 2017, https://www.youtube.com/watch?v=Dm3Nyb2lCvs&t=152s
164 http://customers.microsoft.com/en-us/story/waberers-professional-service-azure-hungary
165 https://www.adweek.com/digital/coca-cola-is-embracing-ai-and-chatbots-in-preparation-for-a-digital-first-future/
166 J. Jacobs, R.C.W. Webber-Youngman,E.A. van Wyk, University of Pretoria, Department of Mining Engineering & Tshwane University of Technology, Department of Computer Science,2016, „Potential Augmented Reality Applications in the Mining Industry"

Key Industry 4.0 technology trends	Indicative Examples from different industry sectors
Big Data Analytics	Similarly to Artificial Intelligence, big data analytics significantly impacts and transforms the Industry, as it can be implemented through different applications across all stages of its value chain. Big data analytics is applicable across all industrial sectors. Data analytics have already led to significant efficiency gains for the ***manufacturing* sector**, enabling businesses to optimize their production quality, pre-empt system failures, streamline the maintenance process, save energy, and achieve sophisticated cross-enterprise inventory management. For instance, Ducati Corse, part of world-leading sports **motorcycle manufacturer** Ducati Motor Holding, collaborated with Accenture to modernise motorbike testing, by combining two disruptive technologies – Data Analytics and Internet of Things (IoT) – to create a mobile application capable of simulating and monitoring a motorbike's performance under a vast array of track and weather conditions. Big data analytics was then applied to the racing performance KPIs and past test data to identify the optimal bike set-up configuration, using advanced algorithms working on the data patterns from the different sensors, machine learning and applying clustering and regression algorithms.[167]
Blockchain	According to recent studies, the blockchain technology can be a powerful tool for organisations' rotation to Industry 4.0. Blockchain can be used for any type of digitised transfer of information. Industry 4.0 develops on the foundation of automation, and blockchain can be used as the ledger to develop trusted and autonomous relationships among different components of smart factories, suppliers and even customers. For example, putting blockchain between interconnected equipment, cyber-physical production systems, and supply partners can enable machineries within the smart factory to securely and autonomously place an order for their replacement parts to further optimize the processes. Blockchain gains significant momentum in the ***agri-food sector***, as it can be applied for food traceability purposes and provides the ability to instantaneously trace the entire lifecycle of food products from origin through every point of contact on its journey to the consumer bolsters credibility, efficiency and safety. Nestlé and Carrefour, both members of the IBM Food Trust, are to offer food traceability for a famous French convenience food, Mousline instant mashed potato, one of Nestlé's brands. By using IBM's blockchain platform, consumers can access reliable and unfalsifiable information about the supply chain and production by scanning the QR code on the product using their smartphones.[168]
Cloud	Together with big data analytics and Artificial Intelligence, cloud is a "horizontal" technology that is leveraged by all industrial sectors and that is expected to significantly enable organisations to transition to the Industry 4.0 era. A leading case study of leveraging cloud capabilities comes from the ***food processing and packaging*** sector. Tetra Pak, a supplier of food processing and packaging solutions to enterprises in more than 175 countries, uses cloud capabilities to predict machine problems and identify potential breakdowns. As a result, it has been able to reduce plant downtimes and the high costs they carry. In addition, by connecting packaging lines to cloud, Tetra Pak has been able to collect operational data to help predict maintenance timing.[169]
Cybersecurity	Through the increased connectivity and use of standard communication protocols that come with Industry 4.0, the need to protect critical industrial systems and manufacturing lines from cybersecurity threats increases dramatically. As a result, secure and reliable communications as well as

167 https://www.accenture.com/us-en/success-traditional-motor-bikes-ducati-corse
168 https://www.ledgerinsights.com/blockchain-food-traceability-nestle-carrefour-ibm/
169 https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE2NFOY

Key Industry 4.0 technology trends	Indicative Examples from different industry sectors
	sophisticated identity and access management of machines and users are essential. The Stuxnet, the notorious malware that infested control systems at the ***nuclear plants*** and manipulated the speed of centrifuges, causing them to spin out of control, is only one of the many cybersecurity threats appeared thus far.[170] A report from professional services firm EY has also shown that 55% of ***mining operators*** fell victim to a serious cybersecurity incident in 2017, with 48% admitting that it is unlikely that they would even be able to identify a sophisticated attack.[171] ABB, a global enterprise providing industrial automation, electrification & robotics solution across different industrial sectors, provides a wide range of cybersecurity solutions to its mining clients. Some of these are fingerprint solutions that can analyse a system's configuration, together with the computers of key personnel, and identify potential weaknesses, Cyber Security Monitoring services that offers continuous, remote monitoring of the control system, as well as periodic reviews of its performance and enhanced access control for critical operations, such as altering the control system, batch operations or configuration changes, etc.[172]
Distributed Intelligence	Centralized systems have disadvantages that make them unsuitable for large-scale integration, including reliance on centralized communication, high complexity, lack of scalability and robustness, and high cost of integration. The use of distributed intelligence system technologies avoids these weaknesses. Distributed intelligence systems are based on the use of cooperative agents, organized in hardware or software components, that independently handle specialized tasks and cooperate to achieve system-level goals and achieve a high degree of flexibility. US technology company Itron provides ***electricity grid operators*** with distributed intelligence solutions, enabling a variety of smart applications, such as load disaggregation and high impedance detection[173]. Distributed intelligence enables greater optimisation and transparency of complex systems such as electrical grids.[174]
Electronic Components & Systems	Electronic Components and Systems are core enablers and differentiators for the development of many innovative products and services in all sectors of the economy.[175] Aemtec Gmbh (Germany), a company that provides technology solutions to customers in the ***equipment manufacturing***, systems integration and applications sectors, leverages ECS in the development of innovative products and services. Some of the industries that use Aemtec's products are: a) **Medicine**, for the development of portable medical technology, wearables or point-of-care diagnostics b) **ICT** for the development of new, highly integrated solutions for chips, optics, packages and complete systems to support the ever increasing need for worldwide networking and increased bandwidth c) **Industry and Automation**, where they manufacture highly advanced sensors and actuators to support the development of reliable control systems.[176]
High Performance Computing	High-performance computing (HPC) is the use of parallel processing for running advanced application programs efficiently, reliably and quickly. The term applies especially to systems that function above a teraflop or 1012 floating-point operations per second. The most common users of HPC systems are

[170] https://www.wired.com/images_blogs/threatlevel/2010/11/w32_stuxnet_dossier.pdf
[171] https://www.ey.com/en_gl/mining-metals/cybersecurity
[172] https://new.abb.com/mining/thought-leadership-topics/cyber-security
[173] https://www.itron.com/it/solutions/what-we-enable/analytics/distributed-intelligence
[174] https://www.itron.com/na/solutions/what-we-enable/analytics/distributed-intelligence
[175] https://www.smart-systems-integration.org/system/files/document/ECS-SRA-2019%20update-v5.3%20for%20web%20publishing%20-%20clean.pdf
[176] https://www.aemtec.com/

Key Industry 4.0 technology trends	Indicative Examples from different industry sectors
	scientific researchers, engineers and academic institutions. Some government agencies, particularly the military, also rely on HPC for complex applications. Robert Bosch (Germany) has invested through their subsidiary Robert Bosch Venture Capital (RBVC) in HPC start-up IONQ which develops **commercial Quantum Computers**. According to RBVC Managing Director Dr. Ingo Ramesohl. "Commercially useable Quantum Computers could disrupt the way we develop products at Bosch." IONQ plans on making its computers commercially available via the cloud and developing next-generation systems for programming these machines.[177]
Industrial Robots	Industrial robots refer to automatically controlled, multipurpose, programmable robots in three or more axes, which can be either fixed in place or mobile for use in ***industrial automation*** applications. American surgical instrument manufacturer, Argon Medical Devices, is an example of how manufacturers in the ***pharmaceutical industry*** benefit from using industrial robots. In its facility in Wheeling, just outside Chicago, an MiR200 robot from Mobile Industrial Robots (MiR) transports materials between production and the warehouse under clean room conditions. As a result, the company has optimized its internal material flow and workflows by freeing staff resources for higher value activities.[178]
Machine-to-Machine (M2M)	Machine-to-machine (M2M) refers to the direct communication between devices using any communications channel, including wired and wireless. M2M applications can be found across different sectors, one of which is the ***vehicle manufacturing***. **Auto manufacturer** Volvo (Sweden) has developed M2M communication capabilities for vehicles in construction sites (e.g. quarries, mines) that help reduce machine running costs, predict maintenance requirements and improve the overall efficiency.[179]
Manufacturing Execution Systems (MES)	MES refer to information systems used in manufacturing, to track and document the transformation of raw materials to finished goods. A key example comes from the ***food and beverage sector***. Carlsberg Group (Denmark), one of the largest **breweries** globally operating in over 50 countries, uses MES to trace and track production processes, resulting in reduced machine downtime, reduced energy costs, reduced overtime and labour costs, reduced manual data collection and report creation, reduced inventory, elimination of duplicate processes, improved equipment utilisation, improved data accuracy for decision making, and in dynamic response capabilities to production or quality issues.[180]
New Materials	The development of new materials and nanostructures (e.g. graphene, composites, PVD, CVD), enable the creation of new components with useful traits such as, durability, shape retention, lightweight, thermo-electric efficiency and re-usability. Flagship examples of the new materials use come from the ***vehicle manufacturing*** enterprises. BMW uses composites to build its **electric cars,** stating that their lighter weight helps the vehicle travel as much as 160 kilometres on a single charge. In addition, Lamborghini's fierce-looking Veneno Roadster is packed with weight-reducing composite parts that enable an acceleration of 0 to 100 km/hour in 2.9 seconds.[181]

[177] https://www.quantaneo.com/Robert-Bosch-Venture-Capital-invests-in-Quantum-Computing-Startup-IonQ_a320.html)
[178] https://www.pharmaceuticalprocessingworld.com/mobile-robots-in-the-pharmaceutical-industry/
[179] https://www.volvoce.com/global/en/news-and-events/news-and-stories/2018/construction-telematics-the-power-of-the-network/
[180] https://www.process-worldwide.com/carlsberg-chooses-siemens-as-its-global-mes-supplier-a-297171/
[181] http://advantage-environment.com/workplace/new-materials-reshape-the-manufacturing-industry/

Key Industry 4.0 technology trends	Indicative Examples from different industry sectors
Photonics, Automation, Sensors & Applications	New technologies such as Photonics, Automations, Sensors and Applications unlock advanced capabilities for seamless intercommunication throughout the ***production plants***. In manufacturing, laser processing will be a basic prerequisite for high-volume, low-cost manufacturing. The Photonics technology will help overcome the limitations of **electronics** in computers through **all-optical computing or even quantum computing**. Photonics will move communications into the terabit era by dramatically increasing data capacity and data transmission speeds, while simultaneously reducing the networks' carbon footprint and the overall cost per bit. Photonics will play a key role in addressing the challenges of energy efficiency, gradually moving towards a low-carbon economy. In the future, solid-state light sources are expected to outperform almost all other sources in terms of efficiency, offering potential energy savings of 50% or even more, when used with intelligent light management systems. Sensor applications in smart power grids, smart buildings and smart industrial process control will contribute significantly to more efficient use of resources and meeting environmental challenges.[182] Volkswagen has partnered with two university institutes at RWTH Aachen and FH Münster, the Fraunhofer Institute for Laser Technology (ILT) in Aachen and the Federal German Ministry of Research, to implement a laser system that will raise micro material processing to a new level of productivity. This system will alternate between hot nanosecond pulses for rapid material removal and cold picosecond pulses to introduce fine micrometre-scale structures. Despite its flexibility, it should be possible to operate this system "without any substantial knowledge of laser ablation procedures. [183]
Simulation	Simulation techniques focus on the simplification of the design, realisation, tests and running a live operation of manufacturing systems. Simulation is widely used across all industrial sectors as well as in the ***transportation and storage sector***. In this context, the port of Le Havre, the largest container port in France, implemented simulation techniques to construct a new multimodal terminal. In this terminal an area would be included where trains and river barges bring containers for further sea transportation and cranes load the containers from the carriers onto rail cars that carry them to sea transports. A simulation model was created that allowed the user to assign arrival times and required times for each container for the multimodal and sea terminal, assign train and river ship arrival & departure timetables, dynamically change the space availability for containers at the terminals, register the costs for different elements of the network, monitor the status of each entity.[184]
Supervisory Control and Data Acquisition Systems (SCADA)	Supervisory control and data acquisition (SCADA) is a system of software and hardware elements that allows industrial organisations to control industrial processes locally or at remote locations, monitor, gather, and process real-time data, directly interact with devices such as sensors, valves, pumps, motors, and more through human-machine interface (HMI) software and record events into a log file. SCADA systems are crucial for industrial organisations since they help to maintain efficiency, process data for smarter decisions, and communicate system issues to help mitigate downtime.[185] SCADA systems are widely used in the ***manufacturing, the electric power generation and the water and sewage sectors***. In manufacturing, SCADA systems manage parts' inventories for Just-In-Time manufacturing. They also regulate industrial automation and robots. Also, to ensure good

[182] https://myoffice.accenture.com/personal/i_papadogiannakis_accenture_com/Documents/Documents/02%20-%20Projects/06-%20Industry%204.0/07-%20Deliverable%201/Technologies/Photonics/Photonics_Roadmap_Layout_Version_4_April_20131.pdf?CT=1578401262703&OR=ItemsView
[183] https://world-of-photonics.com/en/newsroom/photonics-industry-portal/technologies/microstructuring/
[184] https://www.anylogic.com/internal-rail-logistics-simulation-for-the-port-of-le-havre/
[185] https://inductiveautomation.com/resources/article/what-is-scada

Key Industry 4.0 technology trends	Indicative Examples from different industry sectors
	output, they monitor process and quality control. In the electric power generation, transmission and distribution sector, SCADA systems are used to detect two key things: current flow and line voltage. They monitor the operation of circuit breakers and also take sections of the power grid online or offline. Finally, state and municipal water utilities use these platforms to monitor and regulate water flow, as well as track reservoir levels and pipe pressure. SCADA systems can also be used across other sectors for better **facility management** (i.e. SCADA to control devices, including heating, ventilation and air conditioning; refrigeration units; lighting; and entry systems) or for improved **mass transit** (i.e. SCADA to regulate electricity to subways, trams and trolley buses, automate traffic signals for rail systems, and track and locate trains and buses, etc.).
The Industrial Internet of Things (IIoT)	The Industrial Internet of Things refers to the network of interconnected and uniform addressed objects that communicate via standard protocols. Through the Industrial Internet of Things, more devices and final products will be enriched with embedded computing and will be connected using digital technologies. This will allow field devices to communicate and interact both with one another and with centralized controllers, as necessary. It will also decentralize analytics and decision making, enabling real-time responses. In Europe, the 365FarmNet brings together equipment makers Claas, Rauch, Horsch and Amazonen-Werke, with Bayer, financial services giant, Allianz, the European Global Navigation Satellite Systems Agency and others to provide **farmers**, through the use of IIoT, with access to data and analysis on diagnostics, crops, fertilizers and other factors important to improving crop yield.[186]

[186] Big Data Comes to the Farm, Sowing Mistrust Seed Makers Barrel Into Technology Business, by Jacob Bunge, Wall Street Journal, February 25, 2014

5 The change of the existing industrial paradigm and the socioeconomic impact of Industry 4.0

5.1 Chapter's Summary

Industry 4.0 creates a "tectonic" tilt on the industrial paradigm. In more detail:

- **Industry 4.0 "reinvents" the products.** The new, smart products are constantly connected to other devices and to the cloud, become "smart" through the incorporation of sensors and on-board processing capability and evolve through the use of Artificial Intelligence.
- **Industry 4.0 transforms all components of the Operating Model of organisations**; it reshuffles how organisations are organized, which processes are automated, what talent organisations need and to which ecosystems organisations shall become part of.
- **Industry 4.0 introduces new Business Models**: The emerging "as-a-Service" or "pay-as-you go" models enable customers to pay for products' uses on a use-based principle. At the same time, in the Industry 4.0 era, companies need to work out whether they also need a platform strategy.
- **Industry 4.0 "democratizes" Work:** As more areas of labour-intensive activity become automated, new roles are introduced to ensure the proper deployment and function of automation, while more transactional and routine tasks will become defunct. At the same time, the increasing digitalisation and techno-centricity of industrial production require new skills from industrial employees, making their constant reskilling and training the new standard. Finally, the rise of machine-assisted work enhances human productivity and creates new capabilities in the domain of human-machine interaction.
- **Industry 4.0 shifts value across value chains and surfaces ecosystems as the new force:** The rise of smart and connected products significantly disrupts traditional linear value chains defined by clear beginnings and endings within siloed organisations, reshuffles the fundamentals of industries and blurs their boundaries.
- **Industry 4.0 impacts the wider society:** Industry 4.0 technologies are maturing rapidly with seemingly limitless applications. This opens up ethical and societal issues and concerns, such as workforce displacement, loss of privacy, potential biases in decision-making and lack of control over automated systems and robots.
- **Industry 4.0 "realizes" the circular economy:** The circular economy is more than a sustainability initiative – it's about helping industrial companies make and save money by better managing their resources and waste efficiently. As industrial companies continue down this path, they need digital solutions that can support their business and operating models – which is why Industry 4.0 is so important. The technologies that underpin Industry 4.0 can make this happen.

Through this "tectonic" tilt, Industry 4.0 enables organisations to:

- Increase their revenues and grow through introducing new, innovative products & services, entering into new markets and expanding their presence in new channels
- Improve customer satisfaction and increase customer penetration and retention

- Optimize their cost structure and achieve reduced labour costs and increased workforce productivity

5.2 Industry 4.0 “reinvents” products

Industry 4.0 will bring about radical shifts in industrial products’ form and functionalities. Digital technologies create smart, connected products, what we also call “living” products. These products share four traits:

- They are constantly connected to other devices and to the cloud
- They become “smart” through the incorporation of sensors and on-board processing capability
- They learn and evolve through the use of Artificial Intelligence
- Finally, they can be offered as a subscription service allowing the customer to pay for use rather than ownership

All this is done with customer outcomes in mind: whether by allowing the product to learn and offer a better service, utilizing data to enhance customer experience through product updates, enabling the product to integrate with other devices, providing effective and timely service, or ridding the customer from the burden of upfront payments and product ownership altogether.

Products are connected with the cloud and with each other. While M2M communication is not a new advancement, the ability to interconnect a range of products with the internet and each other is a development that will surely revolutionize the practice of industrial production.

Products will become “smart” through sensors. The ability to generate huge loads of data from in-built sensors and processors in smart devices, combined with the storing and computing capabilities of cloud and edge computing will allow products to autonomously execute real-time analytics for insights and informed decision making. As a result, the process of releasing new software upgrades and iterations could well become an almost continuous, automated process – a built-in, hyper-contextualized capability of the Industry 4.0 smart product.

Given the affordability of the various technology mixes enabling Artificial Intelligence, it is only a matter of time before it becomes ubiquitous. In the Industry 4.0 context, all industrial products will eventually be reinvented with AI, moving as much as possible towards autonomy. Powered by the continuous innovation of semiconductor technologies and the emergence of AI platforms, the “cognification” of industrial products is just around the corner.

Furthermore, products will become increasingly offered “as-a-service”. As the demand for satisfactory use takes precedence over that for ownership, end users will demand access to increasingly higher quality ancillary services such as maintenance, training, and consultation. This increase in standards, coupled with the low switching costs for “as-a-service” customers, will make meeting industrial best practices for service support crucial to the survival of all Industry 4.0 manufacturers.[187]

[187] Accenture, ‘Reinventing the product’ book
& https://www.accenture.com/_acnmedia/pdf-77/accenture-strategy-ecosystems-exec-summary-may2018-pov.pdf

Let's consider in more detail, how traditional products stack up against the new, smart ones. Below, ten defining features are presented for both groups. In this table it becomes evident what a departure from the "old world" means in terms of value-rich "living" product existence.

Product Features	Traditional Products	Smart, Connected Products
1. 'Always on' with super speed highway access	No or very low speed / bandwidth connection	'Always on' high-speed / high-bandwidth connection to cloud and between devices
2.Sensorized for awareness	No/few sensors	Multiple to several hundred sensors capturing up to terabytes of data per day
3. Smarter than smart	Fairly 'dumb'	Increasing artificial intelligence and processing power at the 'edge' Processing power of basic device can exceed mainframe from 20 years ago
4. Software eats hardware and digital eats software	Value primarily from the hardware, but software gaining value in last two decades	80% of product value from software and digitally enabled services
5. Evergreen via upgrade	No or very limited upgradability	Living product that regularly receives software upgrades adding significant functionality
6. Digital age user interface (UI)	Physical controls, keyword entry or basic guided touchpad	Digital voice-based UI widely adopted with some products also using gestures, eye movements, or augmented reality as UI
7. Hyper-personalized	No or limited user-customisation	Automated personalisation based on actual usage behaviour preferences and, in some cases, user's current mood and context adaptive experience hyper-contextualized
8. A platform for multiple parties	Stand-alone product	Platform with open APIs to enable third party partners; comes with the robust ecosystem to 'feed' the platform
9. Embedded in ecosystems	None	Dozens (potentially thousands) of ecosystem partners that code and develop products, build applications for them, leverage their data or service the products
10. Digital thread as an eternal umbilical cord	Limited linkage between engineering, manufacturing and 'as is' installed data	End-to-end data models and systems enabling ability to compare the 'as designed' to the 'as manufactured' to the 'as is' product over the entire life cycle

Case Study: Faurecia

As cars become increasingly digitally savvy and autonomous vehicles are on the horizon, automobile interiors are expected to forego significant changes and become an extension of the home and the office. When it comes to car sharing services, users will be able to hop on to any self-driving car and seamlessly load their customized settings and services. Car manufacturers will need to transform quickly to keep up and provide a new range of services. As such, car manufacturers are looking to their suppliers to provide more innovative concepts that will help differentiate their vehicles in the market. As one of the world's leading automotive technology companies, Faurecia has set a stellar example of innovation in the face of industrial transformation.

Faurecia's focus for the 'Cockpit of the future' was twofold: developing cognitive technologies to reinvent the on-board user experience and creating services to enhance customer comfort and wellness. For the purpose of each, Faurecia is conducting a series of innovation initiatives that apply artificial intelligence (AI), advanced analytics, augmented and virtual reality, and blockchain technology - all of which are pursued by a "digital services factory", designed for the ideation of new concepts and prototypes.

By putting their customer at the centre of their thinking and focusing solely on improving the car passenger of the future, Faurecia developed an open platform in collaboration with Parrot Automotive and Accenture, which integrates a large range of infotainment services, with an in-cockpit virtual assistant and various other capabilities including postural and thermal comfort, an immersive sound experience and new HMI solutions.

By opening its platform to third party developers, Faurecia facilitates continued innovation, leading to a much more multifaceted product which is constantly being enriched by new applications. Furthermore, Faurecia's partnership with several manufacturers will allow the company to engage a broad market of customers with common, personalized Faurecia accounts, thereby decoupling the 'cockpit experience' from the underlying car, allowing Faurecia customers to personalize a wide range of cars seamlessly according to their own settings.

Faurecia has already received €1,5 billion in orders from customers and its new SmartLife on Board technologies. By 2025, these sales will reach €4,2 billion, at an average annual growth of 33% between 2020 and 2025.

Source: The new face of industry in France, https://www.accenture.com/gr-en/case-studies/industry-x-0/industryx0-client-faurecia

To conclude the "reinvention" of products through leveraging Industry 4.0 technologies are expected to benefit organisations **primarily** across the following areas:

Organisations' high-level strategic objectives							
Revenue & Growth			Customer Satisfaction		Operational Efficiencies & Cost Optimisation		
Enter in New Markets	Produce new, innovative Products & Services	Sell through new Channels	Increase Customer Satisfaction	Increase Customer Penetration	Reduce of labour costs	Increase workforce productivity	Improve tech capital efficiencies
	√		√	√			

5.3 Industry 4.0 transforms Operating Models

Industry 4.0 and the rise of smart, connected products push businesses to digitally transform. This unequivocally demands a comprehensive change in each component of the organisations' business and operating model including the products and services these offer, the way these are organized and deploy processes and technologies, as well as the ecosystems they create and in which they participate. As indicated in Figure 34 below, in order to achieve financial value, businesses are required to "go digital", through the provision of a new, digital experience to their customers while at the same time "become digital", through digitising their operations. A failure to transition from traditional to Industry 4.0 operating models is expected to significantly minimize revenue opportunities, as organisations will not be able to compete in their product and service delivery using traditional waterfall models. According to Accenture research, companies which fail to adopt operating models that support agility at speed risk losing 10-20% revenue growth.[188]

As should be clear, these dual drives of internal and external digitisation must work hand in hand. Most product companies still run very profitable core product or service lines, and these should not be discarded but renovated through transformational steps to enable the internal innovation drive. In addition, a second innovation engine for thinking outside the box must be kick-started to come up with new, visionary data-based customer propositions unrelated to the old world.

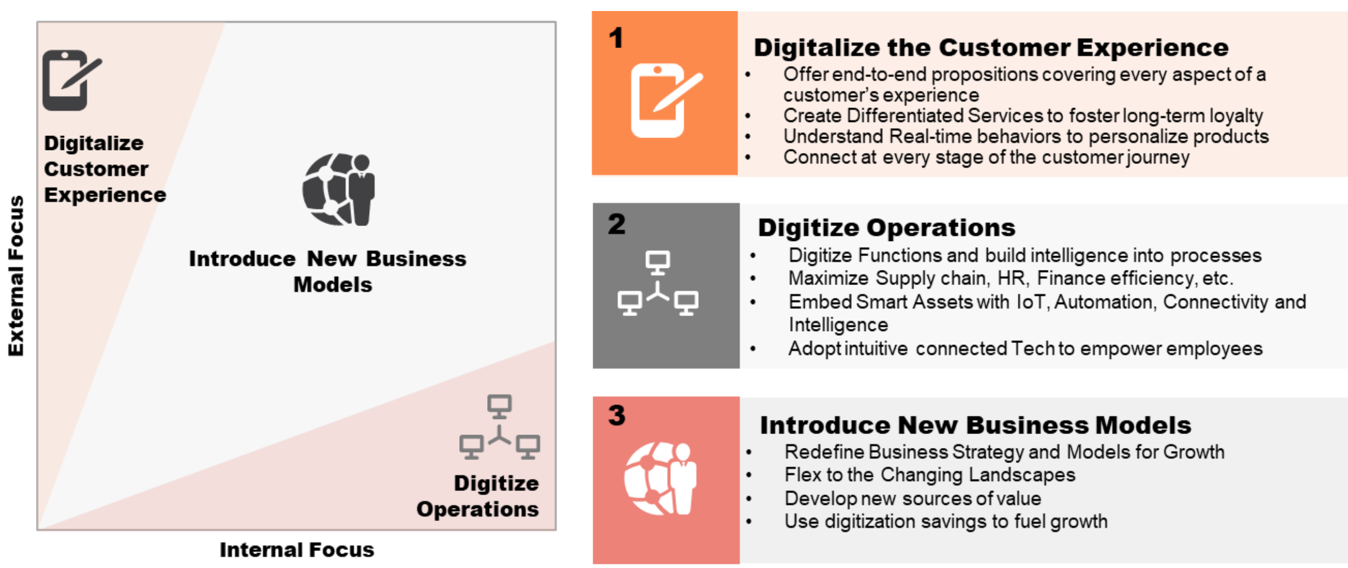

Figure 34: Companies should focus both externally and internally to become "Industry 4.0 enterprises" – Source: Accenture Analysis

5.3.1 Companies "Go Digital"

On the one hand, digitisation must be applied externally through the invention of new, connected products. This will create new markets, drive market value creation and digitise customer experience. In fact, the need to provide a customer experience that competes within and outside of the industry core, leaves

[188] Agile operating model in the digital age, Accenture https://www.accenture.com/_acnmedia/pdf-67/accenture-strategy-adapt-to-survive-pov.pdf

businesses with plenty to think about. Companies strive to become more customer-centric and to offer innovative and personalized products and services. Next to the highly customized products, we see companies to experiment in giving away their core product for free, in order to monetize services and drive revenues over the lifetime of their customers (see Figure 35).

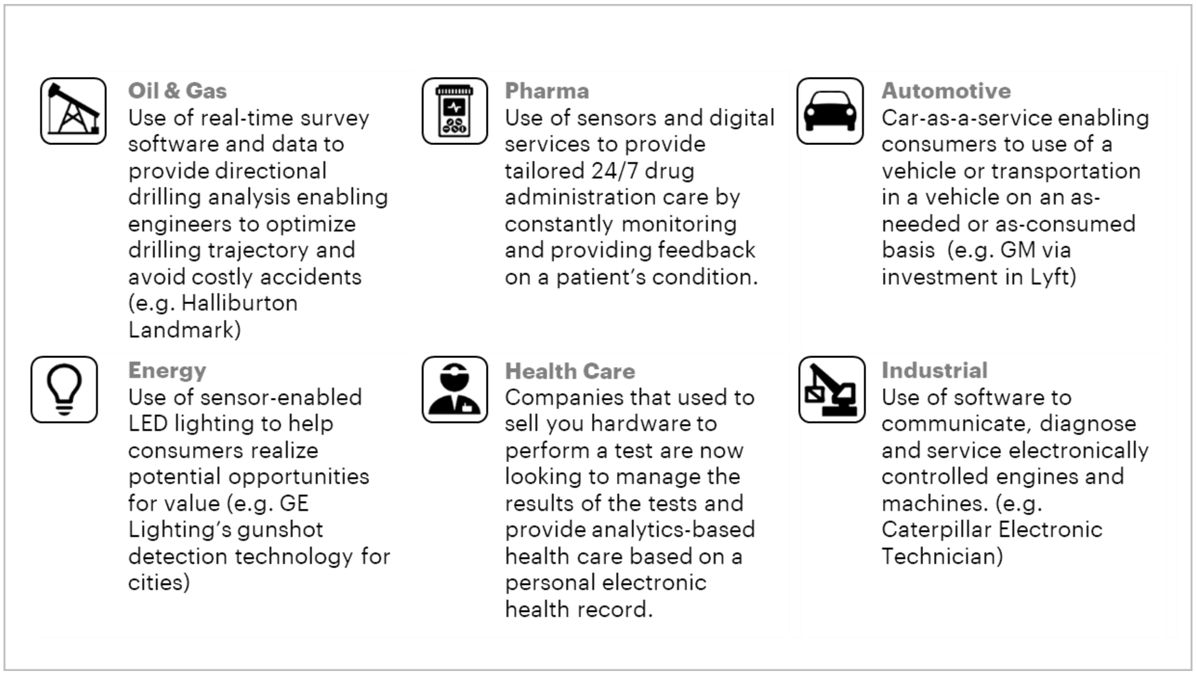

Figure 35: The "Everything-as-a-Service" Trend – Source: Accenture Analysis

At the same time, other companies like Nespresso are employing the latest technologies not just to create captivating digital experiences, but to harness their digital prowess and enhance their overall customer offering, spanning the digital and physical worlds.

Case Study: Nespresso

Nespresso heavily invested in creating an innovative and transformative experience for its customers. The company's focus was to enable simple digital transactions, drive personalisation and customisation across channels, leverage digital media to craft and deliver a compelling brand, and blend digital and physical for a meaningful omni channel experience. Nespresso is all about consumer's experience, not just the product. Unlike the grab-and-go culture of Dunkin' Donuts and the creative coffee lounge Starbucks fashions itself to be, Nespresso is meant to be enjoyed slowly and luxuriously in the comfort of your own house. Everything about the brand is aimed to provide as unique, personalized experience. Nespresso makes it extremely easy to get its products to your home with a seamlessly designed e-commerce experience that competes with some of the best Retail experiences in any vertical. Following a simple process on the web or in Nespresso's mobile app, users ("Club Members" as Nespresso refers to its most loyal customers, thus reinforcing its luxury status) can order the brand's products that will be delivered anywhere in the U.S. within just two days. User's order history is retained in order to facilitate any new orders. This simple reorder is just the beginning of Nespresso's shrewd data strategy that enables user personalisation and customisation across all Nespresso channels.

Nespresso leverages a cloud-based customer engagement solution that analyses all customer data - web and app orders, in-store orders, behavioural analytics, and interactions with Nespresso kiosks - into one unified single customer view. The advantage of this transformative experience is that it's not limited only to its digital touchpoints. The brand's experience design extends beyond its mobile application and website to a seamless in-store experience. Nespresso invests in its physical locations, which calls "boutiques", by carefully selecting the actual location, and artfully design it with luxurious leather, wood, and glass, thus creating an upscale brand value proposition.

Source : https://centricdigital.com/blog/digital-trends/digital-transformation-at-nespresso/

Companies that "Go Digital" are expected to **primarily** benefit across the following areas:

Organisations' high-level strategic objectives							
Revenue & Growth			**Customer Satisfaction**		**Operational Efficiencies & Cost Optimisation**		
Enter in New Markets	**Produce new, innovative Products & Services**	**Sell through new Channels**	**Increase Customer Satisfaction**	**Increase Customer Penetration**	**Reduce of labour costs**	**Increase workforce productivity**	**Improve tech capital efficiencies**
√	√	√	√	√			

5.3.2 Companies "Become Digital"

On the other hand, businesses must leverage new technologies to bolster internal efficiency throughout their value chain. The main goal here is for them to gain as much flexibility as possible to react to the fast-moving markets and to the ever-changing customer demands. In these markets, different customer groups request tailored products or services. To address these, organisations must build their internal structures to react quickly and fluidly.

In “Industry 4.0 enterprises”, linear processes are “dying”, and the walls come down between silos so the business can work collaboratively and in new ways. Companies are required to be more flexible and fluid so that they can organize around customer outcomes. Traditional capabilities will still have a home in “Industry 4.0 enterprises”, but not in discrete functional silos. Capabilities are now becoming modular. These capability “blocks” can be stacked together to deliver a desired customer outcome and solve the challenges of the moment. Similarly, they can be dismantled and reconfigured to achieve a different customer outcome (see Figure 36).

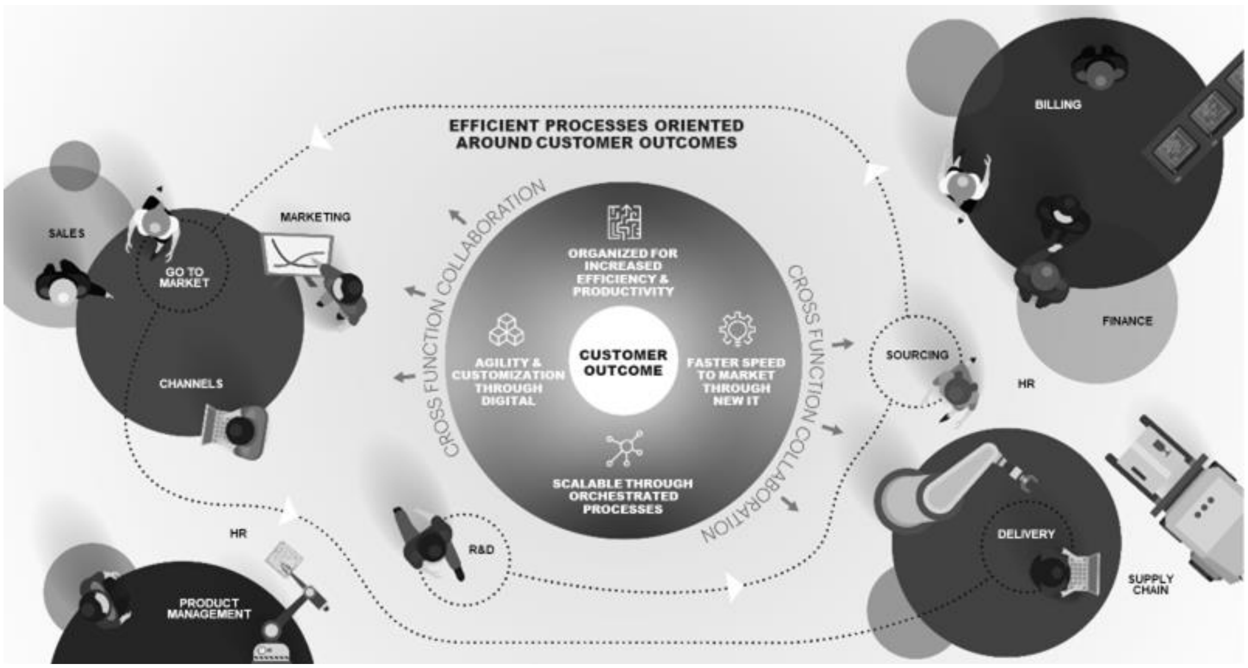

Figure 36: Processes oriented around customer outcomes – Source: Accenture Analysis

At the same time, the introduction of Industry 4.0 technologies across the production line and the organisation's internal operations provides dramatic improvements in automation and optimisation, leading to increased operational efficiency and accuracy. On the surface it may appear that the implementation of Industry 4.0 technologies is a simple transfer of tasks from man to machine. However, a closer look reveals that the real power of Industry 4.0 lies in its ability to fundamentally change traditional ways of operating, for businesses and individuals alike. This technological innovation offers scale, speed, and the ability to cut through complexity invigorating the workplace and is changing the rules of what is possible.

Case Study: Knapp AG

Knapp AG, a global logistics company, leverages augmented reality to optimize the picking process in warehouses. Knapp AG's KiSoft Vision 15 is a wearable AR headset that enables employees to see information which is superimposed along their field of vision through KiSoft's see-through display.

KiSoft Vision enables employees to locate with greater speed and precision, while providing alerts regarding the stacking of fragile objects and guiding employees on optimal pallet building. Its integrated camera has image processing capabilities which enable employees to capture serial and IoT numbers, facilitating real-time stock tracking. Moreover, by eliminating the need to use paper, KiSoft Vision makes it possible for employees to have both hands free while handling items.

Knapp AG's innovative AR-powered approach to warehouse picking has a track record of proven benefits to its adopters. These include the reduction of the error rate by 40% when compared to the traditional, pick-for-paper approach, the reduction of training time for new and seasonal workers, as well as significant reductions in the time required to complete the picking process.

Source: Knapp Website, http://www.knapp.com

Companies that "Become Digital" are expected to **primarily** benefit across the following areas:

Organisations' high-level strategic objectives							
Revenue & Growth			Customer Satisfaction		Operational Efficiencies & Cost Optimisation		
Enter in New Markets	Produce new, innovative Products & Services	Sell through new Channels	Increase Customer Satisfaction	Increase Customer Penetration	Reduce of labour costs	Increase workforce productivity	Improve tech capital efficiencies
					√	√	√

5.4 Industry 4.0 introduces new Business Models

As Industry 4.0 brings about new capabilities and ways of doing business, industrial manufacturers and equipment providers are introducing new business models to adjust to new needs and offerings. Two distinct business models are likely to play a key role in the development of Industry 4.0: As-a-Service models and Platform-based business models.

5.4.1 From Product to "As-a-Service" Business Models

"As-a-Service" or "pay-as-you go" models have already been adopted by a wide range of automation and technology providers. In this business model, a provider's industrial equipment is still located at the buyer's premises, but the latter will pay for its uses on a use-based principle. So, instead of purchasing a piece of equipment, the manufacturer will purchase a subscription for its use over a time period of their preference, including any maintenance and support services that may be offered by the provider.

The so-called "serviceasation" of industrial products offers significant benefits to the buyer and seller alike. The manufacturing company purchasing such a service will be able to enjoy greater flexibility and minimize the financial risk involved in scaling up through costly upfront investments on new assets. The transition to a service-based model will enable manufacturers to minimize their fixed costs by turning a traditionally CapEx expense like the purchase of industrial equipment into a more variable OpEx expense. The seller of "As-a-Service" goods benefits from data collection over the course of the machine's operation for maintenance and product quality optimisation purposes, as well as from a steadier income stream. In addition, the seller has in hand a more attractive product offering, which places upfront commitment on the buyer, who does not have to pay the full price of the product upfront.

Case Study: Rolls-Royce

Rolls-Royce has a 35% market share of engines installed in the passenger fleet for widebody aircraft. Civil aerospace engines, Rolls Royce's core business offering, accounted for more than 7£ billion of revenues in 2018.

Over the past years, Rolls Royce has leveraged its engineering expertise and maintenance capabilities to develop a new offering, Rolls Royce TotalCare, for the provision of after-market services. The TotalCare service utilizes new technologies and analytical insights to produce a value-creating outcome for both Rolls Royce and its customers. The success of Rolls Royce "As-a-Service" business model is demonstrated by the fact that revenues from TotalCare currently account for 52% of Rolls Royce's Civil Aerospace Business revenue, with the remaining 48% attributed to the sale of original equipment.

The success of Rolls Royce's "As-a-Service" business model lies in its ability to align the interests of the company and its customers at once. While, Rolls Royce continues to sell its equipment to its customers, the TotalCare service package ensures that Rolls Royce retains the responsibility for the engine's performance according to a customer's requirements. As a result, asset lifetime is extended, and maintenance costs are optimized, resulting in efficiency gains for the customer and a new revenue stream for Rolls Royce.

In the long term, TotalCare will optimize Rolls Royce's customer care, product/service design, and resource efficiency by enabling the Rolls Royce to leverage data and insights from a broad customer base over time, in a way which would not have been possible under the traditional one-time equipment sale business model.

Rolls Royce's TotalCare offering demonstrates that business models are closely correlated with shifts in revenue and profitability sources for companies. The 52% share of total revenues attributed to service revenues, shows that Rolls Royce's adoption of the "As-a-Service" business model brought about a complete reconfiguration of the company's sources of income. In a service-based business model, the installed base of products in use can become a driver of recurring revenue during a product's lifecycle. This aligns the manufacturer's financial performance with their ability to ensure that their products are kept in optimal performance for as long as possible.

Source : http://www.r2piproject.eu/wp-content/uploads/2019/05/RollsRoyce-Case-Study.pdf

5.4.2 From Product to Platform Business Models

The concept of a platform is nothing new, but in the Industry 4.0 era of smart, connected products, manufacturing and hardware-centric companies need to work out whether they also need a platform strategy. While platform-based business models offer tremendous value creation potential, not all traditional product companies need to, nor will be able to make this pivot. Several Internet and software companies have already created successful connected product platforms. As such, the traditional players will need to consider whether to plug into these platforms as partners or compete directly.

Market Researcher IDC predicted that more than 50% of large enterprises will – and more than 80% of enterprises with digital transformation strategies – have created or partnered with platforms in some form by the end of 2018.[189] In fact, platform-based companies like Facebook and Twitter, search engines like Google, ride-sharing and accommodation companies like Uber and Airbnb have disrupted long-established sectors, taking incumbents by surprise. These companies are reshaping the global economy and fuel the next wave of breakthrough innovation and disruptive growth. At the same time, traditional, global manufacturing brands, like Coca Cola, BMW, Mercedes, Bosch etc. are embracing digital platforms to capture new growth opportunities and provide increasingly innovative services and better outcomes to their customers.

Platforms are characterized by the "network effect", meaning that the value of the whole platform grows in correlation to the number of its participants. As a result, whereas traditional producers aimed solely at achieving supply-side economies of scale, (i.e. build scale in areas like manufacturing, procurement, etc. to drive down the cost of production) the emergence of the platform brings achieving 'demand-side economies of scale' into the agenda of network-based platform companies. This means that platform companies focus more on scaling the number of users and the usage of their platform. To achieve this, large upfront investments are required to build both capabilities and grow the platform's user base until a tipping point is reached when the cumulative value of services provided by the platform is greater than the cost of developing and running it. After that point, the upside potential is enormous.

Key prerequisite for a successful platform is the existence of a strong ecosystem. Leading platform providers have thousands of developers, innovation partners, system integrators and service partners that

Case Study: Bosch

As a market leader in open source IoT platforms, has been an innovator in the field of platform creation and a facilitator of cross company collaboration.

The Bosch IoT Suite empowers its partners to produce a broad range of IoT solutions, services, and projects. It incorporates the Bosch Group's industry know-how and is available across all industries, such as agriculture, energy, homes & buildings, retail, mobility, and manufacturing. The Bosch IoT Suite has enabled partners to create applications across all the aforementioned.

Bosch's decision to adopt an open source software (OSS) strategy has been central to the company's ability to encourage cross-company collaboration around IoT solutions, resulting in a more complete product offering for Bosch's customers.

Bosch's IoT Suite's strengths are its pre-packaged service offerings for device management for at-scale deployments, its support of flexible deployment models (on the Bosch IoT Cloud or on private cloud infrastructures), the Bosch IoT Remote Manager and Bosch IoT Rollout services, which provide customers with product lifecycle management at scale, and Bosch's extensible southbound device protocol integration.

Source: Bosch Website. https://www.bosch-si.com/media/bosch_si/iot_platform/analysten/machnation/bosch-leading-iot-platform_machnation-device-management-scorecard_report.pdf

[189] Murray, S. "IDC Predicts the emergence of "the DX Economy" in a Critical Period of Widespread Digital Transformation and Massive Scale Up of 3rd Platform Technologies in Every Industry, Business Wire, 4 November 2015
https://www.businesswire.com/news/home/20151104005180/en/IDC-Predicts-Emergence-DX-Economy-Critical-Period

support their platform. In the case of industrial businesses, platform partners can even comprise other product makers or third-party service providers. In a healthy ecosystem, all participants co-exist and share value continuously.

Companies that invest in new business models are expected to **primarily** benefit across the following areas:

Organisations' high-level strategic objectives							
Revenue & Growth			**Customer Satisfaction**		**Operational Efficiencies & Cost Optimisation**		
Enter in New Markets	**Produce new, innovative Products & Services**	**Sell through new Channels**	**Increase Customer Satisfaction**	**Increase Customer Penetration**	**Reduce of labour costs**	**Increase workforce productivity**	**Improve tech capital efficiencies**
√	√	√		√			

5.5 Industry 4.0 democratizes Work

The transformation brought about by Industry 4.0 technologies in business and operating models will, in turn, bring about significant shifts in the workplace. As more areas of labour-intensive activity become automated, new roles will be introduced to ensure the proper deployment and function of automation, while more transactional and routine tasks will become defunct. At the same time, the increasing digitalisation and techno-centricity of industrial production will require new skills from industrial employees, making their constant reskilling and training the new standard. Finally, the rise of machine-assisted work, will enhance human productivity and create new capabilities in the domain of human-machine interaction. To put it simply, Industry 4.0 is expected to redefine "what work is performed" and "how this is performed".

In the early days of digital, technological advances were associated primarily with efficiency. Taking human intervention out of work and replacing it with automation changed the very foundations of how work was performed. Now, through the combinatorial effect of Industry 4.0 technologies, digital redefines the notion of jobs and dramatically augments human capabilities. Big data analytics provides the workforce with the ability to process and analyse vast amounts of data from myriad sources. AI virtual assistants, i.e. Siri, Cortana & Alexa, employ advanced interfaces such as voice-driven, natural language processing to facilitate interactions between people or on behalf of people. Workers collaborate with embodied robots and exoskeleton suits to augment their physical work and perform precise, arduous or routine physical work.[190] The emerging Industry 4.0 workplace will lead to significant increases in labour productivity, as each employee will be assisted by a wide range of artificial intelligence and automation solutions.

Case Study: Mercedes-Benz

Mercedes - Benz plant in southwest Germany processes fifteen hundred tons of steel a day, pumping out more than four hundred thousand vehicles a year. Despite, these numbers Mercedes has ditched its robot-dominated assembly line and redesigns its processes to centre them around people. The driver for this change is the rise of customizable cars. Customers are now able to go online and choose from an expansive set of features for their next car. With so much variation in car manufacturing, the only way to assemble cars fast enough is to bring people back. "We're moving away from trying to maximize automation, with people taking bigger part in industrial processes again" says Markus Schaefer, head of production planning at the Mercedes. "When we have people and machines cooperate, such as a person guiding a part-automatic robot, we're much more flexible and can produce many more products on one production line. The variety is too much to take on for the machines."

In the Mercedes - Benz factory, a new breed of "cobots" is now enabling people and robots to work side by side or in collaboration. These cobots are built with smart software that learns over time and sensors that allow them to adapt to the situation at hand and be responsive to people.

Cobots take on repetitive and precision tasks as well as heavy lifting, while a person brings the brains and dexterity to the operation. Cobots, in this way, are literally extending the workers' physical capabilities.

Source: "Meet the cobots: humans and robots together on the factory floor," Financial Times, May 5, 2016 https://www.ft.com/content/6d5d609e-02e2-11e6-af1d-c47326021344

[190] Human + Machine, Reimagining Work in the Age of AI, Paul R. Daugherty, H. James Wilson

At the same time, Industry 4.0 technologies overhaul and "reimagine" traditional job roles and re-write job descriptions. In many industries, the most in-demand occupations or specialties did not exist ten or even five years ago. By one popular estimate, 65 percent of children entering primary school today will work in jobs that currently have not been invented.[191]

Digital advances may indeed displace certain types of work. Typically, highly repetitive, predictable and transactional activities are the prime candidates. According to the latest projections by the U.S. Bureau of Labor Statistic (BLS), occupations like farmers, postal services officers and clerks, word processors and typists are expected to massively decline in number and percentage of workers between 2010 and 2020.[192] At the same time, new types of work will be created, leveraging unique human capabilities like empathy, emotional intelligence, judgment, creativity and complex problem solving. Moreover, as the manufacturing sector becomes more digitalised, skills and know-how relating to digital will be increasingly central to the workplace. For instance, the ability to comprehend and leverage data analytics for operational decision-making is likely to become a prerequisite for industrial operators at all levels. In addition, employees will be required to understand the basics of information systems to navigate the challenges and leverage the benefits of fully integrated industrial solutions.

The new jobs will redefine our relationship with "work" in a more positive and socially beneficial way. For one, the increasing importance of user experience in digital products and services may potentially give rise to a new class of C-suite executives, the Chief Experience Officers. The rise of Augmented Reality offerings can potentially create employer demand for Augmented Reality Architects. Furthermore, the growing trail of data created by Industry 4.0 is likely to introduce the Digital Archaeologist, whose capabilities for searching and recovering old data from legacy systems will be a useful service to future data- oriented enterprises.[193]

In such a rapidly evolving employment landscape, the ability to anticipate and prepare for future skills requirements is increasingly critical for businesses and Governments alike. This is a key challenge for the success of their digital transformation. At the same time, digital and Industry 4.0 trends bring about an unprecedented rate of change in the core curriculum content of many academic fields. Nearly 50 percent of subject knowledge acquired during the first year of a four-year technical degree is outdated by the time students graduate.[194]

Industry 4.0 also shakes the foundations of labour management to its core as functional roles and rigid job descriptions give way to people coalescing around joint goals to be delivered via collaborative teams. Siloes and hierarchies collapse in emerging organisational forms, powered by seamless collaboration and the ability to pull resources on demand. This enables the introduction of flatter, leaner organisational structures and devolves greater decision making to the lower levels of the organisation.

[191] McLeod, Scott and Karl Fisch, "Shift Happens", https://shifthappens. wikispaces.com.
[192] https://www.forbes.com/pictures/lmj45ighg/top-20-disappearing-jobs/#2c24d5994bc5
[193] The new jobs are based on Accenture's research and internal analysis
[194] Infosys, Amplifying human potential: Education and skills for the fourth industrial revolution, 2016, http://boletines.prisadigital.com/%7B6139fde3-3fa4-42aa-83db-ca38e78b51e6%7D_Infosys-Amplifying-Human-Potential.pdf

Finally, collaboration is extending beyond organisational walls. Organisations can now quickly and easily source talent from anywhere within or outside company boundaries. This is called the “liquid” workforce.

Case Study: Procter & Gamble

Procter & Gamble reinvents the traditional approach to the workforce and experiments with larger external talent marketplaces. The 180-year-old company is embracing on-demand talent as true innovation, augmenting their current workforce with freelance workers. P&G recently completed a pilot program using Upwork’s freelance management system Upwork Enterprise, and the results speak for themselves: products from the pilot program were delivered faster and at lower cost than with conventional methods 60 percent of the time.

Source: “The Talent Potential: Leveraging the Freelance Marketplace to Harness a Global Talent Pool,” Panel Discussion at the 2016 CWS Summit, North America, September 19, 2016. http://www.cvent.com/events/2016-workforce-solutions-connect/custom-39-c06c1a44bbe34ddaa35cbfddbf0c199d

Companies that invest in the digital upskilling and reskilling of their workforce and/or which invest in new ways of working will **primarily** benefit across the following areas:

Organisations’ high-level strategic objectives							
Revenue & Growth			Customer Satisfaction		Operational Efficiencies & Cost Optimisation		
Enter in New Markets	Produce new, innovative Products & Services	Sell through new Channels	Increase Customer Satisfaction	Increase Customer Penetration	Reduce of labour costs	Increase workforce productivity	Improve tech capital efficiencies
					√	√	

5.6 Industry 4.0 shifts value across value chains and surfaces ecosystems as the new force

Industry 4.0 and the rise of smart, connected products lead to major disruptions across industries’ value chains. For instance, the distribution of infrastructure ownership changes, freeing customers from the burden of ownership costs. In addition, capital expenditure needs to shift massively from the customer side of the market to the providers of smart products, services and outcomes. In some digital business models, a software platform provider can also act as an intermediary who shifts the capital expenditure from the end customer to another provider. For instance, the ride-hailing app Uber, has shifted capital expense of a car purchase from the end customer to the professional drivers.[195]

In addition, many of the Industry 4.0 technologies are driven by small companies or startups that specialize in a narrow field. These companies, which are usually more agile and flexible than their larger, traditional competitors, inevitably lead to the transformation of the competitive landscape for the classic

[195] Accenture, Eric Schaeffer, David Sovie, Reinventing the Product, How to transform your business and create value in the digital age

manufacturing value chain. In fact, the number of players is likely to increase, driving up complexity and the multiplicity of interfaces (see Figure 37).[196] Small players now have an opportunity to enter the competitive landscape and capture new value pools. At the same time, larger traditional companies shall decide whether to collaborate with these new players or develop strategic alliances.

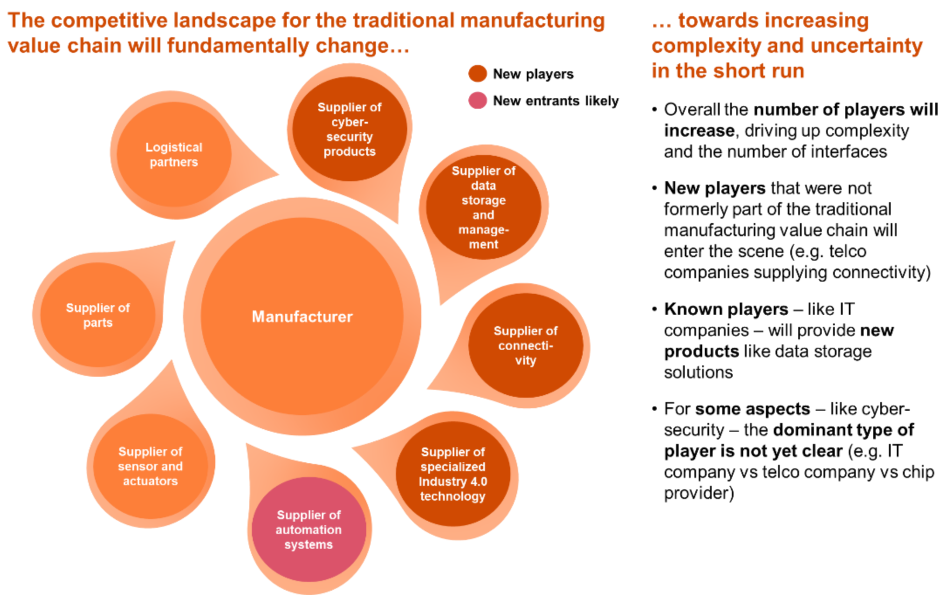

Figure 37: Changes in the competitive landscape are likely and will probably increase – Source: McKinsey report, "Industry 4.0 How to navigate digitisation of the manufacturing sector", 2017

Industry 4.0 also has the capacity to reshuffle the fundamentals of industries and to blur their boundaries. The spread of digital and the declining cost of technology enabled new, disruptive, technology-driven companies to take over entire manufacturing sectors. This disruption often did not come from direct competitors in the same industry or even from companies with a remotely similar business model. Digital disruptors leveraged scale and divergent business models to write off incumbents' positions of strength. Uber is now the largest taxi company, Airbnb is the world's biggest accommodation provider, while Amazon is amongst the world's most valuable retailer.

In this increasingly complex competitive landscape, businesses must develop a strong ecosystem of partners stretching across the value chain if they are to generate new forms of growth. Ecosystems' capacity to seamlessly source innovation through a decentralized network of integrated actors will facilitate their prevalence over traditional linear value chains, or single vertically integrated enterprises that offer a single offering end-to-end. When it comes to providing customers with superior outcomes, ecosystems outpower traditional industrial structures in terms of scale and agility.

Market leaders recognize the need to participate in such ecosystems. Over 70 percent of Accenture research's respondents said they would be increasing their partnerships and alliances as they attempt to boost digital growth in the next three years.[197]

[196] McKinsey & Company, Industry 4.0 How to navigate digitisation of the manufacturing sector. 2015
[197] "Being Digital: Seven no regret capabilities", Accenture, 2015 https://www.slideshare.net/accenture/being-digital-seven-essential

Companies increasingly integrate their core business with third parties, shaping digital ecosystems and unlock new waves of growth. An ecosystem can extend a company's footprint, amplify its market share and lead to revenue growth giving the associated company a competitive edge. Ecosystem partners help overcome limitations of internal resources to build new solutions and scale business.

An emblematic example of an ecosystem play can be the automotive industry. Nowadays, major manufacturers build "connected" cars. The technology in the connected cars is fuelling a rich ecosystem that is becoming the next major hub for innovation. Companies across industries join this ecosystem and offer a wide array of digital services. Such services are mobile hotspots, remote diagnostics, safety and security, infotainment, variable insurance, car sharing, and much more. This digital ecosystem is redefining what automakers do. Rather than just building cars, they now engage with customers throughout the vehicle lifecycle, directly manage software upgrades, diagnostics, and car/ passenger/ citizen safety.

But changes aren't limited to the automotive industry. As the ecosystem matures, it becomes the foundation for more widespread disruption. For example, the telematics data from connected vehicles transforms the way businesses optimize their supply chains - reinvents logistics and reduces costs with real-time asset tracking and on-time delivery. It is also becoming an integral piece of smart cities - enabling local Governments to start developing advanced services, from smart traffic monitoring to road planning and energy management.

Nevertheless, the new ecosystem-powered digital landscape will create new strategic dilemmas. For one, business leaders in Industry 4.0 will have to consider whether they will join an ecosystem and accept its hardware and software standards or build an ecosystem around their own product. Ecosystem alignment will be crucial to a company's success and business model. Moreover, in the second case, companies will have to decide whether to design an open or closed ecosystem, with hardware and data controlled by the ecosystem orchestrator.[198]

Case Study: UBER - The UberHEALTH Platform

The company started by building a mobile device platform to create an ecosystem of connected cars and drivers that disrupted the taxi industry. As this foundation has settled, Uber now uses that same ecosystem to push disruption into new sectors- such as the recent trial of UberHEALTH in Boston. With its existing network of cars and customers, and a new set of skilled Workers - registered nurses - Uber has been able to provide on-demand delivery of flu shots and similar vaccinations. Neither hospitals nor major pharmacy chains in the United States would have ever previously seen Uber as a competitor.

Source : https://newsroom.uber.com/us-illinois/uberhealth-in-boston-3/

[198] https://www.accenture.com/_acnmedia/pdf-77/accenture-strategy-ecosystems-exec-summary-may2018-pov.pdf

Companies that aim at participating in new emerging ecosystems will **primarily** benefit across the following areas:

Organisations' high-level strategic objectives							
Revenue & Growth			**Customer Satisfaction**		**Operational Efficiencies & Cost Optimisation**		
Enter in New Markets	**Produce new, innovative Products & Services**	**Sell through new Channels**	**Increase Customer Satisfaction**	**Increase Customer Penetration**	**Reduce of labour costs**	**Increase workforce productivity**	**Improve tech capital efficiencies**
√	√	√	√	√			

5.7 Industry 4.0 "realizes" the circular economy

Today's economy mainly supports a linear model, in which manufacturing takes raw materials from the environment and turns them into new products, which are then disposed after use. In this linear system raw materials might eventually run out while waste is accumulated. For this reason, multi-dimensional supply chains with new flows and formats and recovery loops for products and materials are needed. According to the first Circularity Gap Report[199], our world economy is only 9,1% circular, leaving a massive circularity gap. There is a growing need for material, water and energy because of both population growth and increased demand by infrastructure, industry and consumers in developing countries. Circular economy activities have the potential to address a significant share of this need— dampening or, possibly, reversing the raise in resource use, and in turn reducing resource depletion, climate change and the pollution of natural areas.

The circular economy is gaining increasing attention worldwide as a means to reduce dependency on primary materials and energy, while at the same time becoming an economically viable alternative to the linear economy. A circular economy is defined as an economy where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized. Essentially, as much as possible, everything is reused, remanufactured, recycled back into a raw material, used as a source of energy, or as a last resort, disposed of (see Figure 38).[200]

[199] De Wit , M, at all (2018), Circularity Gap Report, Circle Economy, https://www.circle-economy.com/news/the-circularity-gap-report-our-world-is-only-9-circular
[200] http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf

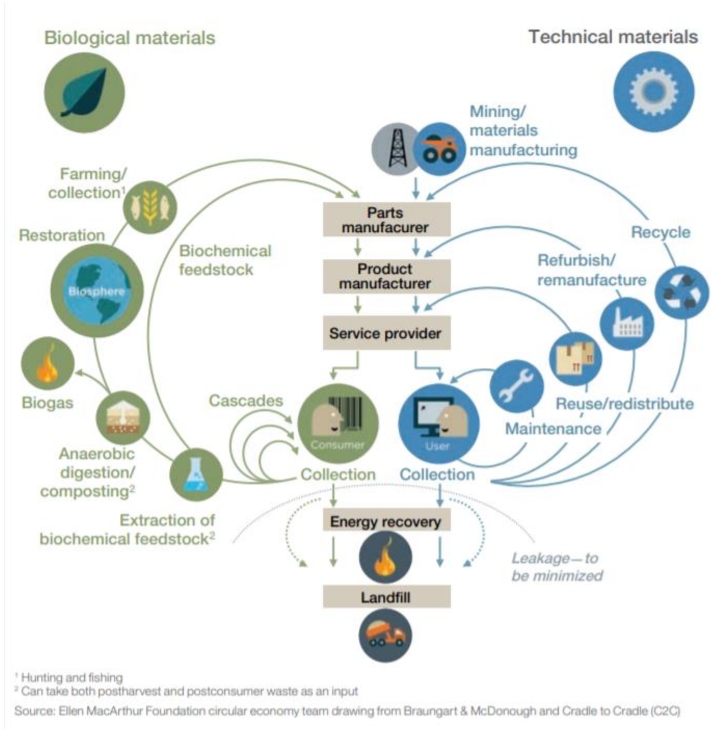

Figure 38: The Circular Economy – Source: Ellen MacArthur Foundation

The transition towards a circular economy requires systematic innovations including new innovative financing models, partnerships, business models and close integration of industry 4.0 technologies. In fact, Industry 4.0 bears enormous opportunities to enable circular economy, in which end of life products are reused, remanufactured and recycled. Increasingly, companies are applying innovative solutions, including through the "Internet of Things" (IoT), cloud computing and 3D printing that will enable more interoperability and flexible industrial processes and autonomous and intelligent manufacturing. In fact, as the Ellen MacArthur Foundation explains, IoT and smart devices in industrial settings help companies unlock the circular economy potential thanks to three main value drivers: Knowledge of the location of the asset, knowledge of the condition of the asset and knowledge of the availability of the asset. Having an overview on these data in real time is of immense value to businesses. In more detail, knowing the location of an asset allows for optimized routes for loading/unloading, maintenance and storage of spares.[201]

Knowing the condition of an asset can lead to high uptime, as it allows for predictive maintenance instead of routine interventions. Parallelly, downtime is quickly detected and handled more efficiently. Thirdly, knowing the availability of an asset allows companies to optimize energy and other resources like raw materials based on usage patterns. Using these three levels, new insights are generated that enable organisations to rethink their production process and set more granular KPIs.

Industry 4.0 leads also to the advent of material science, which has introduced low-cost, low-waste synthetic alternatives to replace traditional materials used for a range of purposes, from clothing to construction.[202] Material science has also sought to replace beef with synthetic alternatives, with a track

[201] https://www.ellenmacarthurfoundation.org/circular-economy/concept
[202] https://sustainabledevelopment.un.org/content/documents/9539GSDR_Nano_brief%204.pdf

record of successful products currently in the market, such as Impossible burger.[203] Such a breakthrough may help curtail the environmental waste caused by the meat processing industry, thereby leading to a more circular global food economy. Furthermore, in agriculture, the application of artificial intelligence and image recognition to crop analysis can facilitate significant levels of reduction of fertilizer use[204], which can be detrimental to the nearby flora and fauna. Finally, advances in smart home and smart grid technologies have allowed utilities to minimize their energy consumption, while the auto-manufacturing industry is increasingly applying I4.0 applications to the energy efficiency of electric vehicles.[205] While leading to significant efficiency gains for businesses, the aforementioned Industry 4.0-related circular economy applications aim to disrupt business practices in ways which coincide with a significant reductions of the end customer's carbon footprint.

Nevertheless, going circular is not just about saving money. On the contrary, the emergence of new business models and particularly the "as-a-service" business model, which are empowered by Industry

Case Study: General Electric (GE)

Having a strong heritage in serving industrial sectors, General Electric offer Industry 4.0 "enablers" for industrial companies looking to explore how to make their own steps towards digitalisation – and even circular operating models. In more detail, GE is currently investing in the development of its analytics powered APM and OPM (Asset Performance Management and Operations Performance Management) suites, as well as upgrades to its core manufacturing and automation suites. They are also developing Digital Value Stream Mapping solutions – to help manufacturers pinpoint where there is waste in their systems, and easily figure out what to do about it.

Source : https://www.ge.com/digital/blog/industry-40-changing-world-could-circular-economy-save-it

4.0, open new and exciting business opportunities for companies to increase their competitiveness and identify additional revenue streams. In fact, under the "as-a-service" business model, enterprises offer clients a subscription to use their goods, taking charge of the entire product lifecycle: maintenance, repairing and recycling. In turn, this facilitates the presence and full accountability of the product manufacturer throughout the product lifecycle. With a wealth of new insights to utilize and the ability to intervene in various stages of the product's use-life, "serviceasation" incentivizes manufacturers to make their products as circular as possible.[206]

Companies that invest and actively participate in the circular economy, will **primarily** benefit across the following areas:

[203] https://www.forbes.com/sites/louisaburwoodtaylor/2019/07/31/impossible-in-full-scale-up-mode-with-new-burger-manufacturing-deal--fda-approval/#1a3aea1671a1
[204] https://news.developer.nvidia.com/ai-and-drones-help-farmers-detect-crop-needs/
[205] https://www.researchgate.net/publication/321140123_Big_Data_Analytics_for_Electric_Vehicle_Integration_in_Green_Smart_Cities
[206] https://www.tandfonline.com/doi/full/10.1080/00207543.2019.1680896

Organisations' high-level strategic objectives							
Revenue & Growth			Customer Satisfaction		Operational Efficiencies & Cost Optimisation		
Enter in New Markets	Produce new, innovative Products & Services	Sell through new Channels	Increase Customer Satisfaction	Increase Customer Penetration	Reduce of labour costs	Increase workforce productivity	Improve tech capital efficiencies
	√		√				√

5.8 Industry 4.0 impacts the wider economy and society

The transformation brought about by the switch to Industry 4.0 is not limited to its micro-economic impact, though this transformation first manifests itself at an individual company level. This switch also represents a major macro-economic challenge faced by all major industrialized nations. At a macro-economic level, Industry 4.0 effects also are expected to be transformative. The World Economic Forum estimates that Industry 4.0 technologies will deliver up to $3.7 trillion in value by 2025.[207] In addition, a BCG report on Germany estimates that Industry 4.0 could lead to 1% GDP growth annually for the domestic economy, corresponding to 60 billion in value annually.[208]

Industry 4.0 can also lead to increased national competitiveness. Germany is the best-known case study for this, as the country invests in Industry 4.0 to primarily remain the global market leader in industrial solutions. About a decade ago Germany was facing several challenges: rising labour costs; rising energy costs in the future; the need to renew infrastructure, and a shortfall in skilled employees. Industry 4.0 supported the country combat the risk of the competitive potential of the existing model being compromised. Germany currently invests in the development of 4.0 solutions as a means of sustaining its dominance in the global market and keeping production volumes steady.[209]

At the same time, Industry 4.0 can enable the relocation or preservation of activities. Leading example for this case is France, which leverage Industry 4.0 to achieve the relocalisation of manufacturing by neutralizing the effects of high labour costs. In fact, the digitisation of the production lines can support countries with weak Industries and manufacturing sectors to reposition themselves. Furthermore, the industry of the future can present a unique opportunity to create a new manufacturing base, one that is able to avoid or bypass the constraints of labour costs. Provided that the conditions are favourable, countries could well nurture a degree of industrial relocation and manufacture products that are currently delocalized (textiles, parts, etc.), while also creating skilled jobs.[210]

According to several studies, Industry 4.0 is also expected to benefit productivity especially within the Industry and manufacturing sectors. A Nokia Bell Labs study estimates that Industry 4.0 could lead to a

[207] http://www3.weforum.org/docs/WEF_Technology_and_Innovation_The_Next_Economic_Growth_Engine.pdf
[208] https://www.bcg.com/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries.aspx
[209] Roland Berger, „The Industrie 4.0 trasition quantified", 2016, https://www.rolandberger.com/publications/publication_pdf/roland_berger_industry_40_20160609.pdf
[210] Roland Berger, „The Industrie 4.0 trasition quantified", 2016, https://www.rolandberger.com/publications/publication_pdf/roland_berger_industry_40_20160609.pdf

30-35% increase in productivity on national economies worldwide by the end of the current decade[211]. Moreover, the European Parliamentary Research Service projects 6-8% annual Industry 4.0-related efficiency gains in the EU manufacturing sector[212]. The effects of Industry 4.0 on productivity can be traced to a range of areas of value creation. Studies have outlined several dimensions which will be influenced by the fourth industrial revolution. For one, Industry 4.0 is expected to measurably increase the speed of production. Data-driven supply chains have the potential to speed up the manufacturing process by an estimated 120% in terms of time needed to deliver orders and by 70% in time to get products to market. Moreover, in terms of production capacity optimisation, factories using Industry 4.0 technologies will cut downtime by an estimated 50% and increase production by 20%. Finally, by enabling manufacturers to better manage the processes of scrapping and reworking defective products, Industry 4.0 could lead to an estimated €160 billion in cost savings among 100 European manufacturers.[213]

Industry 4.0 opens up vast opportunities to the society and the economy. The 4th Industrial Revolution offers boundless possibilities. Nevertheless, at the same time it entails several ethical and societal issues and concerns, such as workforce displacement, loss of privacy, potential biases in decision-making and lack of control over automated systems and robots and cybersecurity threats. In fact, growing public backlash against technology, disruptions in workforces and new digital threats to already-vulnerable populations can be considered as signs of an increasingly unequal 4th Industrial Revolution.

For this reason, stakeholders from industry, government, academia and philanthropy alike shall recognize that building inclusive futures, amid fast-paced technological change will require stronger engagement with people, communities and organisations in civil society - in the short-term and in the long-term. From deploying technology products to developing new digital protections in already-unequal societies, it is no longer a question for the industry and the government of "why", but rather of "how" to involve civil society organisations and citizens in the governance of digital and emerging technologies.

Key questions need to be answered: How can leaders strategically engage with civil society to develop, deploy, use and govern Industry 4.0 technologies? What partnership models, evidence and levels of trust are needed to accelerate broader civil society engagement with technology and effect organisational change for ready and responsive civil societies in the Fourth Industrial Revolution?

Acknowledging this need, the European Union has formed the European Group on Ethics in Science and New Technologies (EGE), an independent, multi-disciplinary body which advises on all aspects of Commission policies where ethical, societal and fundamental rights issues intersect with the development of science and new technologies.[214] In addition, EU has launched the Communication on Building Trust in Human-Centric Artificial Intelligence that shall be applied by developers, suppliers and users of AI in the European market, establishing an ethical level playing field across all Member States.[215] At the same time, through the introduction of the EU Cybersecurity Act in June 2019, the EU revamped and strengthened

[211] https://www.weforum.org/agenda/2018/01/fourth-industrial-revolution-massive-productivity-boom-good/
[212] https://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf
[213] https://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf
[214] https://ec.europa.eu/info/research-and-innovation/strategy/support-policy-making/scientific-support-eu-policies/european-group-ethics-science-and-new-technologies-ege_en
[215] Communication: Building Trust in Human Centric Artificial Intelligence, https://ec.europa.eu/digital-single-market/en/high-level-expert-group-artificial-intelligence

the EU Agency for cybersecurity (ENISA) and established an EU-wide cybersecurity certification framework for digital products, services and processes.[216]

The World Economic Forum also actively focuses on accelerating civil society readiness and responsiveness in Industry 4.0, through its "Partnering with Civil Society in the Fourth Industrial Revolution Initiative (CS4IR)".[217] This initiative includes:

- Providing a multi-stakeholder platform for identifying and testing new partnership models and approaches with civil society on technology
- Connecting industry, government, academia and philanthropy with a network of regional and global expert civil society leaders and experts on digital and emerging technologies
- Helping to create, contextualize and disseminate critical strategic intelligence on digital and emerging technology for broader understanding and guidance for civil society organisations and their partners
- Building evidence for change through both accelerating existing initiatives and co-creating multi-stakeholder "prototypes" for collective action and evidence aimed to scale civil society learning and partnership models with other stakeholders

Technology is neither good nor bad – it's how economies and societies use it that makes the difference. In the coming decades, all major stakeholders shall ensure the establishment of guardrails to keep the Industry 4.0 innovations on a track to benefit all of humanity.

As Prof. Schwab says, ***"The Fourth Industrial Revolution can compromise humanity's traditional sources of meaning – work, community, family, and identity – or it can lift humanity into a new collective and moral consciousness based on a sense of shared destiny. The choice is ours."***[218]

6 Industry 4.0: State of Play in EU countries & Greece

6.1 Chapter's Summary

Countries around the world have started responding to this new Industry 4.0 paradigm, albeit at a variable degree. This Industry 4.0 rift surfaces through the review of multiple Industry 4.0 related indexes both at a national and at an industry level, namely the World Economic Forum's Future of Production (FOP)[219], the European Union's Digital Economy and Society Index (DESI)[220], Accenture's Digital Economic Opportunity Index (DEOI)[221], the European Union's Digital Transformation Scoreboard[222].

Zooming into Greece, the country appears to lag behind across all Industry 4.0 and digital indicators. In more detail, according to EU's DESI Index, in 2019, Greece ranked 26th out of 28 EU member states with regards to its digital maturity and was positioned at the tail end of the index, with a score 28% lower than

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[216] https://ec.europa.eu/digital-single-market/en/eu-cybersecurity-act
[217] https://www.weforum.org/projects/preparing-civil-society-for-the-fourth-industrial-revolution
[218] Schwab, Klaus. "The Fourth Industrial Revolution". World Economic Forum, Geneva, Switzerland, 2016
[219] WEF, Readiness for the Future of Production Report 2018, http://www3.weforum.org/docs/FOP_Readiness_Report_2018.pdf
[220] The Digital Economy and Society Index 2019, https://ec.europa.eu/digital-single-market/en/desi
[221] "Digital Greece: The Path to Growth". Accenture, 2017
[222] European Commission, Digital Transformation Scoreboard 2018, https://op.europa.eu/en/publication-detail/-/publication/683fe365-408b-11e9-8d04-01aa75ed71a1

that of the European average. Greece's unfavourable rating in the DESI index is aligned with the country's low ranking across Accenture's Digital Economic Opportunity Index (DEOI), where Greece scored at the lowest end of the digital maturity curve in 2018 (22nd out of the 22 countries of the sample) and EU's Digital Transformation Scorecard. The Greek enterprises' low level of digitization is also evidenced by the results of Industry 4.0 survey that capture the Greek enterprises' perception on their digitization progress. This is further analysed in Chapter 9.

If we further examine the level of adoption of a set of digital technologies that underpin the Industry 4.0 rotation of an economy, it is evident that Greece is suboptimally positioned across all areas below:

- In terms of the adoption of cloud computing technologies, Greece's enterprises show low rates of adoption, with only 13% of enterprises making use of the technology, half the EU average of 26%. Greece ranks 25th in Europe, with a mere five percentage points above the lowest ranked country, Bulgaria (8%).[223]
- With regards to RFID technologies, Greek enterprises also recorded the lowest levels of adoption in the EU along with Hungary and Romania, reporting 7% RFID adoption in 2017.[224]
- In addition, just 2% of Greece's enterprises used industrial robot technology in 2018, demonstrating the country's slow rate of adoption in terms of industrial robotics.[225]
- Greek enterprises have also been moderately too slow in their adoption of Customer Relationship Management (CRM) systems, with just 20% of Greek enterprises using the technology (EU average 33%).[226]
- Greece has also been slow to bring nanotechnology into its industrial landscape, reporting just 52 nanotechnology job positions in 2016. At less than 1 basis point of the total workforce, the Greek economy has yet to make any measurable contributions to the nanotechnology sector.[227]
- With regards to additive manufacturing, 924 job positions are currently classified as Additive Manufacturing related jobs. This is a small but not negligible part of the workforce, at 0,03%, which indicates that the Greek industry has made some initial steps, in terms of adopting this technology.[228]
- If we shift our focus on circular economy, Greece is Europe's lowest ranking country, with regards to the average circular use of materials as a percentage of total material use, reporting only 1% circular material use. The average circular use of materials as a percentage of total material use was 12% in the EU in 2016.[229]

Exception to Greece's overall low digital maturity is the strength that the country demonstrates on the use of big data analytics. In fact, Greek companies have understood that data is the new digital capital and

[223] Eurostat, Cloud computing services, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicce_use&lang=en
[224] Eurostat, Enterprises using radio frequency identification (RFID) instrument, https://ec.europa.eu/eurostat/web/products-datasets/-/tin00126
[225] No data was available with regards to the use of industrial robots by Greek manufacturers
[226] Eurostat, Enterprises using software solutions, like CRM to analyse information about clients for marketing purposes, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tin00116&lang=en
[227] European Commission, Key Enabling Technologies Observatory 2015, https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/library/kets_observatory_second_report.pdf
[228] European Commission, Key Enabling Technologies Observatory 2015, https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/library/kets_observatory_second_report.pdf
[229] European Commission, EU Circular Economy Action Plan, https://ec.europa.eu/environment/circular-economy/

increasingly exploit the potential of Big Data Analytics. This is evidenced by the fact that 13% of Greek enterprises (compared with 12% of the EU average) invest in data collection and Big Data analytics.[230]

With regards to the dimensions of digital infrastructure, digital skills and digital public services, that drive Greece's Industry 4.0 transformation in Greece, the country is also suboptimally positioned. Nevertheless, Greece demonstrates an adequate STEM-oriented human capital that if appropriately supported could be used as the basis for the setup of a "knowledge-intensive" Industry 4.0 economy. In more detail:

- With regards to the **digital infrastructure**, in 2019 Greece ranked last among all EU countries (28 out of 28 member-states) according to EU's DESI Index. In fact, Greece's Connectivity score was 31% lower than the European average and 44% lower than Denmark, the EU leader, which recorded a score of 0,74 (out of 1) in 2019.[231]
- Greece's limited **digital skills** is also considered a structural inhibitor towards the country's rotation towards Industry 4.0.
    - In particular, in 2019 Greece ranked 25th in DESI's Human Capital dimension, with an overall score of 0,33 units, which is 32% lower than the European average. During the past 6 years, Greece's score in the Human Capital dimension has remained stable. The relatively stagnant performance of the country combined with the evolution of digital skill capabilities within other EU member states is creating a widening gap between Greece and EU average in the Human Capital dimension.[232]
    - Nevertheless, Greece has a significant number of people with a track record in tertiary education. In fact, for 2017, Greece contributed 4% of the overall tertiary education students across the EU.[233] In addition, Greece's share of ICT graduates is on par with the average EU country, with 3% ICT graduates, when compared to 4% reported on average in the continent.[234] Finally, with regards to the number of graduates in tertiary education in science, math, computing, engineering, manufacturing, and construction, Greece is also in sync with the EU average, with 18% of Greek graduates pursuing tertiary education in the abovementioned fields.[235] These observations indicate that Greece has an adequate percentage of ICT & STEM graduates that could be "infused" in the Greek industry to accelerate its digitisation. This opportunity can be further enhanced, as an important number of domestic enterprises employ ICT specialists as their workforce. In 2018, 22% of Greek enterprises had ICT specialists on their payroll, ranking the country above the EU average (20%).[236]
    - Despite their appetite to employ ICT-oriented employees, the Greek enterprises appear unwilling to further invest in their human capital's digital upskilling. Only 12% of Greek enterprises offered ICT skills training to their employees in 2018, compared to the EU

[230] Eurostat, Digital Economy and Society, https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/comprehensive-database
[231] EU's DESI Report 2019, „Connectivity - Broadband market developments in the EU", https://ec.europa.eu/digital-single-market/en/desi
[232] EU's DESI Report 2019, „Human Capital - Digital Inclusion and Skills", https://ec.europa.eu/digital-single-market/en/desi
[233] Eurostat, Tertiary education statistics, https://ec.europa.eu/eurostat/statistics-explained/index.php/Tertiary_education_statistics
[234] Eurostat, ICT education - a statistical overview, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=ICT_education_-_a_statistical_overview&oldid=454538
[235] Eurostat, Graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction, by sex - per 1000 of population aged 20-29, https://ec.europa.eu/eurostat/web/products-datasets/product?code=educ_uoe_grad04
[236] Eurostat, ICT specialists in employment, https://ec.europa.eu/eurostat/statistics-explained/index.php/ICT_specialists_in_employment

average of 23%.[237] If we turn our attention to the country's industrial workforce, it appears that with only 13% of manufacturers providing ICT training to their personnel, Greece's industry ranks low among its EU peers, nine points below the EU average (EU average 22%).[238]

- Finally, with regards to the state of eGovernment applications for Greece, according to **EU's DESI Index 5th pillar of Digital Public Services**, Greece is among the lowest ranking EU countries, positioned at the 27th place among the EU 28.[239]
    - Focusing on the level of eGovernment use, Greece, performs poorly, scoring last among all 28 EU countries, with just 36% of Greek citizens submitting forms to public authorities over the internet during 2018.[240]
    - In terms of the digital public services for businesses, Greece also scores poorly, indicating that the country must significantly upgrade its current framework for accommodating the eGovernment needs. Greece's score was 65 points in 2018, 20 points below the EU average.[241]

[237] Eurostat, Enterprises that provided training to develop/upgrade ICT skills of their personnel, https://ec.europa.eu/eurostat/en/web/products-datasets/-/ISOC_SKE_ITTN2
[238] Eurostat, Enterprises that provided training to develop/upgrade ICT skills of their personnel, https://ec.europa.eu/eurostat/en/web/products-datasets/-/ISOC_SKE_ITTN2
[239] EU's DESI Report 2019, „Digital Public Services", https://ec.europa.eu/digital-single-market/en/desi
[240] EU's DESI Report 2019, „Digital Public Services", https://ec.europa.eu/digital-single-market/en/desi
[241] EU's DESI Report 2019, „Digital Public Services", https://ec.europa.eu/digital-single-market/en/desi

6.2 Introduction

Industry 4.0 and its underpinning technologies, such as the Internet of Things, artificial intelligence, robotics and additive manufacturing, spur the development of new production techniques and business models that fundamentally transform the industry. Countries around the world need to decide how to best respond to this new production paradigm and how to incorporate it in their national strategies, in order to leverage production as a national capability. Countries need to transform now. Industry 4.0 is at the heart of this transformation and can offer unprecedented opportunities.

As a first step, the aim of this Chapter is to describe the Industry 4.0 state of play at a global, European and national level, using a set of relevant indexes. As a second step, we will depict the state of the European and the Greek digital “enablers”. These are the key prerequisites that shall be in place to enable countries’ transition to Industry 4.0. They include:

- the use of advanced digital technologies
- the state of other industry 4.0 technological groups
- the digital knowledge of total population and industrial workforce
- the state of digital infrastructure
- the implementation of eGovernment applications

The completion of these two steps will enable us to surface the current Industry 4.0 state of play both for the European Union and Greece and evaluate the factors and conditions that appear to have the greatest impact on the transformation of countries’ Industry.

6.3 Industry 4.0 Analysis at a National Level

6.3.1 The Readiness of Future Production (FOP) Index

Several indexes at a worldwide basis have been established in an effort to measure and quantify the readiness of countries for the 4th Industrial revolution. The Readiness for Future of Production (FOP) Index, published by the World Economic Forum, (WEF), is one of the most widely used. This index assesses countries’ readiness to shape and benefit from the changing nature of production in the future. Readiness is generally regarded as the ability to capitalize on future production opportunities, mitigate risks and challenges, and be resilient and agile in responding to unknown future shocks.[242] To capture both the scale and the technological maturity of countries globally, the FOP assesses them across two dimensions: Structure of Production (a country’s current baseline of production) and Drivers of Production (key enablers that enable a country to capitalize I4.0 and transform production systems).

The Structure of Production dimension is made up of two sub-dimensions, economic complexity and scale:

- <u>Economic complexity</u> is the measure of knowledge in a society as expressed in the products it makes and is calculated based on the diversity of exports produced and their relative

[242] World Econonmic Forum, Readiness for the Future of Production Report 2018, http://www3.weforum.org/docs/FOP_Readiness_Report_2018.pdf

ubiquity. Japan's industry ranks first globally in terms of economic complexity, while the EU's frontrunner is Switzerland, occupying the 2nd position globally.

- The Scale of production subdimension refers to the value added by manufacturing as a percentage of total GDP, as well as the magnitude of an industry's value added in absolute terms. China's industry ranks 1st along with this subdimension, while Germany leads the way in Europe, ranking 4th globally.

The Drivers of Production FOP dimension is made up of six subdimensions: Technology and Innovation, Human Capital, Global Trade and Investment, Institutional Framework, Sustainable Resources, and Demand Environment.

- The Technology and Innovation dimension consists of indicators such as the availability and use of ICT, the level of digital security and data privacy, the research intensity of a country, and the amount of patent applications submitted. The United States ranks 1st under the technology innovation subdimension, followed by the UK which comes in 2nd.
- Along the Human Capital subdimension, which measures a number of indicators related to skills in the workforce, Switzerland ranks 1st, followed by Singapore and the United States.
- The Global Trade & Investment subdimension measures trade openness, market access, investment and financing and logistic performance in the economy. Singapore ranks 1st along this dimension. The Netherlands are Europe's frontrunner coming in 3rd globally.
- The Institutional Framework subdimension measures the regulatory efficiency of government, the level of corruption, and the rule of law. The leader along this dimension is Singapore, followed by Norway in the 2nd place.
- The Sustainability subdimension measures countries' emission levels, the percentage of alternative and nuclear energy use, water quality and level of emissions. Norway ranks 1st globally along this subdimension, followed by Sweden and Switzerland.
- Finally, the Demand Environment subdimension measures foreign and domestic demand levels for a country's goods and services, as well as domestic customer sophistication. The US ranks first on this subdimension, while Germany leads the EU member states coming in 4th globally.

Instead of producing an absolute rank among countries, their performance along the two dimensions of the Readiness for Future of Production Index places countries along a 2x2 matrix which categorizes countries into four archetypes (see Figure 39):

- Nascent (limited current base, at risk for the future)
- Legacy (strong current base, risk for the future)
- High Potential (limited current base, positioned well for the future)
- Leading (strong current base, positioned well for the future).

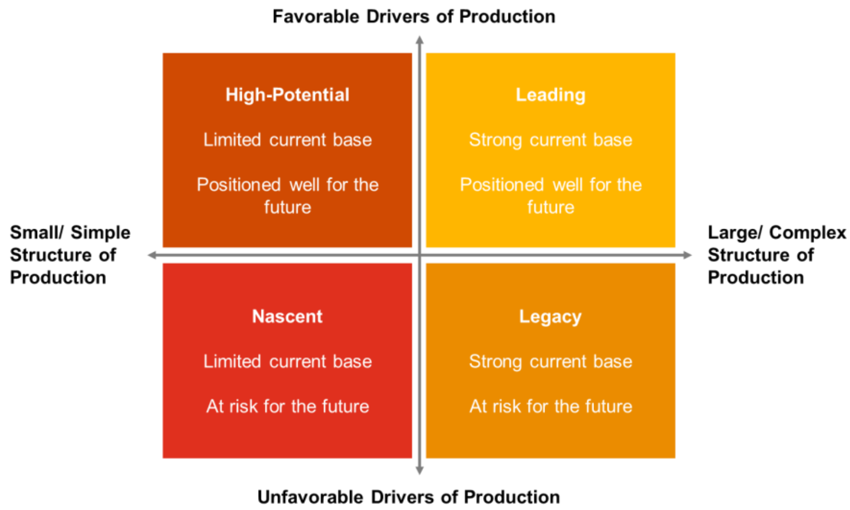

Figure 39: Countries' Archetypes – Source: WEF, Readiness for the Future of Production Report 2018

The depiction of the 100 countries on the 2x2 matrix indicates that there is a clear divergence on regional performances among different groups of countries across the world (see Figure 40).

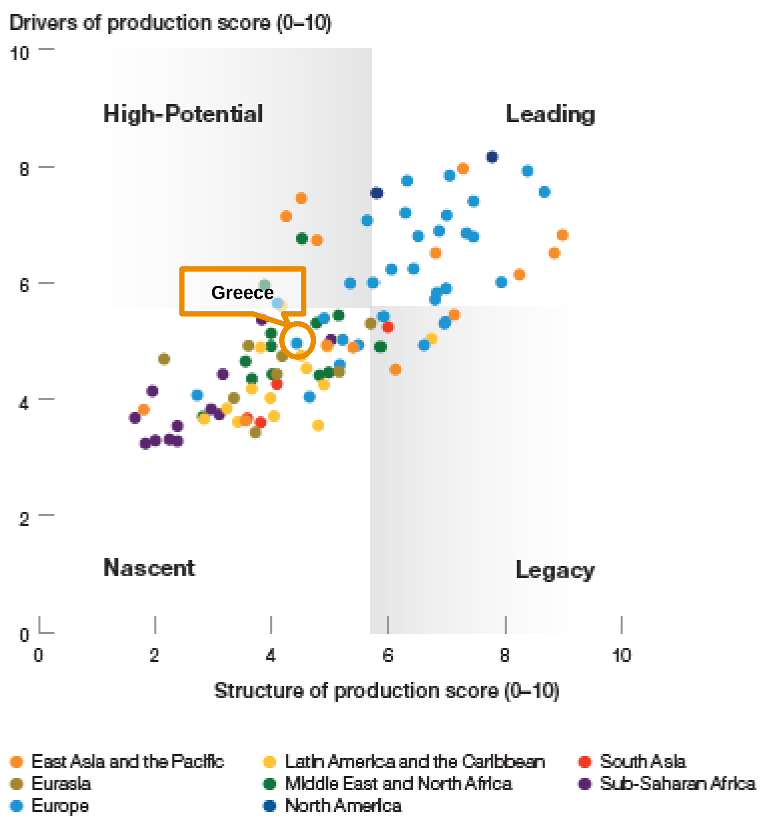

Figure 40: Global Map of Readiness Assessment - Source: WEF, Readiness for the Future of Production Report 2018

Of the 100 economies included in the index, only 25 countries from Europe[243], North America and East Asia are classified as leading countries and are best positioned to benefit from Industry 4.0. China, Germany, Japan, Republic of Korea and the United States are amongst the leading countries. At the same time, approximately 90% of the countries from Latin America, Middle East, Africa and Eurasia included in the assessment are classified as Nascent countries, or the group least ready for the future of production.

The nascent group also includes Greece, indicating that the country has still significant steps to make in order to bridge its digital gap and reap Industry 4.0's benefits. Apart from Greece, the following EU countries are also classified as nascent countries: Cyprus, Croatia, Bulgaria, and Latvia.

6.3.2 The Digital Economy & Society Index (DESI)

Similarly to WEF, the European Union has created the Digital Economy and Society Index (DESI)[244], to track the digital maturity of EU member states at a national level. In addition, the Digital Economic Opportunity Index (DEOI) developed by Accenture in 2017[245], enables us to capture the extent to which digital has penetrated selected European countries' economic activity both at a national and at an industry level. A cross-index analysis of EU countries' performance along the DESI and the DEOI index will offer a well-rounded understanding of the European state of play with regards to Industry 4.0 transformation and readiness.

The Digital Economy and Society Index (DESI) summarizes relevant indicators of Europe's digital performance and tracks the performance and evolution of EU member states in digital competitiveness. The index depicts the digital performance of the 28-member states across five key dimensions, which are briefly presented below.

Key DESI Dimensions	Definitions
Connectivity	The Connectivity dimension measures the deployment of broadband infrastructure and its quality. Access to fast and ultrafast broadband-enabled services is a necessary condition for competitiveness
Human Capital	The Human Capital dimension measures the skills needed to take advantage of the possibilities offered by digital
Use of Internet	The Use of Internet Services dimension accounts for a variety of online activities, such as the consumption of online content (videos, music, games, etc.) video calls as well as online shopping and banking
Integration of Digital Technology	The Integration of Digital Technology dimension measures the digitisation of businesses and e-commerce. By adopting digital technologies, businesses can enhance efficiency, reduce costs and better engage customers and business partners. Furthermore, the Internet as a sales outlet offers access to wider markets and potential for growth

[243] European countries classified as leading countries: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Slovenia, Spain, Sweden, United Kingdom, Switzerland
European countries classified as legacy counties: Hungary, Lithuania, Romania, Slovak Republic
European countries classified as high-potential countries: Norway, Portugal
European countries classified as nascent countries: Greece, Cyprus, Croatia, Bulgaria, and Latvia
[244] The Digital Economy and Society Index 2019, https://ec.europa.eu/digital-single-market/en/desi
[245] "Digital Greece: The Path to Growth". Accenture, 2017

Digital Public Services	The Digital Public Services dimension measures the digitisation of public services, focusing on eGovernment and eHealth. Modernisation and digitisation of public services can lead to efficiency gains for the public administration, citizens and businesses alike

The Digital Economy and Society Index is measured on a standardized scale from 0 to 1, which reflects the contribution of the aforementioned dimensions at enhancing the digital maturity of a country. The higher the score, the broader and deeper the adoption of connectivity infrastructure and digital skills, the use of internet services and the penetration of digital technologies in a country's economic and societal activities.

According to the DESI index for 2019, Europe gradually becomes more digital. During the last 6 years EU's average digital performance has improved by 0.13 units, which translates to an increase of 33% (see Figure 41).[246]

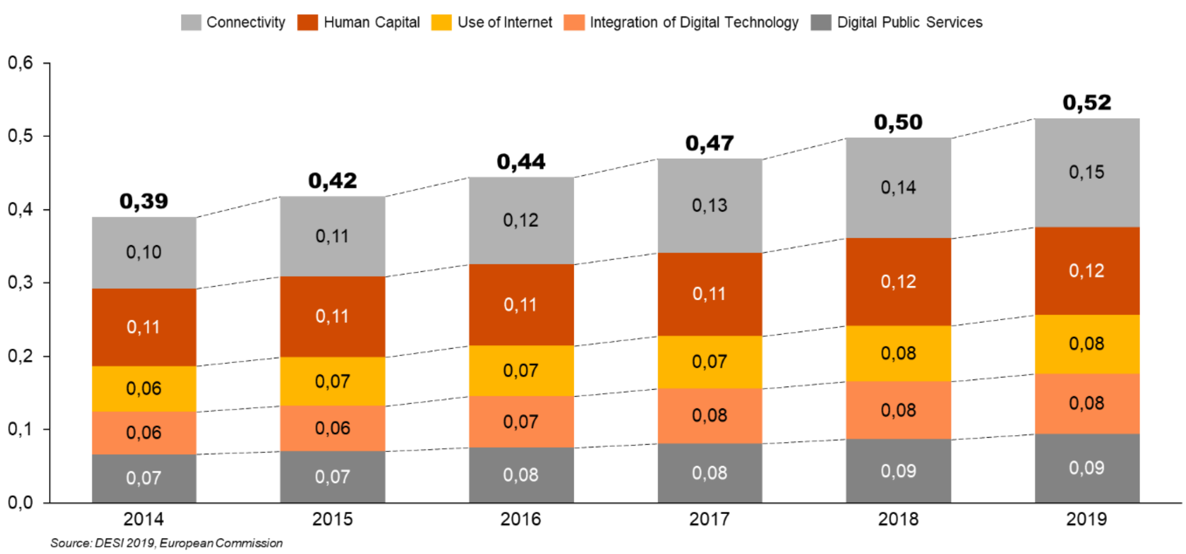

Figure 41: EU 28 DESI score, 2014-2019 (# out of 1) – Source: DESI 2014-2019

Over the last few years, connectivity throughout Europe has substantially improved with the penetration of mobile and fixed broadband networks constantly increasing and the 4G coverage being almost universal. Specifically, Fast broadband (Next Generation Access - NGA) covers 83% of homes, up from 79% a year ago, Ultrafast broadband is available in 60% of EU's homes, up from 57% a year ago, and 4G mobile covers 94% of European households.[247]

[246] The Digital Economy and Socety Index 2014-2019, https://ec.europa.eu/digital-single-market/en/desi
[247] 2019 DESI Report Connectivity, https://ec.europa.eu/digital-single-market/en/desi
A more detailed analysis for this dimension is provided in paragraph 6.5.4

On the digital skills area, moderate improvements have been recorded. Still, an impressive 43% of European citizens has an insufficient level of basic digital skills such as using email or connecting to various devices.[248]

With regards to the use of internet services, 83% of European citizens have reportedly used the internet at least once per week during 2018, compared to 81% during 2017. Nevertheless, the use of internet services by the elderly and by those with low education levels remains well below that percentage, which puts them at risk of digital exclusion.[249]

With regards to the integration of digital technology by the European businesses, a slight improvement is noted in the use of big data analytics (from 10% in 2017 to 12.3% of businesses in 2018) and in the use of cloud (from 13.5% in 2017 to 17.8% of businesses in 2018). On the eCommerce space, SMEs show increased adoption of digital practices but still mostly sell to domestic customers and not cross-border.[250] A more detailed analysis of the integration of digital technology by the European Businesses, per country, is presented in section 6.5.1.

Finally, the quality of European online public services improved with an increase of 5.8% in the eGovernment users and melioration of the score of digital public services for businesses by 2.4%.[251]

Despite EU's total digital upgrade, significantly divergent country performances are observed. In 2019, the digital gap between the most and least digital countries was 0.34 units, with Bulgaria at the bottom, having a score smaller by 48% than that of Finland's, which is leading the race (see Figure 42).[252]

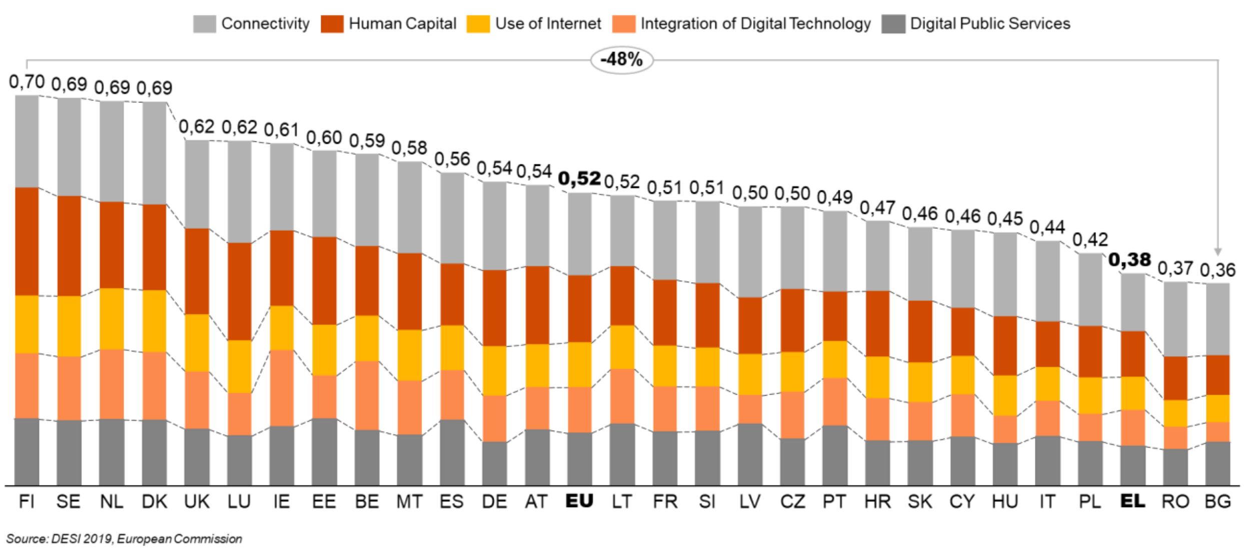

Figure 42: Digital Economy and Society Index (DESI) 2019 ranking – Source: DESI 2019

[248] 2019 DESI Report Human Capital, https://ec.europa.eu/digital-single-market/en/desi,
A more detailed analysis for this dimension is provided in paragraph 6.5.3
[249] 2019 DESI Report Use of Internet Services, https://ec.europa.eu/digital-single-market/en/desi
[250] 2019 DESI Report Integration of Digital Technology, https://ec.europa.eu/digital-single-market/en/desi
A more detailed analysis for this dimension is provided in paragraph 6.5.1
[251] 2019 DESI Report Digital Public Services, https://ec.europa.eu/digital-single-market/en/desi
A more detailed analysis for this dimension is provided in paragraph 6.5.5
[252] The Digital Economy and Socety Index 2019, https://ec.europa.eu/digital-single-market/en/desi

The abovementioned results of DESI indicate a notably wide digital rift between the top performers and countries remaining near the bottom. Digital leaders such as Finland, Sweden, the Netherlands and Denmark have long started their digital transformation and have already advanced regarding their digital performance. This group of leaders also includes United Kingdom, Ireland, Luxembourg and Estonia, a European country that during the last years is pioneering in digital innovation. At the other side of the spectrum, several EU countries including Cyprus, Hungary, Italy, Poland, Greece and Bulgaria are lagging behind in their digital performance compared to the EU average. In 2019, Greece ranked 26th out of 28 EU member states with a score 28% lower than that of the European average.

6.3.3 The Digital Economic Opportunity Index

To evaluate countries' digital maturity and identify the underlying factors that can drive economic growth in the digital economy, Accenture, supported by Oxford Economics, applied in 2018 the Digital Economic Opportunity Index (DEOI).[253] This index was used to capture the extent to which digital has penetrated select European countries' economic activity both at a national and at an industry level. The implementation of the DEOI methodology exposed the digital maturity of the countries in scope. It also provided valuable insight into how countries and their industries have prioritized their digital investments across different dimensions. The DEOI Index consists of three equally weighted levers - digital skills, digital technologies and digital accelerators.

Key DEOI Levers	Definitions
Digital Skills	Digital skills measure the digital nature of occupations and the abilities and knowledge required to perform specific jobs. The key dimensions valued in this lever are: • Stock of digital Skills: degree to which the ICT workers are present in the economy • Digital skills development: effort performed by companies to train their employees in digital skills • Digital ways of working: presence of digital assets and tools such as mobility, social media, etc. in the day to day tasks
Digital Technologies	Digital technologies measure the productive assets available (hardware, software and communications equipment). The key dimensions valued in this lever are: • Digital capital stock: degree of investment by companies in software and hardware assets • Digital engagement: use of digital assets in interactions with employees and customers • Digital enablement: adoption of innovative technologies such as Cloud, Analytics and IOT
Digital Accelerators	Digital accelerators measure the environmental, cultural and behavioural aspects of the digital components of the economy. The key dimensions valued in this lever are: • National communications infrastructure: availability and quality of internet connectivity and degree of access penetration of an economy • Open Data & e-participation: degree to which a Government's actions and investments incorporates digital as a key asset, in order to promote the use of Open Data and enhance e-Participation • Digital business environment: facilities provided by the environment to digital ways of working and digital business models

[253] Accenture 2018, „Digital Cyprus: Catalyst for Change", https://www.accenture.com/gr-en/insights/digital/digital-cyprus-catalyst-change

Similarly to EU's DESI Index, Accenture's DEOI index surfaces divergent country performances. In 2018, Sweden, the United Kingdom and Switzerland lead the DEOI index, followed by Denmark, Finland and the Netherlands. Greece scored at the lower end of the digital maturity curve, with an overall score of 20,2 out of 100. This confirms Greece's relatively weak position against its global peers. In fact, our analysis of Greece's DEOI index indicates that Greece scores low across all three levers. In more detail, the Greek economy demonstrates a relatively higher maturity across its digital skills and accelerators levers but displays significant room for improvement across its digital technologies (see Figure 43).[254, 255]

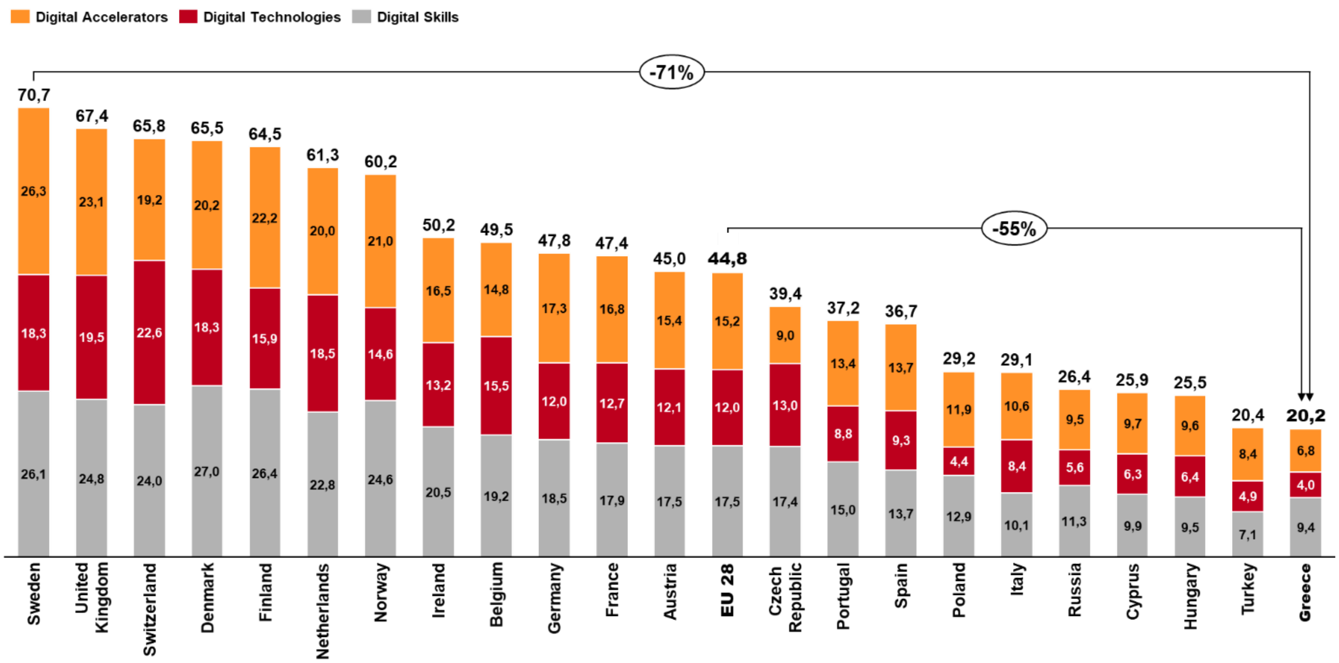

Figure 43: DEOI Index, 2018, European countries' ranking – Source Accenture 2018, „Digital Cyprus: Catalyst for Change"

[254] Accenture 2018, „Digital Cyprus: Catalyst for Change", https://www.accenture.com/gr-en/insights/digital/digital-cyprus-catalyst-change
[255] Countries included in this sample refer to the broader European area. Turkey is included in our sample as a transcontinental country in Eurasia.

Zooming into the Digital Skills lever, in 2018 we find Denmark at the top of the ranking (27 points), which is positioned 9,5 points above the sample's average. In 2018, Greece scored 9,4 points out of 100. This score brought Greece at a low position against its peers, ranking 21st out of 22 and 8,1 points below the sample's average score (17,5 points) (see Figure 44).[256]

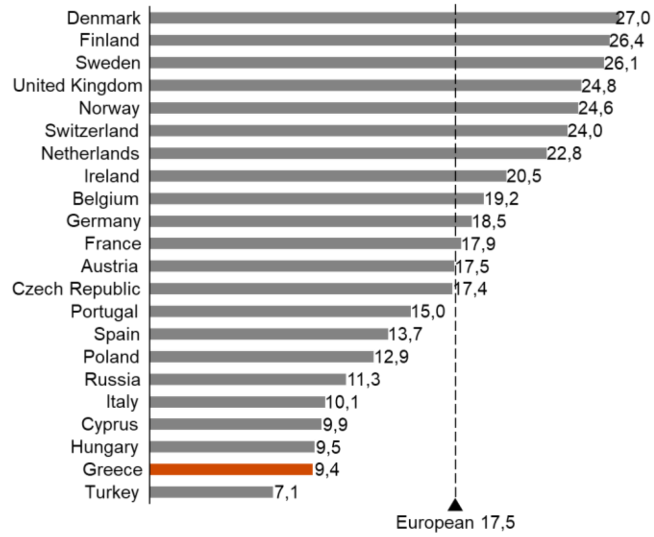

Figure 45: The digital economic opportunity index (DEOI) 2018, European sample (# out of 100) - The Digital Skills lever – Source Accenture 2018, „Digital Cyprus: Catalyst for Change"

Moving to the second digital maturity lever, Digital Technologies, Switzerland and the United Kingdom appear to be frontrunners with regards to their adoption and implementation of new digital technologies, scoring 22,6 and 19,5 points respectively. On the contrary, Greece appears to have made limited progress into integrating digital technologies in the fabric of its industry and society. This leads to an overall low maturity across the Digital Technologies lever (DEOI score: 4,0 out of 100). (see Figure 45).[257]

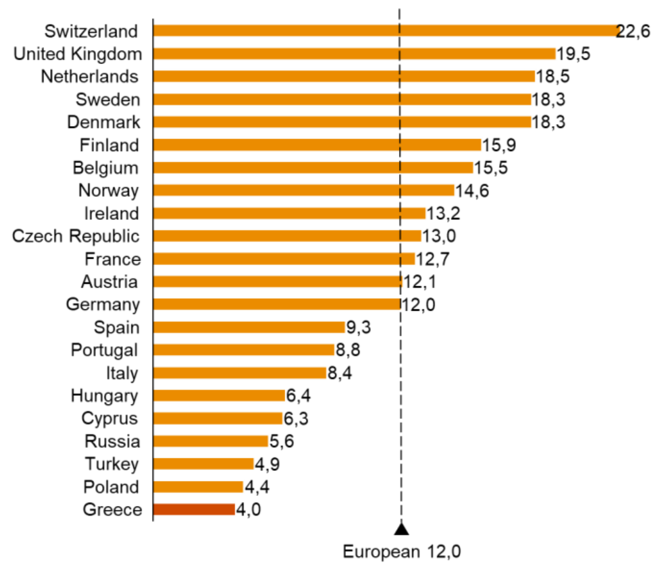

Figure 44: The digital economic opportunity index (DEOI) 2018, European sample (# out of 100) - The Digital Technologies lever – Source Accenture 2018, „Digital Cyprus: Catalyst for Change"

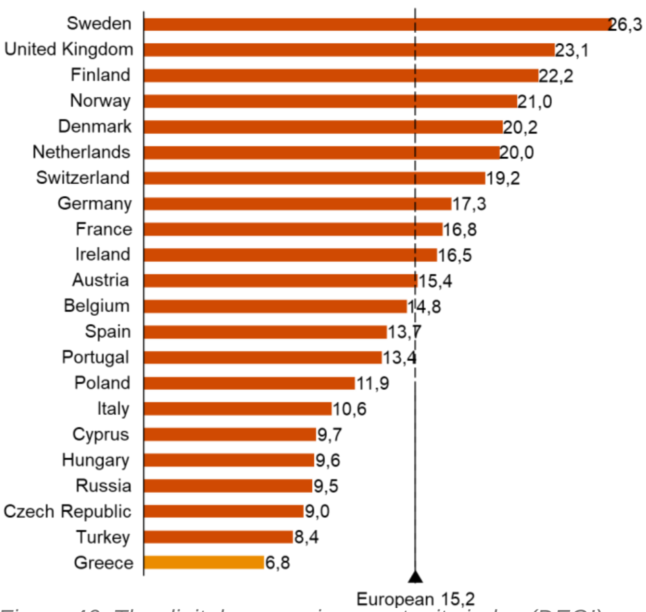

Figure 46: The digital economic opportunity index (DEOI) 2018, European sample (# out of 100) - The Digital Accelerators lever – Source Accenture 2018, „Digital Cyprus: Catalyst for Change"

Finally, if we shift our focus to the Digital Accelerators lever, we observe that Sweden, the United Kingdom and Finland demonstrate the highest maturity across the Digital Accelerators level. If we shift our focus to

[256] Accenture 2018, „Digital Cyprus: Catalyst for Change", https://www.accenture.com/gr-en/insights/digital/digital-cyprus-catalyst-change
[257] Accenture 2018, „Digital Cyprus: Catalyst for Change", https://www.accenture.com/gr-en/insights/digital/digital-cyprus-catalyst-change

Greece's Digital Accelerators lever, we observe that the country scores at the lowest rank of the table. In fact, Greece's 6,8 points position the country last amongst its European counterparts. The sample's average score (15,2 points) is also 8,4 points higher than the respective score for Greece. This indicates that the country lags behind its counterparts with regards to the provision of a digitally favourable business and regulatory environment (see Figure 46).[258]

Greece's unfavourable ratings on the DESI and DEOI indexes is aligned with the country's low ranking across a number of indices (EGDI (2018)[259], IDI (2017)[260], DEI (2017)[261], FOP (2018)[262]) that assess the digital maturity of countries around the world (see Figure 47).

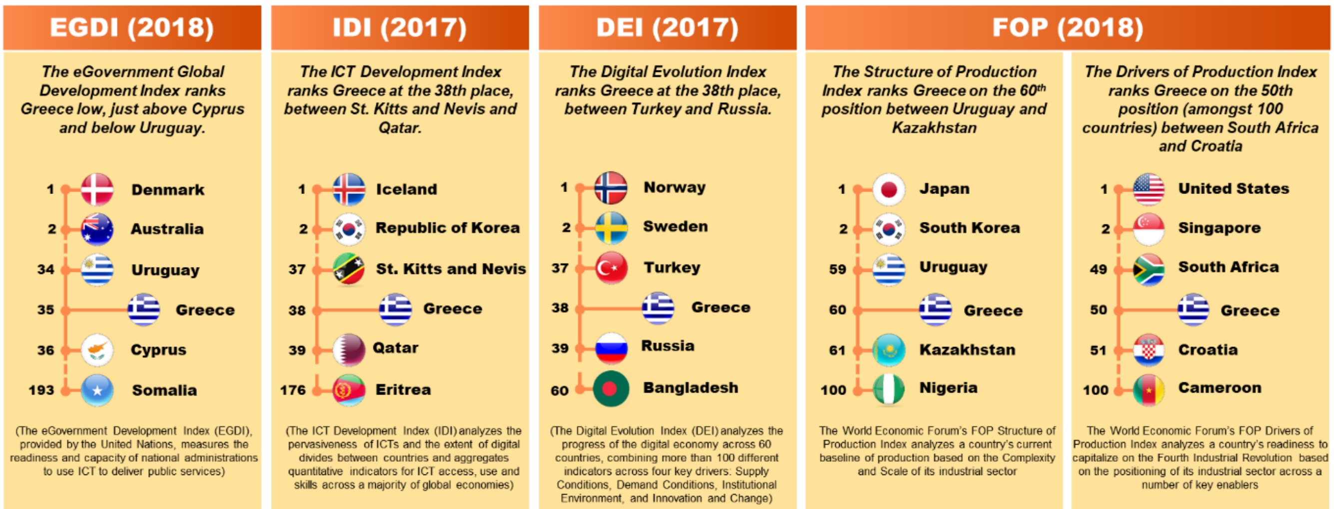

Figure 47: Greece's ranking in the following indices: EGDI (2018), IDI (2017), DEI (2017) and FOP (2018) – For sources please refer to footnotes 245 - 248

6.4 Industry 4.0 Analysis at an Industry Level

6.4.1 Digital Transformation Scoreboard

The Digital Transformation Scoreboard (DTS) is part of the Digital Transformation Monitor, an initiative that aims to foster the knowledge base on the state of play and evolution of digital transformation in Europe.[263] Unlike DESI, which focuses on digitalisation on the broad national level, the main goal of the Digital Transformation Scoreboard is to monitor the transformation of the existing industry and enterprises in each country. The Scoreboard's dimensions are divided into two categories, enablers and outcomes.

- Enablers are measured by the **Digital Transformation Enablers Index (DTEI)** and include indicators measuring digital infrastructure, investments and access to finance, supply and demand of digital skills, e-leadership, and entrepreneurial culture.

[258] Accenture 2018, „Digital Cyprus: Catalyst for Change", https://www.accenture.com/gr-en/insights/digital/digital-cyprus-catalyst-change
[259] eGovernment Survey: Gearing eGovernment to Support Transformation towards Sustainable and Resilient Societies, United Nations, 2018, https://www.unescap.org/resources/eGovernment-survey-2018-gearing-eGovernment-support-transformation-towards-sustainable
[260] Measuring the Information Society Report, ITU, 2017
[261] Digital Planet 2017: How Competitiveness and Trust in Digital Economies vary across the World, The Fletcher School Tufts University, 2017
[262] Readiness for the Future of Production Report, World Economic Forum, 2018
[263] European Commission, Digital Transformation Scoreboard, https://ec.europa.eu/growth/tools-databases/dem/monitor/scoreboard

- Outcomes are measured by the **Digital Technology Integration Index (DTII)** and include indicators measuring the prevalence of ICT start-ups and the integration of digital technology by enterprises and SMEs alike.

With regards to the EU Digital Transformation Enablers Index, the Netherlands, Finland and Sweden were leading the pack in 2018 (see Figure 48). While all three leaders score highly on most indicators, each demonstrates different strongest attributes. While the Netherlands perform best in terms of connectivity and entrepreneurial culture, Finland's strongest points are e-leadership and access to finance, and Sweden's greatest strengths are its high level of innovation outputs and its large percentage of ICT start-up 'birth rates'. On the other side of the spectrum, Croatia, Latvia, and Romania score last among EU member states. Among the DTEI laggard countries, insufficient digital skills, access to finance and poor digital infrastructure are discussed the most in individual DTS country analyses.[264]

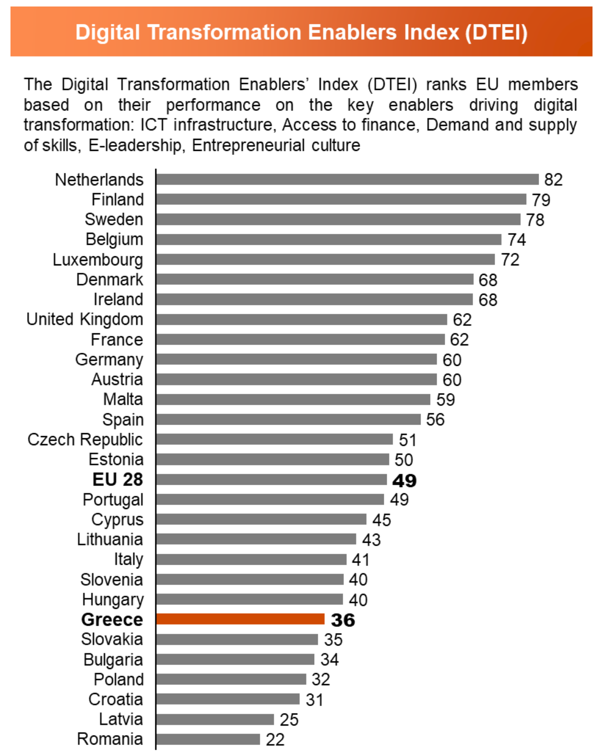

Figure 48: EU Digital Transformation Enablers Index (DTEI) – Source : European Commission, Digital Transformation Scoreboard

The Greek industry appears to score low amongst its EU counterparts in the DTEI. In fact, Greece is placed on the 22nd position, scoring 36 points on the index. This practically means that it is positioned 46 points below its Dutch counterpart, which leads the EU sample, and 13 points below the EU average. Greece's low score on the DTEI signifies that the Greek industry performs below par, on aggregate, in terms of digital infrastructure, access to finance, the demand and supply of digital skills, e-leadership, and local entrepreneurial culture. A granular view on Greece's key enablers, i.e. digital infrastructure, investments and access to finance, supply and demand of digital skills, etc. will be provided in paragraph 6.5. Findings over that paragraph will reconfirm Greece's low position on the DTEI.[265]

[264] European Commission, Digital Transformation Scoreboard, https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/Digital%20Transformation%20Scoreboard%202018_0.pdf
[265] European Commission, Digital Transformation Scoreboard, https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/Digital%20Transformation%20Scoreboard%202018_0.pdf

With regards to the Digital Technology Integration Index northern and western EU Member States score highest in terms of digital transformation, with Denmark showing the biggest improvement since 2017. On the other hand, the Greek industry scores poorly with respect to its enterprises' digitisation, ranking 23rd among the 28 EU countries and 35 percentage points below the EU average. Greece's low ranking with regards to the DTII indicates that Greek enterprises have performed thus far limited, nascent steps with regards to their digitisation. In addition, Greece's economic environment is not as favourable to the birth and growth of new digital businesses as that of other western EU Member States (see Figure 49).[266]

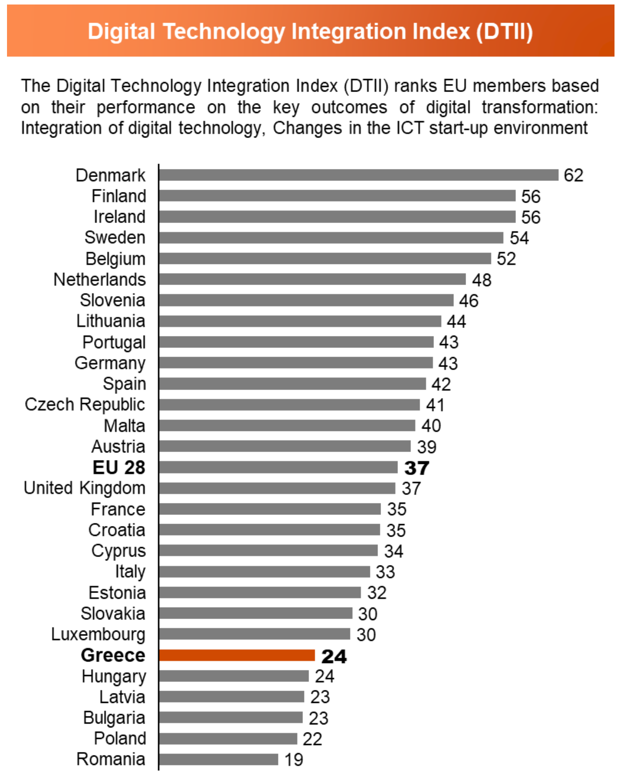

Figure 49: Digital Technology Integration Index (DTII) – Source: European Commission, Digital Transformation Scoreboard

[266] European Commission, Digital Transformation Scoreboard, https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/Digital%20Transformation%20Scoreboard%202018_0.pdf

6.4.2 Digital Economic Opportunity Index (DEOI) – Industry Level

The Digital Economic Opportunity Index (DEOI) that Accenture developed in 2018[267], has also progressed the analysis on countries' digital maturity one step further, as it provided a granular view on select countries' industries' digital maturity. In fact, the Digital Economic Opportunity Index (DEOI) was applied for eleven select industries over a four-year time period (2015 - 2018).

Accenture's analysis suggests that the United Kingdom appears to have the most digitally mature industries across our European sample, as it holds the first position across nine different industries. The top three includes also the Netherlands and Sweden, while almost all German industries in scope hold the fourth position. On the other hand, all eleven Greek industries are sub optimally placed with regards to their digital maturity, when compared to their European peers over the last four years (see Figure 50).

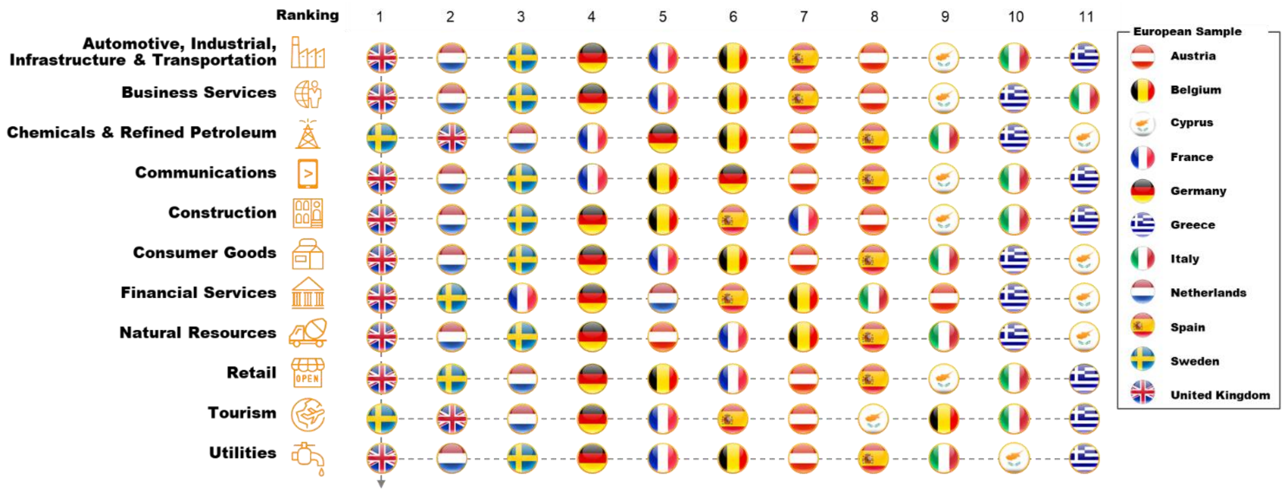

Figure 50: European Industries' digital maturity ranking 2018 – Source: Accenture 2018, „Digital Cyprus: Catalyst for Change"

In fact, Greek industries in scope for our engagement (i.e. Automotive, Industrial, Infrastructure & Transportation, Chemicals & Refined Petroleum, Construction, Consumer Goods, Natural Resources and Utilities) score last or second from last compared to their European counterparts. These results suggest that the breadth and depth of the digital interventions required to be implemented by the Greek organisations shall be significantly deep and wide.

[267] Accenture 2018, „Digital Cyprus: Catalyst for Change", https://www.accenture.com/gr-en/insights/digital/digital-cyprus-catalyst-change

6.5 Key Industry 4.0 “Enablers”

In order to evaluate countries’ Industry 4.0 state of play, we should also review and evaluate the state of their digital “enablers”. These are the key prerequisites that shall be in place to enable countries’ transition to Industry 4.0. They include:

- the use of advanced digital technologies
- the state of other industry 4.0 technological groups
- the digital knowledge of total population and industrial workforce
- the state of digital infrastructure
- the implementation of eGovernment applications

EU countries’ (including Greece’s) state of play is analysed below. More information on detailed indicators and metrics is also provided in Appendix I.

6.5.1 Use of advanced digital technologies and applications

Across the EU, adoption of advanced digital technologies and applications varies significantly. A better understanding of the position of each country in terms of advanced digital technologies adoption can be achieved through a deep dive into the relevant indexes and the different adoption rates of countries and their economies across a set of different technologies.

The DESI Index – Pillar 4: Integration of Digital Technology by Businesses

Digital revolution is radically transforming all sectors of the economy. Implementation and adoption of digital technologies are no longer an optional activity for businesses, but a key factor for survival. The 4th pillar of the DESI index calculates the prevalence of business digitisation and e-commerce in European economies.[268] It comprises of two sub-dimensions:

- The “business digitisation” sub-dimension that covers the use of social media, big data analytics, cloud solutions and electronic information sharing by businesses.
- The “e-commerce” subdimension covers the percentage of small and medium-sized enterprises (SMEs) selling online, e-commerce turnover as a percentage of total turnover of SMEs, and the percentage of SMEs selling online cross-border.

At an aggregate level, European companies appear to have begun their digital transformation, albeit at a variable degree. Overall, Greece ranks 22nd in 2019 in integrating digital technologies into its entire economy. Ireland appears to be the leader in the Integration of Digital Technology dimension, followed by the Netherlands and Belgium, all of which demonstrate some of the largest percentages of business digitisation in the EU, as well as a high share of e-commerce adoption by their SMEs. On the other side of the spectrum, Bulgaria ranks last, followed by Poland and Romania. Shifting our focus to Greece, while Greek companies seem to have started their digital transformation, they still lag behind the EU average

[268] The Digital Economy and Society Index 2019, Integration of Digital Technology, https://ec.europa.eu/digital-single-market/en/desi

by 20 percentage points, with a score of 0,33 points (out of 1) and the 22nd position amongst its counterparts (see Figure 51).[269]

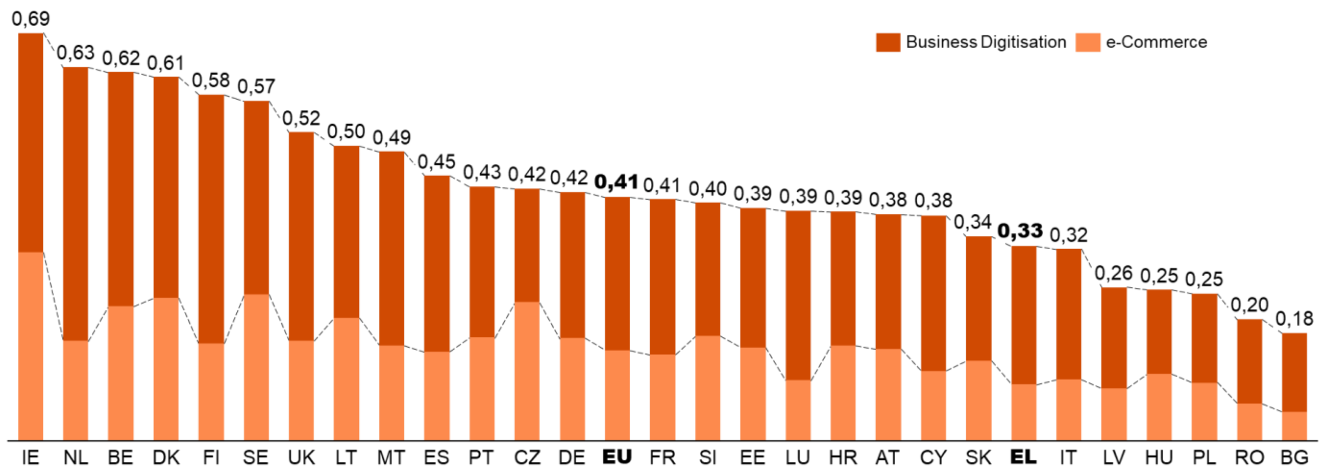

Figure 51: Digital Economy and Society Index (DESI) 2019 – Pillar 4: Integration of Digital Technology by Businesses ranking – Source: DESI 2019, Integration of Digital Technology

More specifically, with regards to the "business digitisation" sub-dimension, the leading countries are the Netherlands (2nd among EU Member States in three indicators: electronic information sharing, social media and big data analysis; 3rd in cloud solutions), Finland (forerunner in the use of cloud solutions) and Belgium (first in electronic information sharing). Bulgaria, Hungary, Romania, Poland and Latvia are lagging behind in the adoption of digital technologies.

With regards to the "e-commerce" subdimension, Ireland, Belgium and the Czech Republic are among the top countries in all the three indicators mentioned previously. Denmark leads the pack with regards to the share of enterprises selling online, whereas Sweden ranks 3rd on this indicator. Sweden is positioned 4th and Denmark 5th regarding the share of e-commerce turnover in total turnover. On the contrary, Bulgarian Romanian and Latvian SMEs are yet to exploit the e-commerce potential.

If we further zoom-into Greece, the country indicates a mediocre performance across the "business digitisation" dimension (18th out of the 28 EU member-states), while it scores significantly low on the "e-commerce" subdimension, holding the 25th position.

The detailed analysis provided in Appendix I demonstrates the EU enterprises' performance across a number of digital technologies and applications. The key findings are also summarized below:

- **Big Data:** On average, only 12% of EU enterprises were analysing big data in 2018. Malta led the European sample, with 24% of the country's enterprises investing in big data analytics. On second and third place, 22% and 20% of enterprises use big data analytics in the Netherlands and Belgium respectively. Greek enterprises appear to also exploit the opportunities provided by big data and social media, since 13 % of them reported using big data in 2018.[270]

[269] The Digital Economy and Society Index 2019, Integration of Digital Technology, https://ec.europa.eu/digital-single-market/en/desi
[270] Eurostat, Digital economy and society, https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/comprehensive-database

- **Cloud computing:** On average, 26% of EU enterprises adopted cloud computing solutions in 2018. On average, only 26% of EU enterprises purchased cloud computing services used over the internet in 2018. Finland led the European sample, with 65% of the country's enterprises having purchased cloud services in 2018. On the second and third place, we find Sweden and Denmark, where 57% and 56% of enterprises respectively used cloud computing services. Only 13 % of the Greek enterprises used cloud computing in the same year.[271]
- **RFID technologies:** The EU has been relatively slow to adopt RFID technologies, with just 12% of EU enterprises using RFID on average in 2017. Finland was the European leader in RFID adoption, with 23% of Finnish companies using the technology. Finland was closely followed by Belgium and Austria, where 21% and 19% of enterprises used RFID respectively. Last among EU countries were Hungary, Romania and Greece, all of which reported 7% of their enterprises using RFID in the same year. [272]
- **Enterprise Resource Planning (ERP) systems:** The European Union demonstrated relatively high levels of ERP adoption, with 34% of EU enterprises using ERP software in 2017. Belgium was the frontrunner, with 54% of its enterprises using ERP systems. The Netherlands and Lithuania came in second and third place, with 48% and 47% ERP adoption rates respectively. Last among EU countries were the United Kingdom, Romania, and Hungary, with 19%, 17%, and 14% of enterprises using ERP in 2017. Greece performed well across this indicator, with 37% of Greek enterprises using ERP platforms. This level of adoption ranked Greece in the top half of European countries (three percentage points above the EU average).[273]
- **Customer Relationship Management (CRM) systems:** The EU demonstrated relatively high rates of CRM adoption, with 33% of EU enterprises using CRM in 2017. The Netherlands and Germany ranked first in the EU, both with 47% of their enterprises reporting using CRM systems in 2017. On the other side of the spectrum, Latvia, Romania, and Hungary demonstrated the lowest adoption rates in the EU with 17%, 14% and 14% respectively. Greek enterprises have been moderately too slow in their adoption of Customer Relationship Management (CRM) systems, with just 20% of Greek enterprises using the technology in the same year. [274]
- **Industrial Robots:** On average, EU enterprises demonstrated a low level of industrial robot adoption, with only 5% of enterprises making use of industrial robots in that year. Finland and Spain were the EU leaders in industrial robot adoption, with 8% of enterprises using industrial robots in 2018 in the two countries. Denmark and the Netherlands rank third and fourth in the EU sample, with 7% adoption. Cyprus demonstrated the lowest percentage rate of industrial robot adoption at 1%, scoring one point below by Greece, Lithuania and Romania, all of which reported 2% adoption in 2018. [275]

[271] Eurostat, Cloud computing services, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicce_use&lang=en
[272] Eurostat, Enterprises using radio frequency identification (RFID) instrument, https://ec.europa.eu/eurostat/web/products-datasets/-/tin00126
[273] Eurostat, Integration of internal processes, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_bde15dip&lang=en
[274] Eurostat, Enterprises using software solutions, like CRM to analyse information about clients for marketing purposes, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tin00116&lang=en
[275] Eurostat, EU enterprises use of robots, https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190121-1?inheritRedirect=true

6.5.2 State of other industry 4.0 technological groups

Nanotechnology

Nanotechnology refers to science and technology applications at the nanoscale of atoms and molecules, and to the scientific principles and new properties that can be understood and mastered when operating in this domain. Due to its ability to pervade virtually all technological sectors nanotechnology is often referred to as 'horizontal' or 'enabling'. Nanotechnology has provided significant contributions to information technology, material science, manufacturing, energy production and storage, food water and environmental research, security, and medical applications.[276] According to a report by the European Commission, 70% of all product innovation is estimated to be based on materials with new or improved properties.[277] The fastest growing market for nanotechnology applications is currently healthcare, with applications ranging from cancer detection and diagnosis using the new materials for imagining and biomarker detection to drug delivery for targeted drug administration (see Figure 52).

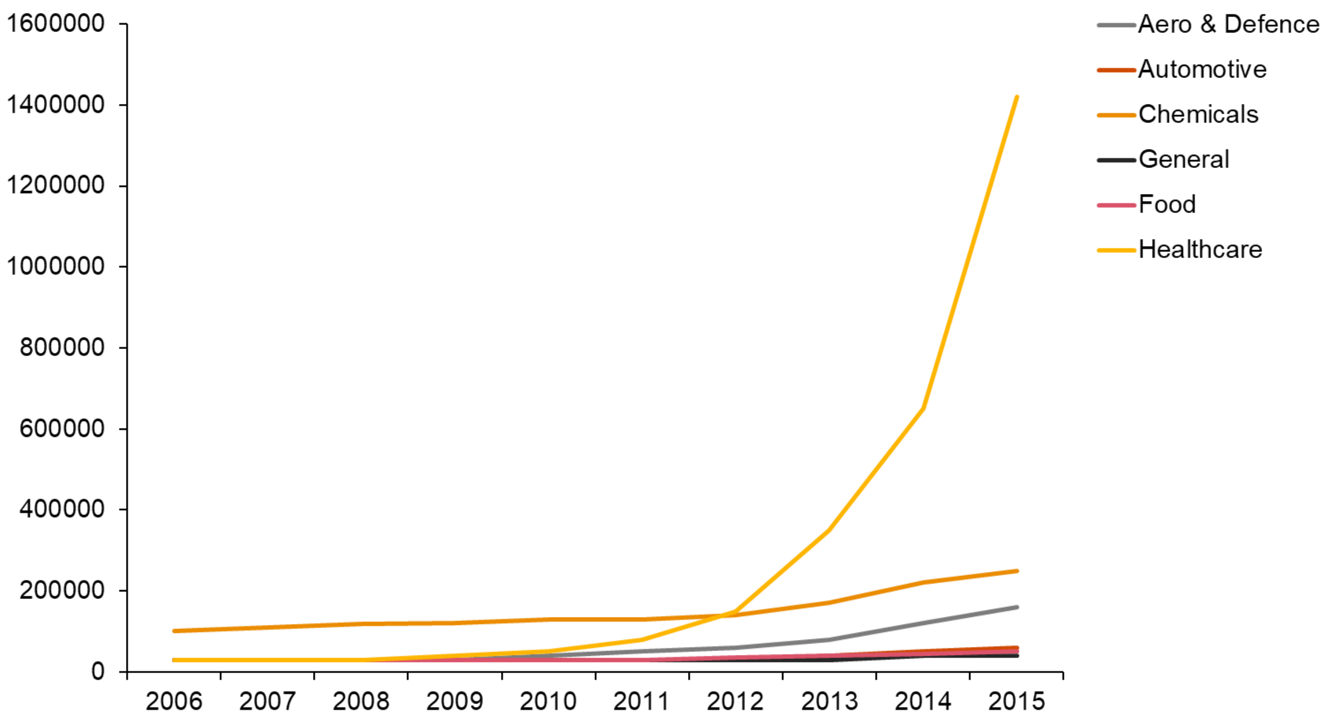

Figure 52: Nanotechnology Market Evolution in US$ million, 2005 – 2016 – Source: European Commission, "Towards a European Strategy for Nanotechnology"

Nanotechnology and advanced materials have already helped bring about a large number of product innovations. Two major applications of nanotechnology have been identified in the context of the 4th industrial revolution. Firstly, nanomaterials can be used to enable IoT sensors to work with higher efficiency. Certain properties of nanomaterials, such as their high electrical conductivity and charge carrier

[276] European Commission, "Towards a European Strategy for Nanotechnology", https://ec.europa.eu/research/industrial_technologies/pdf/policy/nano_com_en_new.pdf
[277] European Commission, Secret Materials – Discover the world of new materials https://ec.europa.eu/info/sites/info/files/research_and_innovation/research_by_area/documents/secret-materials-box_en_0.pdf

mobility, make them ideal for use as 'sensing materials' in industrial sensors where high sensitivity and data accuracy is required for optimal performance. Secondly, nanomaterials have the potential of facilitating the faster and more efficient transmission of data through different components communicating with each other at the nano level. The latter, still in development, has been deemed the Internet of Nano Things (IoNT).[278]

The European Commission estimates the sector to be worth more than $1 trillion[279], and is considered to be growing. The EU has invested approximately EUR €1.4 billion[280] in nanotechnology related research and is the world leader in nanotechnology research. The EU's Joint Research Centre (JRC) has state-of-the-art equipped laboratories for studies on nanomaterials[281]. Among EU member states, Germany ranks first with respect to the number of patents granted (378 by the United States Patent and Trademark Office (USPTO)), followed by France (235), the UK (144) and the Netherlands (122) (see Figure 53). All four countries rank in the top ten globally for published patents.[282]

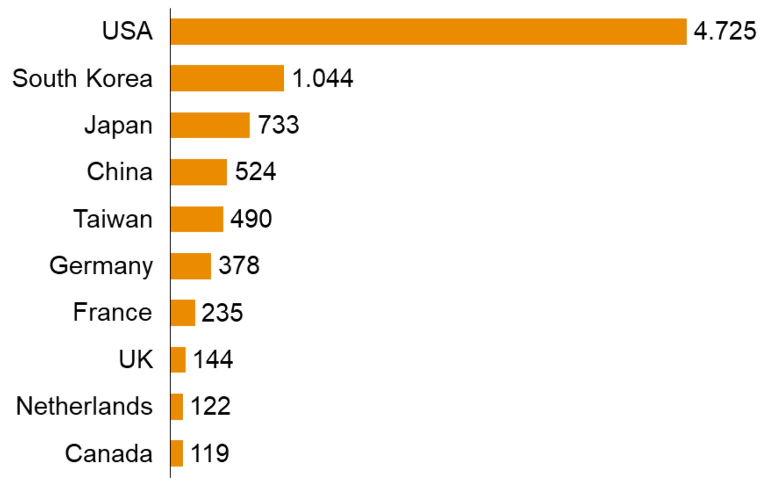

Figure 53: Top ten countries worldwide with regards to the number of nanotechnology granted patents published by the United States Patent and Trademark Office (USPTO) in 2017 – Source: USTPO

Greece has been slow to bring nanotechnology into its industrial landscape, reporting just 52 nanotechnology job positions in 2016. At less than 1 percentage point of the total workforce, the Greek economy has yet to make any measurable contributions to the nanotechnology sector.[283] At the same time, the Greek industry's share of nanotechnology related production was 0,01% in 2015, ranking Greece last in the EU, along with Bulgaria. Mirroring the low performance of the Greek industry along other nanotechnology-related dimensions, Greece scores last in the EU in terms of the country's share of scientific nanotechnology publications. Greece's share of 0,02% nanotechnology publications (over the

[278] Mouser, Where Nanotechnology, the IoT, and Industry 4.0 Meet, https://www.mouser.com/blog/where-nanotechnology-the-iot-and-industry-40-meet
[279] GAEU Consulting, This is nanotechnology – one of the fastest growing markets in the world, https://gaeu.com/artiklar/this-is-nanotechnology-one-of-the-fastest-growing-markets-in-the-world/
[280] European Commission, EU world leader in nanotechnology research, https://ec.europa.eu/jrc/en/news/eu-world-leader-nanotechnology-research-7483
[281] European Commission, JRC Nanobiotechnology Laboratory, https://ec.europa.eu/jrc/en/research-facility/nanobiotechnology-laboratory
[282] Statnano, Top Ten Countries in Nanotechnology Patents in 2017, https://statnano.com/news/62082/Top-Ten-Countries-in-Nanotechnology-Patents-in-2017
[283] European Commission, Key Enabling Technologies Observatory, https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/library/kets_observatory_second_report.pdf

total number of scientific publications) is significantly behind the EU average, at just a third of the share of scientific nano-technological publications produced in the continent.[284]

Case Study: Shape Memory Alloy for Clothing

By leveraging the capabilities of innovative fibre technology scientists have been able to create a wide variety of smart textiles. One such textile is shape memory alloy, modified for its incorporation into a woven structure. An example of the applications of this textile is a shirt produced by the Italian company Grado Zero Espace, which can be ironed automatically using only a hair dryer. The thermal space memory alloy enables the fabric to return to its original geometry when heated.

Source: Tomellini, Renzo. 'Secret Materials: Discover the world of New Materials'. European Commission https://ec.europa.eu/info/sites/info/files/research_and_innovation/research_by_area/documents/secret-materials-box_en_0.pdf, https://www.gzinnovation.eu/material/7/shape-memory-materials

Additive Manufacturing

The global market size for additive manufacturing is currently estimated at $9 billion USD according to the respective report published by EY. Over the past 3 years the market has grown by 29%, demonstrating the vast potential and applicability of additive manufacturing in 3D printing technologies. By 2023, the global market for additive manufacturing is projected to grow by $27 billion.[285] The European Union is the largest additive manufacturing market by company number, home to 722 additive manufacturing organisations, followed by the Americas with 421 companies and Asia with 168 companies (See Figure 54).[286]

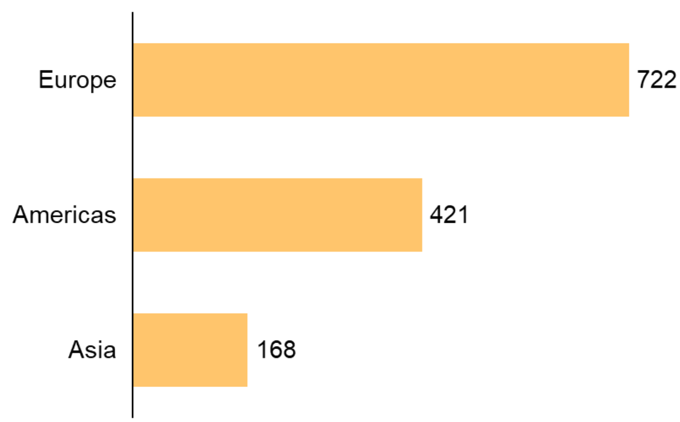

Figure 54: # of companies using Additive Manufacturing, 2018 – Source: EY Report 2019, "3D printing: hype or game changer?"

[284] Key Enabling Technologies Observatory, https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/library/kets_observatory_second_report.pdf
[285] EY, 3D printing: hype or game changer? 2019, https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/advisory/ey-3d-printing-game-changer.pdf
[286] Additive Manufacturing Market, https://www.marketsandmarkets.com/Market-Reports/additive-manufacturing-medical-devices-market-843.html?gclid=Cj0KCQjwjcfzBRCHARIsAO-1_OrG_KtGBZ_VttAEBd26JW1n-W6raR1U_zjLzCn_rbfYzzSP8uExPpkaAnmuEALw_wcB

If we further zoom-into the EU countries and review their enterprises that currently use 3D printing capabilities, we observe that only 4% of European enterprises on average used 3D printing in 2018. The EU leader in 3D printing was Finland, with 7% of Finnish enterprises using 3D printing, followed by Denmark, Malta and the UK, all of which reported a 6% 3D printing adoption in the same year. (see Figure 55).[287]

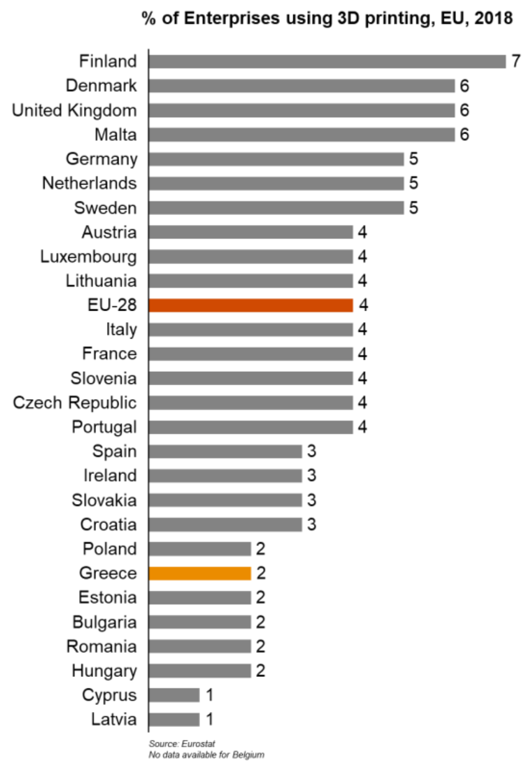

Figure 55: % of Enterprises using 3D printing EU, 2018 – Source: Eurostat, 3D printing and robotics

[287] Eurostat, 3D printing and robotics, https://data.europa.eu/euodp/data/dataset/yzsEuBlwUUxizsj3hSOdQ

The proportion of EU enterprises using 3D printing in the manufacturing sector is much larger on average, with 9% adoption when compared to 4% adoption in the EU cross-industry sample. The EU leaders are Finland and Denmark, both of which report that 17% of their domestic manufacturers used 3D printing in 2018. Romania scores last, with just 2% of the country's manufacturers using 3D printing (see Figure 56).[288]

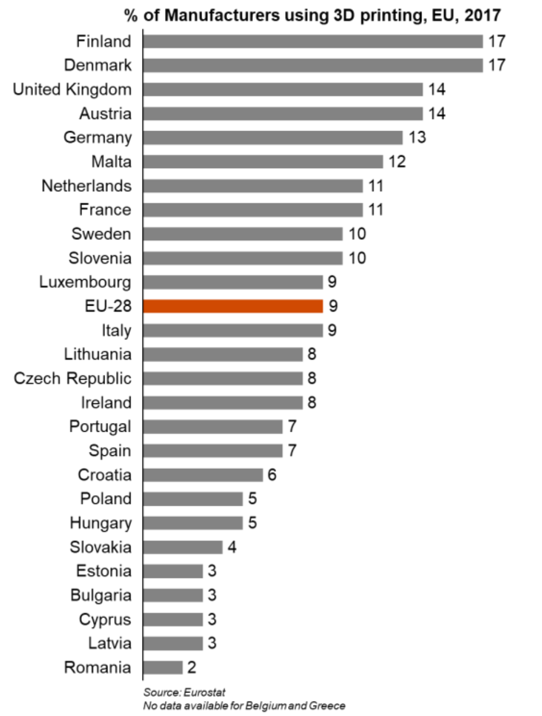

Figure 56: % of Manufacturers using 3D printing, EU 2018 – Source: Eurostat, 3D printing and robotics

In Greece, 924 job positions are currently classified as Additive Manufacturing related jobs. This is a small but not negligible part of the workforce, at 0,03%, which indicates that the Greek industry has made some initial steps, in terms of adopting this technology. In addition, Greece's low performance in this technology is also mirrored by the country's low share of Advanced Manufacturing patents (1,07% of all Greek patents), which is the lowest in the EU (see Figure 57).[289]

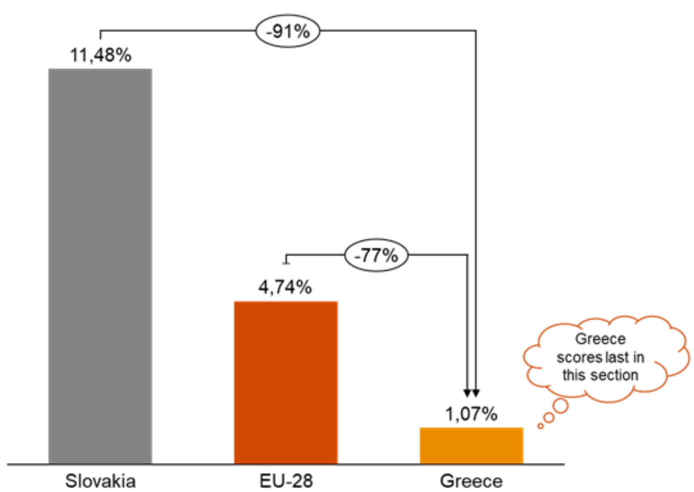

Figure 57: Advanced manufacturing technologies, % share of patents, EU, 2015 - Source: European Commission, KET Observatory

[288] Eurostat, 3D printing and robotics, https://data.europa.eu/euodp/data/dataset/yzsEuBlwUUxizsj3hSOdQ
[289] European Commission, Key Enabling Technologies Observatory, https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/library/kets_observatory_second_report.pdf

Nevertheless, Greece performs on par with the EU average in terms of its share of scientific publications in the field of Additive Manufacturing Technologies. 0,03% of all Greek scientific publications concern Additive Manufacturing and place Greece on par with the EU average (see Figure 58).[290]

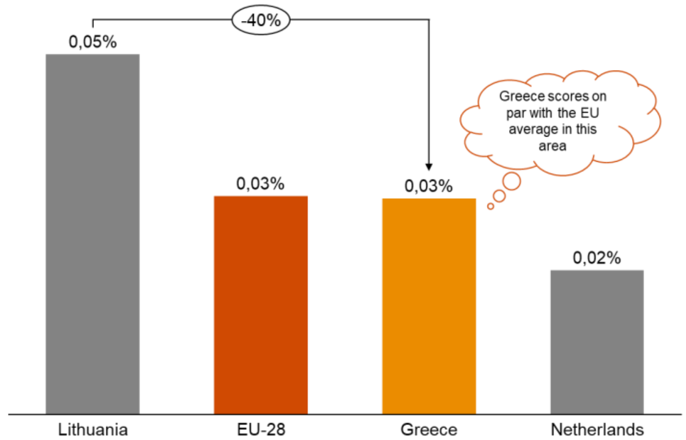

Figure 58: Advanced manufacturing technologies, % Share of Scientific Publications, EU, 2015 - Source: European Commission, KET Observatory

Greece ranks low in terms of the export orientation of additive manufacturing applications. The share of the Greek additive manufacturing related exports as a share of overall Greek exports was 0,12% in 2015, scoring significantly below the EU average (0,75%) (see Figure 59). [291]

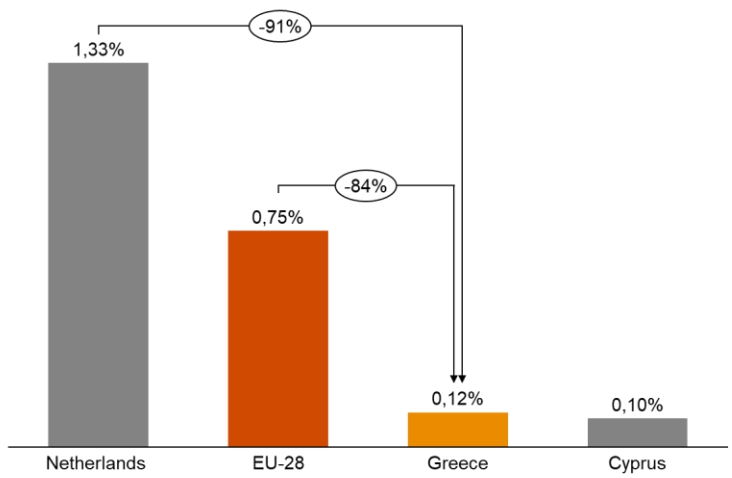

Figure 59: Advanced manufacturing technologies, % Export Share to Manufacturing Exports, EU, 2015 - Source: European Commission, KET Observatory

[290] European Commission, Key Enabling Technologies Observatory, https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/library/kets_observatory_second_report.pdf
[291] European Commission, Key Enabling Technologies Observatory, https://ec.europa.eu/growth/tools-databases/kets-tools/sites/default/files/library/kets_observatory_second_report.pdf

Case Study: EOS

EOS, a German company focusing on additive manufacturing solutions, leveraged AM technologies to design and implement the production process for a cable routing mount for the new Airbus A350XWB. The result was a significantly simplified production process with 90%-time reductions and 30% weight reduction in the final component without sacrificing the mount's strength and durability under traditional production methods.

Instead of proceeding to produce the cable routing mount in the conventional way, which would require more than 20 individual parts in total, EOS partnered with Sogeti to develop an integrated additive manufacturing solution consisting of a single part, thereby significantly reducing construction and installation times in addition to overall weight.

The time required to produce the mount to 19 hours instead of the 70 days previously required, which corresponds to a reduction in production time well in excess of 90%. While the conventionally manufactured original part weighed 452 grams, the additively manufactured cable mount weighs just 317 grams – 30% less – which is not an insignificant achievement in an industry which counts every single gram in the interest of cutting fuel consumption to a minimum.

Source: Eos Website https://www.eos.info/press/case_studies/sogeti-additive-manufacturing-for-the-new-a350-xwb

Circular Economy

In 2015, The European Commission adopted several measures to help stimulate Europe's transition towards a circular economy, in order to boost global competitiveness, foster sustainable economic growth and generate new jobs. The EU's action plan for the Circular Economy includes goals related to overall production and consumption, waste management, use of secondary raw materials and the revised legislative proposal on waste. Indicatively, common EU targets include recycling 65% of municipal waste by 2035, 70% of packaging waste by 2030, and a number of minimum requirements for extended producer responsibility schemes to improve cost efficiency and governance.[292]

According to Eurostat data, the average circular use of materials as a percentage of total material use averaged 12% in the EU on 2016. On the country level, the circularity of national economies varies highly with the Netherlands leading the way at 29% circular material use while Greece, Europe's lowest ranking country, reports only 1% circular material use (see Figure 60).[293]

Furthermore, only 6 out of 28 EU countries scored above the EU average. This implies that the disproportionately high levels of circular material use in leading countries like the Netherlands, France, Belgium, the UK, Italy, and Estonia are responsible for raising the average significantly higher than the median proportion of circular material use in the EU, which is approximately around 7%. Consequently, most EU countries need to speed up their transition to the circular growth model.

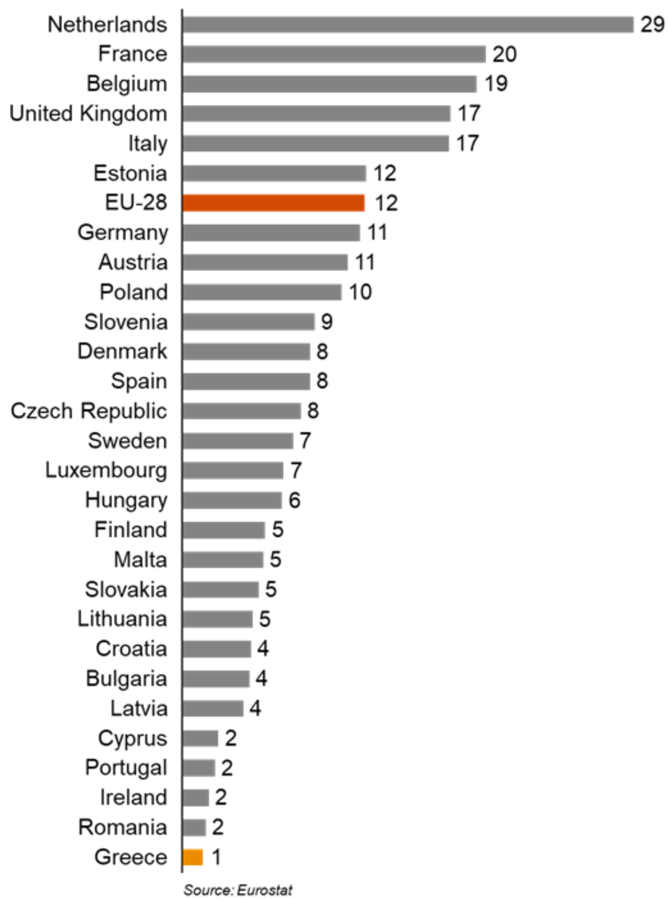

Figure 60: EU Circular material use rate, % of total material use, 2016 – Source: Eurostat, Circular material use rate

[292] European Commission, Circular Economy Action Plan, https://ec.europa.eu/environment/circular-economy/
[293] Eurostat, Circular material use rate, https://ec.europa.eu/eurostat/databrowser/product/view/cei_srm030?lang=en

Case Study: AkzoNobel

AkzoNobel is a global paints and coatings company and a major producer of specialty chemicals. In an effort to make its business more environmentally sustainable, AkzoNobel took action to make its chemicals business more sustainable.

To achieve its objective, AkzoNobel adopted a sustainability-anchored strategy of "more valuable from fewer resources". Through close collaboration with its own customers, AkzoNobel identified a range of emerging sustainable end-market segments that could support the needs of its customers while also increasing the sustainability of tis operations. One major example of AkzoNobel's work in this area is the development of a new coating made from plant-based oils and recycled PET bottles.

As a result of this strategy, AkzoNobel estimates that 30% of its revenues will come from Eco-premium products in 2015. Furthermore, 20 % of the organic materials that AkzoNobel currently uses are bio-based, a share which is set to increase even more in the near future. In doing so, AkzoNobel wants to reduce its cradle-to-cradle footprint by more than 25% to 2020. The success of AkzoNobel's sustainability strategy resulted in its ranking first the 2013 Dow Jones sustainability index in its industry.

Source: http://greenchemicalsblog.com/2013/06/05/akzonobel-solvay-deepen-bio-partnership/

6.5.3 Digital knowledge of total population and industrial workforce

A country's human capital is central to its competitiveness and resilience to ever changing technological landscapes. Ensuring digital skills in the workforce can be a catalyst for growth, however, not doing so could lead to even greater risks. Developing digital skills is the most reliable safeguard against the risk of large-scale automation-driven unemployment. Setting the basis for a highly skilled workforce that can take on the challenges and opportunities of Industry 4.0 is of critical importance for a successful I4.0 transition.

The DESI Index – Pillar 2: Human Capital

The DESI Human Capital dimension captures the level of digital knowledge in the population and workforce, through two subdimensions.[294]

- The 'internet user skills' sub-dimension is computed based on the number and complexity of activities involving employee use of digital devices and the internet.
- The 'advanced skills and development' sub-dimension is computed through a number of indicators that measure the prevalence of ICT specialists in the workforce and ICT graduates.

Finland, Sweden, and Estonia lead the Human capital Dimension, while Bulgaria, Romania, Italy and Greece rank last among all EU member states (see Figure 61).[295]

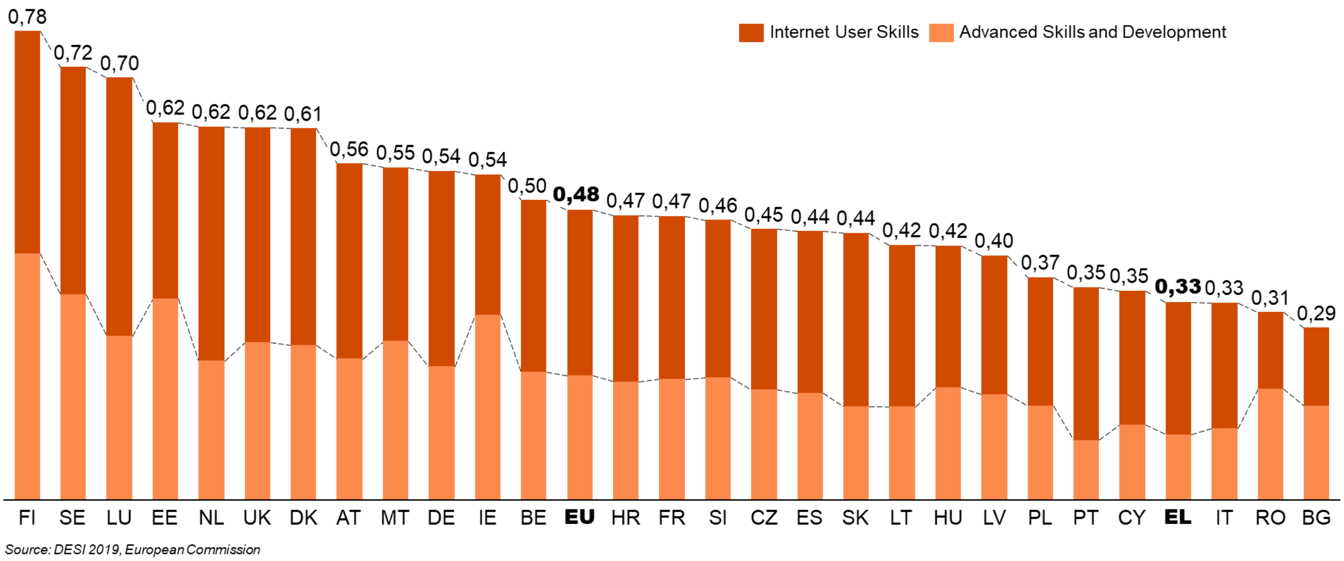

Figure 61: DESI Index 2019 - Pillar 2: Human Capital, EU Rankings - Source: DESI 2019, Human Capital

Luxembourg, the Netherlands and Sweden are the top performers in terms of the "internet user skills" sib-dimension, whereas Finland, Sweden and Estonia have the highest scores in the "advanced skills and development" dimension.

[294] The Digital Economy and Socety Index 2019, Human Capital, https://ec.europa.eu/digital-single-market/en/desi
[295] The Digital Economy and Socety Index 2019, Human Capital, https://ec.europa.eu/digital-single-market/en/desi

In Greece, the population has been slow to adopt digital skills when compared to most EU countries. This is demonstrated by the country's low ranking on the human capital dimension, where the country holds the 25th position for 2019.

An in-depth analysis of the different indicators that comprise the human capital dimension indicates countries' performance and Greece's deficiencies regarding digital skills adoption in the population. This analysis is presented in Appendix I. Below we present the key outcomes of this analysis.

- **Digital Skills in the overall population[296]:** Across Europe, in 2018, the level of digital skills varies significantly. On average, over half (57%) of Europeans have **basic or above** basic digital skills. However, the gap between Luxembourg (85%), the EU leader in digital skills, and Bulgaria (29%), the lowest ranking country, amounts to a skill gap representing more than 50% of the national population. In 2018, 46% of Greeks were reported to have basic or above basic digital skills. In other words, 46% of the population are capable of accessing information, communicating, problem solving, and creating content at a basic level using digital technologies. Specifically, only 46% of people aged 16-74 possess at least basic digital skills, when compared to 57% in the EU. In fact, out of 54% of Greeks without basic digital skills, 31% have no digital competence, while the same number averages just 17% in the EU.

  Looking at the level of **'above basic'** digital skills for 2018, the EU-28 average is significantly lower, at half the levels reported for basic digital skills or above (31%). Moreover, the variation among EU countries seems to be lower and the overall range between the frontrunner (Luxembourg at 55%) and the lowest scoring country (Romania at 10%) is lower than that for overall digital skills at 45 percentage points. Contrary to the EU average, only 22% of the Greek population demonstrate advance digital skills.

- **Digital Skills in the EU Education[297]:** On average, ICT graduates in Europe represent a small percentage of the total number of EU graduates, with only 4% of EU graduates holding ICT-related degrees. Nevertheless, the share of ICT graduates varies significantly among EU member states. Finland, Ireland and Malta lead the EU, with 7% of their graduates having received ICT degrees in 2018. This number contrasts starkly with the European laggards, Portugal and Italy, where only 1% of graduates completed degrees in ICT-related fields. In terms of the number of graduates in science, math, computing, engineering, manufacturing, and construction, EU countries average 18 graduates for every 1000 citizens aged 20-29. In similarity to the percentage of ICT graduates, EU countries demonstrate significant variations along this metric. Ireland leads the European sample with 33 graduates per 1000 citizens in science and engineering-related fields, followed by France at 26 and Poland at 24.
  Greece is positioned well with regards to its ICT and STEM graduates. The country's share of ICT graduates is on par with the average EU country, with 3% ICT graduates, when compared to 4% reported on average in the continent. With regards to the number of graduates in tertiary education in science, math, computing, engineering, manufacturing, and construction, Greece appear also in sync with the EU average, with 18% of Greek graduates pursuing tertiary education in the abovementioned fields. Greece's moderate performance along the indicator demonstrates that the

[296] The Digital Economy and Socety Index 2019, Human Capital Dataset, https://digital-agenda-data.eu/datasets/desi/indicators
[297] The Digital Economy and Socety Index 2019, Human Capital Dataset, https://digital-agenda-data.eu/datasets/desi/indicators

country has the potential of accommodating the human capital requirements of Industry 4.0, which is expected to rely on increasing levels of scientific literacy.

- **Digital Skills in the Workforce[298]:** On average, EU countries report that 20% of their enterprises are currently employing ICT specialists. Ireland is the EU leader at 32%. Followed by Denmark 28% and Belgium 28%. In addition, in 2018, 23% Of European enterprises reported providing some form of ICT skills training. While the front runners report that more than one third of their enterprises provide ICT skills, the first 3 being Finland (38%), Belgium (35%) and Austria (31%), the weakest performers in Europe report significantly lower percentages, with Romania coming last at 4% followed by Bulgaria (9%) and Latvia (10%).

  A contracting picture is highlighted for Greece in this area. In 2018, 22% of Greek enterprises had ICT specialists on their payroll, ranking the country above the EU average (20%). Nevertheless, despite their appetite to employ ICT-oriented employees, the Greek enterprises appear unwilling to further invest in their human capital's digital upskilling. Only 12% of Greek enterprises offered ICT skills training to their employees in 2018, compared to the EU average of 23%. If we turn our attention to the country's industrial workforce, it appears that with only 13% of manufacturers providing ICT training to their personnel, Greece's industry ranks low among its EU peers, nine points below the EU average (EU average 22%). This being said, it is of paramount importance for the Greek Industry, supported by the Greek Public Administration and academia, to intensify their efforts in digitally upskilling and reskilling of their workforce, if not for the digital skills gap between the country and the EU to further widen.

[298] The Digital Economy and Socety Index 2019, Human Capital Dataset, https://digital-agenda-data.eu/datasets/desi/indicators

Case Study: The United Kingdom – Industrial Strategy

Britain's Industrial Strategy will invest 406 million GBP in maths, digital and technical skills in England. The amount includes £84m over the course of five years aiming at the delivery of a comprehensive programme to improve the teaching of computing and drive up participation in computer science. Moreover, the strategy aims at up-skilling 8,000 computer science teachers and work with industry to set up a new National Centre for Computing Education. Additionally, the strategy aims at creating a new engineering university, the New Model in Technology & Engineering, which will offer co-created courses with employers, mandatory work placements of 6-12 months before graduation, and accelerated degrees that allow students to graduate in 2 years. In the field of reskilling, the UK has created a National Retraining Scheme, aiming to help people up-skill and re-skill, with a £64m investment for digital and construction training. The scheme is informed closely by the career learning pilots, whose role it is to test the barriers to adults engaging in learning.

Furthermore, the strategy aims to leverage digital technologies to achieve better results in digital skills training. Firstly, investment of £30m will be made to test the use of AI and innovative education (edtech) in online digital skills courses. Secondly, the British government will utilize new technologies to achieve a better understanding of digital skills gaps in the workforce. Building on the work of Skills Advisory Panels and local Digital Skills Partnerships in England, the government and industry will explore how data analytics can be used to build an evidence base about the skills required by industry, thereby improving the understanding of employer demand for skills.

Source: https://www.gov.uk/government/topical-events/the-uks-industrial-strategy

6.5.4 State of digital infrastructure

In the new digital era, internet connectivity has become a utility, and the rotation to digital is impossible without it. Connectivity drives productivity and innovation and plays a critical role for countries that move towards becoming digital nations. Countries' successful digital transformation is not underpinned only by the provision and access to an up-to-date ICT infrastructure. The high level of ICT usage and the intent to use it effectively are of equal importance for the nation's digital rotation. For these reasons, it is important to review the digital connectivity state of play for the EU member-states, to assess countries' readiness for digitisation.

The DESI Index – Pillar 1: Connectivity

The DESI Connectivity dimension[299] accesses the demand and supply side of fixed and mobile broadband. In the case of fixed mobile broadband, the availability as well as the take-up of basic, fast (at least 30MBps), and ultrafast (at least 100MBps) broadband and domestic broadband retail prices. The dimension also calculates the availability of mobile broadband with one indicator for 4G and one measuring 5G readiness. In more detail, this dimension consists of following sub-dimensions:

- Fixed broadband sub-dimension, that measures the availability as well as the take-up of basic broadband

[299] The Digital Economy and Socety Index 2019, Connectivity, https://ec.europa.eu/digital-single-market/en/desi

- Mobile broadband sub-dimension, that measures the availability of take-up of mobile broadband and 4G coverage
- Fast broadband sub-dimension, that measures the availability as well as the take-up of fast (at least 30MBps) broadband
- Ultrafast broadband sub-dimension, that measures the availability as well as the take-up of ultrafast (at least 100MBps) broadband
- Broadband price index, that measures the domestic broadband retail prices

The Denmark, Luxembourg, and the Netherlands were the European leaders in terms of connectivity in 2019, while Lithuania, Hungary and Greece rank last among their European peers. Specifically, Greece's Connectivity score was 31% lower than the European average and 44% lower than Denmark, the EU leader, which recorded a score of 0,74 in 2019 (see Figure 62).[300]

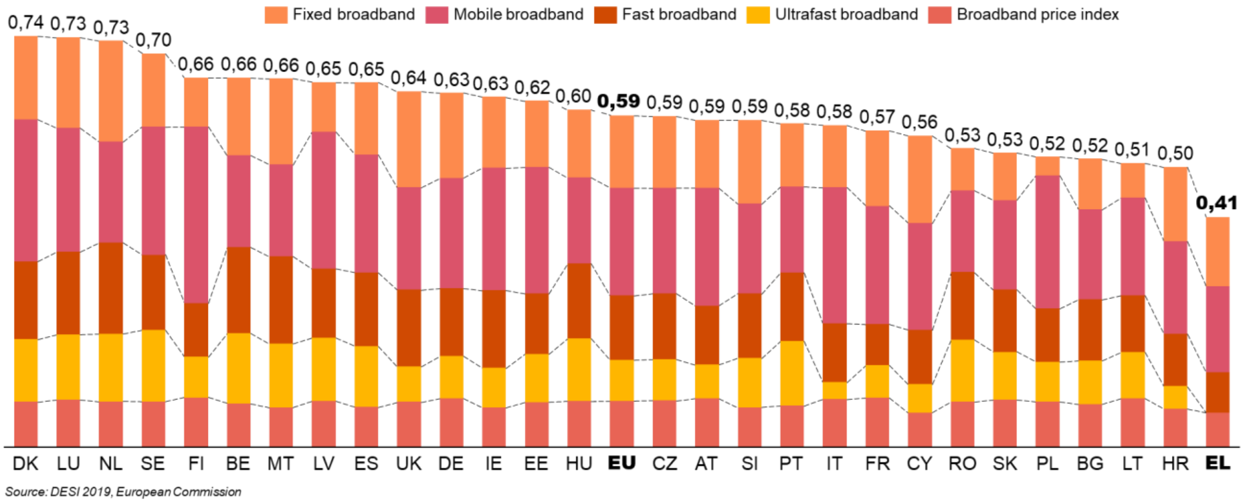

Figure 62: DESI Index 2019 - Pillar 1: Connectivity and its sub-dimensions: Fixed & Mobile Broadband, Fast & Ultrafast Broadband, Broadband price index - EU ranking – Source: DESI 2019, Connectivity

An in-depth analysis of the different indicators that comprises the connectivity dimension is presented in Appendix I. Below we present the key outcomes of this analysis.

- **Broadband coverage for European Member States[301]:** With regards to fixed broadband (basic, fast, ultrafast), the Netherlands and Luxembourg ranked on top of the EU, while Greece, Poland and Croatia were the worst performers in 2019. With the EU at an average level of 97%, more than 10 Member States had a score above 99% regarding their fixed broadband coverage. Nevertheless, the uptake of Next Generation Access broadband was significantly more varied, with approximately 90% coverage among EU leaders (Malta, Netherlands, Belgium) and low-ranking countries like France, Lithuania, Greece and Poland with less than 67% of homes using NGA. These divergences become increasingly more pronounced when comparing access to Ultrafast fixed broadband, where Malta, the Netherlands, and Belgium have more than 90% access, while Greece, at the tail end of the European sample, has 1% Ultrafast fixed broadband access.

[300] The Digital Economy and Society Index 2019, Connectivity, https://digital-agenda-data.eu/datasets/desi/indicators
[301] The Digital Economy and Society Index 2019, Connectivity, https://digital-agenda-data.eu/datasets/desi/indicators

Mobile Broadband coverage was highest in Finland, Latvia, and Italy, with Romania and Hungary scoring the lowest. While more than 70% of all active mobile SIM cards in the EU use mobile broadband, the prices and availability of mobile broadband vary significantly between EU member states. Across the board, countries demonstrating low overall DESI connectivity scores, also have some of the highest internet broadband prices. As such, the prices for the basket of 300 voice calls and 1GB data are cheapest in Italy and Luxembourg (below €10) and highest in Bulgaria (€59) and Greece (€56). Finally, with regards to 5G readiness, Finland ranked first in 2019, with the EU average still with less than 20% of assigned spectrum as a percentage of total harmonised 5G spectrum.

Greece enjoyed a decent broadband coverage as it scored close to the EU average for Fixed broadband in the 2019 DESI Index. When it came to more advanced types of broadband connections however, Greece performed significantly worse than its EU peers. Greece ranked last in the European sample with regards to fast broadband (above 30MBps) coverage and fell significantly behind in terms of ultrafast broadband coverage (above 100 MBps).

Broadband take-up for EU households[302]: Although fixed broadband coverage is provided to 97% of the European households, only 77% of them had a fixed broadband subscription in 2018. The Netherlands, the UK, Luxembourg and Germany appeared to lead the pack in terms of fixed broadband subscriptions, while Bulgaria, Finland, Poland and Latvia demonstrate the lowest take-up rates.

In 2018, 74% of Greek households reported using fixed broadband, placing Greece close to the EU average of 77% households connected to fixed broadband. In terms of fast-broadband access (at least 30MBps), Greece performs significantly worse. In fact, the country was positioned last among EU countries in 2018. Only 11% of Greek households have a fast-broadband subscription, approximately a fourth of the average reported for European households. This indicates that European households have already transitioned towards fast broadband, while Greece is still at the nascent stages of adoption.

- **Broadband take-up for EU Businesses[303]:** The availability of digital infrastructures for doing business has shown significant progress over the past decade in the EU. Indicatively, the percentage of enterprises with a broadband connection has increased by 10%, from 85% in 2010 to 96% in 2017. However, there are still variations in the quality of digital connectivity among EU member states. While enterprises in the Netherlands, Lithuania, Finland and Denmark report 100% access to broadband, the lowest rates of connectivity in countries like Bulgaria (89%), Greece (85%) and Romania (82%) are placed significantly below the EU average (97%). Nevertheless, the performance of EU member states is mixed with regards to fast (30-100MBps) and Ultra-fast (>=100MBps) broadband connectivity among enterprises. Denmark ranked first among all other EU countries in 2018 with 23% and 21% enterprise adoption of 30-100MBps and >=MBps respectively, while Croatia came in last with just 1% of enterprises using fast and ultra-fast broadband.

[302] The Digital Economy and Society Index 2019, Connectivity, https://digital-agenda-data.eu/datasets/desi/indicators
[303] The Digital Economy and Society Index 2019, Connectivity, https://digital-agenda-data.eu/datasets/desi/indicators

Broadband connectivity is just as important for Greek businesses however, the share of Greek enterprises with a broadband connection has remained relatively static over the past decade, growing by just four percent, from 81% in 2010, to 85% in 2017. The slow increase of broadband connections in Greek enterprises is troubling and could be due to several reasons, however decreasing the cost of broadband tariffs and increasing fast and ultrafast broadband coverage in Greece are key actions for promoting broadband adoption. In terms of fast (30-100MBps) and Ultra-fast (>=100MBps) broadband connectivity among enterprises, Greece also performs poorly, ranking 26th out of the 28 countries in the EU sample. Only 5% of Greek enterprises used fast broadband in 2018, compared to 12% of enterprises across the continent. In terms of ultra-fast broadband, with speeds of above 100 MBps, only 2% of Greece's business reported coverage when compared to the EU average of 7% in the same year.

Case Study: The United Kingdom – Voucher scheme to boost broadband connectivity for Businesses

Telecom suppliers offer vouchers worth between £500 and £3000 to local businesses, which can then be used to pay for the installation of gigabit speed connections. The aim of this initiative is to encourage the market to extend full fibre infrastructure across the UK. This is expected to increase demand and to reduce the cost to customers. Key benefits that stem out of a full fibre gigabit connection include:

- allowing businesses to upload and download massive files in a matter of seconds
- enabling the widespread use of videoconferencing throughout an organisation
- allowing businesses in remote communities to compete on an even technology playing field with those companies based in major cities who may already have full fibre connectivity

Minister for Digital Matt Hancock stated: "A world-class digital communications network is essential to ensure the UK's future competitiveness in the global market and its ability to attract investment. Faster and more reliable connections are transforming the way we live and work, and better broadband supports businesses to grow and become more productive. These voucher pilots, alongside a range of other actions, are testament to Government's ambition for full fibre infrastructure across the UK to underpin our digital economy."

This program is part of the government's £23 billion National Productivity Investment Fund aimed at improving productivity. This fund has already earmarked £740 million specifically for improving Britain's digital infrastructure, ensuring that the UK is match-fit for the future.

Source : https://www.gov.uk/government/news/broadband-boost-for-businesses

Case Study: Italy – 5G National Strategy

Italy initiated its 5G strategy in 2016 when the domestic NRA announced the start of a fact-finding survey for the development of mobile and wireless systems towards the 5G and the utilisation of the spectrum above 6 GHz.

In March 2017, the Government selected five 5G trial cities, including Milan (Vodafone), Prato (Wind Tre-Open Fibre), L'Aquila (Wind Tre-Open Fibre), Bari and Matera (Telecom Italia-Fastweb-Huawei Technologies), that will use 100 MHz of 3.6-3.8 GHz spectrum. Provisional licences are valid from September 2017 to 2020.

At year-end 2017, the "Bari-Matera plan" involving MNOs, cities, research centres and equipment vendors was unveiled and began. The 60 MEUR over four years (2018-2021) plan gathers 55 partners including seven universities and research centres, public interest communities, vertical leaders, start-ups and telecom players (TIM, Fastweb, Huawei). The plan focuses on ten application areas including media/virtual reality, smart port, smart city, smart agriculture, public safety, industry 4.0, health 5.0, road safety, tourism and culture, and environmental monitoring over 70 use cases.

Source:https://5gobservatory.eu/public-initiatives/national-5g-plans-and-strategies/#1533565760052-892598e5-15f1

6.5.5 State of integrated eGovernment applications

Digital adoption doesn't come in a vacuum. On the contrary, it also sets as a prerequisite that the Public Administrations of EU countries undertake targeted efforts towards providing transparent, simpler, faster and more user-centric digital services to increase citizens' and businesses' engagement, trust and motivation in the Industry 4.0 technologies.

To assess the Europe's current state with regards to their integrated eGovernment applications, we will use both the 5th pillar of the DESI index, dedicated to the digital public services[304], EU's eGovernment Benchmark 2019 report[305] and a set of additional indexes that demonstrate EU countries' maturity with regards to their provision of eGovernment services and applications.

The DESI Index – Pillar 5: Digital Public Services

The 5th dimension of the EU's DESI Index – Digital Public Services, assesses the quality level of online public administration services for EU member states. The dimension consists of the following sub-dimensions:

- The "eGovernment" sub-dimension that includes: the eGovernment users measured as a percentage of those internet users who need to submit forms to the public administration (the eGovernment users indicator), the extent to which data that is already known to the public administration is pre-filled in forms presented to the user (the pre-filled forms indicator), the extent to which the various steps in dealing with the public administration can be carried out completely online (the online service completion indicator), the degree to which public services for businesses are interoperable and cross-border (the digital public services for businesses indicator) and the government's commitment to open data (the open data indicator).
- The "eHealth" sub-dimension that includes: the percentage of people who used online health and care services without having to go to a hospital or doctors surgery (the e-health services indicator); the extent to which general practitioners are using electronic networks to exchange medical data with other healthcare providers and professionals (the medical data exchange indicator); and the extent to which general practitioners are using electronic networks to transfer prescriptions to pharmacists (the e-prescription indicator).

In 2019, Finland, Estonia, and the Netherlands scored the highest among the EU while Hungary, Greece, and Romania held the last positions in the ranking (see Figure 63). In fact, Greece was positioned at the 27th place among the EU 28, with a score 25% lower than the EU average and 41% lower than Finland, the EU leader.[306]

[304] The Digital Economy and Society Index 2019, Digital Public Services, https://ec.europa.eu/digital-single-market/en/desi
[305] European Commission, eGovernment Benchmark 2019, https://ec.europa.eu/digital-single-market/en/news/egovernment-benchmark-2019-trust-government-increasingly-important-people
[306] The Digital Economy and Society Index 2019, Digital Public Services, https://ec.europa.eu/digital-single-market/en/desi

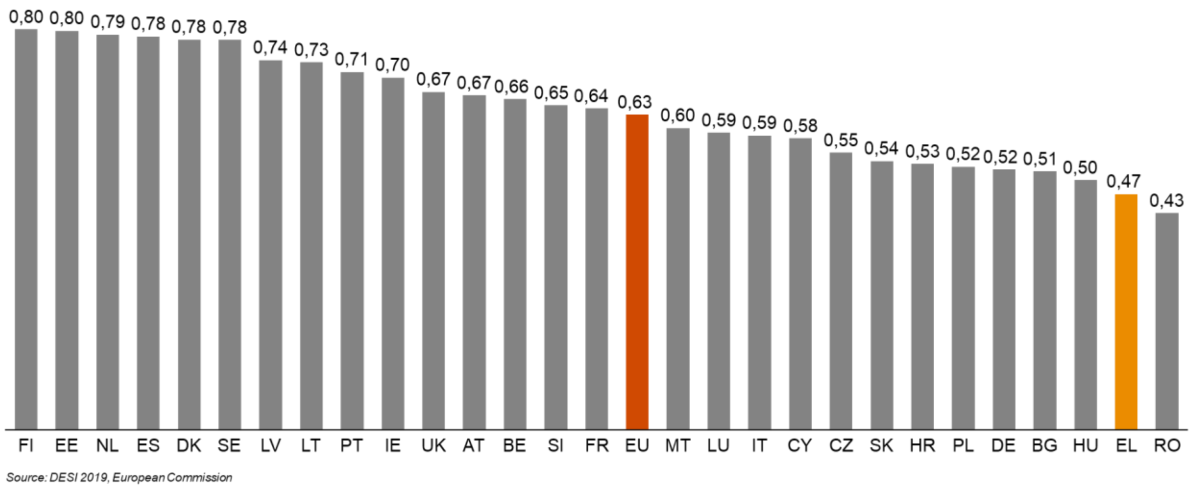

Figure 63: DESI Index 2019 - Pillar 5: Digital Public Services, EU ranking – Source: DESI 2019, Digital Public Services

An in-depth analysis of the different indicators that comprise the Digital Public Services dimension is presented in Appendix I. Below we present the key outcomes of this analysis.

- **Demand of eGovernment applications[307]:** With regards to the demand of eGovernment applications, it appears that a high number of EU citizens used eGovernment services in 2018 (64% in 2018 against 57% in 2017). Sweden, Estonia, Finland and Denmark performed best, with more than 90% of internet users who submitted filled forms to the public administration via governmental portals.

  Focusing on the level of eGoverment use, Greece, performed poorly in 2018, scoring last among all 28 EU countries, with just 36% of Greek citizens submitting forms to public authorities over the internet. Nevertheless, with regards to the Online Service Completion dimension, which calculates the extent to which citizens utilised their country's eGovernment services to complete services online, Greece performed well, scoring 82 points, just slightly below the EU average of 87 points in 2018.

- **Provision of eGovernment services to citizens and businesses[308]:** With regards to the provision of e-government applications and the extent to which the steps required in order to deal with the government can be done completely online, Malta, Portugal and Estonia led the way in 2018, while Bulgaria, Romania and Hungary scored last.

  Looking at the EU countries' economies, the provision of eGovernment public services for their businesses appeared to progress during the last years since it has increased by more than 25% from 2014 to 2018. In 2018, Malta and Portugal were the frontrunners in the provision of eGovernment services to their businesses, while Bulgaria, Romania and Hungary ranked last among their EU counterparts.

[307] The Digital Economy and Society Index 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators
[308] The Digital Economy and Society Index 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators

In terms of the e-government services for businesses, Greece scored poorly, indicating that the country must significantly upgrade its current framework for accommodating the e-government needs. Greece's score was 65 points, 20 points below the EU average.

- **Open Data Use[309]:** With regards to open data use, Ireland, Spain and France were the leaders among EU countries in 2018, while Denmark, Malta and Estonia underperform, scored last. It is important to highlight that countries with lower open data maturity appear to solely focus on modernising their national portals. On the contrary, "mature" open data countries have already established fully functional national portals and now focus on boosting the quality of their open data. On this front, Greece scores moderately well, demonstrating that the government's data is accessible to its citizens to a significant degree.

- **eHealth services[310]:** In terms of eHealth services, more than half of the people in the EU want online access to their medical records, but only 18 % of them used online health and care services without having to go to a hospital or a doctors surgery (for example, by getting a prescription or a consultation online) in 2018. At the same time, more than 40 % of general practitioners used electronic networks to exchange medical data with other healthcare providers and professionals in 2018.

  For Greece the percentage of online health and care services was even lower than the EU average (10% of Greeks used eHealth services in 2018), while approximately 20% of general practitioners used electronic networks to exchange medical data in the same year.

[309] The Digital Economy and Society Index 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators
[310] The Digital Economy and Society Index 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators

7 EU Industry 4.0 strategies and initiatives & Greek Initiatives towards an industry 4.0 economy and society

7.1 Chapter's Summary

To support and accelerate the digitisation of their Industries, Governments all over Europe have architected national Industry 4.0 strategies and adopted relevant initiatives. In this context, we have collected, reviewed and analysed sixteen national strategies & initiatives across different dimensions. Although, every country's plan differs significantly with regards to its strategic focus, key audience, policy design, implementation approach, and funding approaches, there are some common traits and characteristics with regards to how these 16 countries have architected their Industry 4.0 strategies.

1. With regards to countries' Industry 4.0 vision, almost all countries aim to strengthen the country's industrial competitiveness and accelerate its digitisation. Nevertheless, besides their common vision, each country appears to have followed a different approach in architecting, implementing and funding their Industry 4.0 strategies and have avoided the single country imitation.
2. The focus of the designed national Industry 4.0 strategies also varies significantly. In terms of sectoral focus, almost none of the national strategies focuses on specific sectors of their economy for their digitisation. Nevertheless, the concept of enhancing wider areas of economic activity and relevant value chains is highlighted in some of those (i.e. the Portuguese Industry 4.0 strategy).
3. A set of strategies focus their efforts on the implementation and integration of specific Industry 4.0 technologies (i.e. Internet of Things, analytics, etc.)
4. In terms of the audience to which national Industry 4.0 strategies refer to, it is worth mentioning that all countries have designed dedicated incentives for the digitisation of their SMEs.
5. The facilitation of collaboration between industry, research, and public authorities is another major theme met within different Industry 4.0 approaches.
6. While all EU member Industry 4.0 strategies give a clear priority to the deployment and application of Industry 4.0 technologies, there are few strategies that also focus on the R&D enhancement for the development of new technologies (i.e. Italian Industry 4.0 strategy). In addition, Industry 4.0 strategies tend to focus equivalently on the design of digital infrastructure and the implementation of digital technologies as well as on digital upskilling and reskilling.
7. In terms of governance and implementation of their designed Industry 4.0 strategies most countries adopt a top-down approach, with national governments being positioned clearly in the driver's seat.
8. While the major national Industry 4.0 strategies significantly rely on public funding, complementary private investments are also important with the leverage effect being considerable.
9. Most of the Industry 4.0 strategies have been designed recently, therefore limited measurable outcomes have been provided yet, with regards to the progress of their implementation and the enhancement of innovation and integration of Industry 4.0 technologies.

Out of the 16 countries, we applied a structured approach and jointly selected together with the Ministry of Development and Investments three countries that will be used as the leading practices for Greece's Industry 4.0 strategy to be designed: Germany, France and Portugal.

In parallel with national Industry 4.0 initiatives, the European Commission acknowledged the new, tremendous opportunities that Industry 4.0 can bring to the European industry. In this context, it launched the Digitising European Industry initiative (DEI) in April 2016. The DEI initiative introduces a framework for the effective coordination between national and EU-level initiatives and promotes relevant policy actions including investments in digital innovation capabilities. In addition, it focuses on the development of ICT standards, explores the creation of favourable regulatory conditions and promotes specific initiatives for the upskilling and reskilling of the human capital.

A thorough review per DEI pillar enables us to highlight three key areas of focus:

- The initiatives that EU has undertaken across each DEI pillar
- A non-exhaustive list of initiatives that other EU member-states have undertaken across each DEI pillar
- The initiatives that Greece has performed thus far across each DEI pillar

Focusing on the third area of observations, it is again highlighted that Greece has taken sporadic, nascent steps regarding its Industry's digitisation. Nevertheless, the new Greek Government has reinvigorated interest in digital and actively supports the digitisation of the Greek Industry.

- With regards to DEI Pillar 1 "The European Platform of national initiatives on digitising Industry ", Greece has not designed yet a national initiative, dedicated to the digitisation of industry. However, the new Ministry of Digital Governance currently works on the revamping of Greece's national digital strategy.[311] The "Bible of Digital Transformation", expected to be published in the spring of 2020 will include a clear national digital vision as well as the guiding principles that should underpin all national digital initiatives and will align the national strategy with the EU requirements and guidelines, the introduction of a set of strategic pillars accompanied by structured digital initiatives that will aim at operationalizing the Greek digital vision and the definition of a clear Governance Model. This model will require Government representation at the highest level. It will introduce robust accountabilities and clear segregation of duties. This will ensure clarity on execution and an uninterrupted flow of information across the Governance structure.

- With regards to DEI Pillar 2 "Digital innovations for all: Digital Innovation Hubs", Greece demonstrates both areas of strengths and areas of developments. To start with, Greece is currently home to a burgeoning start-up scene. From 2012 to 2016, investment in Greek Start-ups grew by a factor of 18, from 5 to 90 million Euros in annual start-up funding per year in 2012 and 2016 respectively, totalling 250 million in the span of five years.[312] Greece is also home to 14 Digital Innovation Hubs (9 fully operational and 5 in preparation status**Error! Bookmark not defined.**) which cover various market domains within manufacturing such as food processing, basic metals, and textiles, and in other sectoral groups, such as agriculture, fishing and construction. While leading EU innovators such as Germany, the Netherlands and France have a significantly higher number of hubs, with 54, 40 and 41 Digital Innovation Hubs respectively, Greece reports a disproportionately high number of DIHs for a country of its size and digital transformation rankings. Notably, as of 2019, Greece reported more Digital Innovation Hubs than Ireland (11), Portugal (4), Denmark (8),

[311] As per the interview that the project team held with the Ministry of Digital Governance on Monday, 13 January 2020
[312] BCG, The Greek startup Ecosystem - http://www.sev.org.gr/Uploads/Documents/50906/BCG_Greeces_Startup_Ecosystem_Apr_2018.pdf

and Sweden (12), all of which significantly outrank Greece in terms of most digitalisation metrics. While quantity does not necessarily imply quality, Greece's relatively high number of DIHs is a positive indicator of the country's potential and promising track record with regards to efforts at fostering innovation in its industry.[313]

Nevertheless, our analysis surfaced also a set of alarming findings. In more detail, with regards to Research & Development (R&D) intensity, defined as the gross domestic spending on R&D as a percentage of GDP, Greece ranks significantly below its EU peers, at 1,18% in 2018, compared to an EU average of 2,12% in the same year.[314] The overall technological development remains also low, as this is reflected in the very low number of Greek patents compared with other countries. While the EU-28 average was 107 patents per million inhabitants in 2017, Greece reported 8 patent applications, 97% less patents than Sweden, the European leader (283 patents).[315]

The most alarming finding in the innovation field, is the fact that the current Greek R&D investments appear disassociated to applied research and industrial implementation. This is evident from the distribution of the Greek R&D personnel across the different sectors of the economy. Namely, contrary to the EU average, where the business sector appears highly involved in R&D (58% FTE), the Greek R&D is mainly dominated by the higher education sector (46% FTE). This highlights that Greek organisations appear hesitant to invest in research of new technologies, as well as in active experimentation of how these could be implemented to drive new sources of revenues.[316]

- With regards to DEI Pillar 3 "Strengthening leadership through partnership & industrial platforms", Greece appears to have performed limited steps until now. In Greece, research networks are rare and cooperation between the public research, academia and industry has been initiated but remains weak. The same picture holds for Greek clusters. According to the European Cluster Collaboration Platform[317], currently in Greece there are only three clusters. Although no assessment is currently available regarding their effectiveness and key outcomes, judging from the total number of enterprises that participate in these and their percentage of SMEs (both are numbers are very small), it is evident that these clusters currently have limited scale.
- With regards to DEI Pillar 4 "Preparing Europeans for the digital future ", the Greek Government has undertaken some key initiatives for the digital upskilling and reskilling of the Greek human capital. In June 2018, the Greek National Coalition for Digital Skills and Jobs was launched.[318] The Greek Coalition was led by the Ministry of Administrative Reconstruction and included Central Government agencies, Local Government agencies, businesses, social partners and NGOs as its members. In addition, in 2017 the "Alliance for Digital Employability (AFDEmp)" initiative[319] provided a 12 or 24- week intensive training course to previously unemployed candidates with no

[313] Information provided by the Ministry of Development and Investments on the Digital Innovation Hubs on 21/02/2020 via e-mail
[314] OECD Data - https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm
[315] EPO Data - https://ec.europa.eu/eurostat/web/products-datasets/product?code=sdg_09_40
[316] Eurostat Data – Total Research by sector of performance – Full Time Equivalent - https://ec.europa.eu/eurostat/web/products-datasets/product?code=tsc00004
[317] European Commission, European Cluster Collaboration Platform, https://www.clustercollaboration.eu/
[318] European Commission, Greek Digital Skills and Jobs Coalition, http://www.nationalcoalition.gov.gr/
[319] Alliance for Digital Employability, https://www.afdemp.org/

ICT background, in order to reskill and certify them as full stack developers in Java or C#. Candidates. Until today, 97% are hired as entry-level, full-stack developers by top companies.

Although the abovementioned initiatives are considered positive steps, the digital skills gap appears to be a key structural inhibitor for the Greek industry. This is explained by the fact that all initiatives undertaken by the Public Administration, academia, federations and private businesses were fragmented, dispersed and were not underpinned by any common digital skills vision and strategic guidelines. In addition, it appears that there is no structured mechanism in place to measure the effectiveness of the undertaken digital skills initiatives. This leads to lack of and/or wrong information with regards to the real level of digital skills across the Greek society and workforce.

To address these issues, the Ministry of Digital Governance aims to design a new digital skills initiative, the "Digital Academy". Digital Academy will act as the platform that will interconnect all digital skills initiatives, will enable collaboration between the various bodies that provide ICT training and certification, will eliminate overlaps and replications, will provide global expertise and best practices and will enable international collaboration.[320]

With regards to DEI Pillar 5 "A regulatory framework fit for the digital age ", In the previous years the Greek authorities have undertaken a limited number of initiatives to transform Greece's regulatory environment and facilitate the Greek digital economy. These initiatives included the Directive (EU) 2016/1148 for Cybersecurity[321] and the national cloud policy.[322] In the latest months, two initiatives have been taken up by the Greek government in order to simplify and promote the regulatory environment of the country: Law 4622/2019 and the new multibill that seeks to address the growth of the economy and the country at multiple levels.

In addition, during the recent years a set of horizontal efforts have been implemented in order to boost and assist the business environment of Greece. More specifically laws L. 4442/2016 & 4512/2018, have been pursued. Furthermore, in 2019, law L.4442/2016 was supplemented and extended by law 4635/2019, introducing simplification of the standardisation, licensing and supervision processes as well as by Law 4512/2018, which establishes a new framework for the supervision of economic activities and the product markets.

Also, since early 2018, the "Better Regulation Delivery Directorate" of the General Secretariat for Industry has been established in order to act towards the successful implementation of the aforementioned laws. Further to that, since June 2017, the electronic licensing platform "Notify business – notifybusiness.gov.gr" was established. Lastly, in a significant effort to reduce the administrative burdens of enterprises, the new law for electronic one-stop shops (e-OSS) was developed (Law 4441/2016 and MD 63577/2018). All of the above are a positive indication of the

[320] As per interview with the Ministry of Digital Governance held on Monday, 13 January 2020.
[321] European Commission, Cybersecurity Announcement, https://eur-lex.europa.eu/legal-content/EL/TXT/PDF/?uri=CELEX:32016L1148&from=EN
[322] Ministry of Digital Governance, G-Cloud, https://www.gsis.gr/dimosia-dioikisi/G-Cloud

willingness of Greek lawmakers to create a regulatory landscape that will encourage organisations to embrace the newly emerging industrial paradigm.[323]

With regards to the circular economy, the Ministry of Environment and Energy of Greece published in 2018 the Circular Economy Strategy outlining previous efforts on Circular economy until now, the basic strategies and policy axes to be undertaken and 8 main goals to be achieved until 2030. This policy axes included the "effective implementation of prioritisation of waste management, promoting the prevention of creating waste and encouraging re-usage and recycling" and the "promotion of innovative forms of consumptions, such as the use of services instead of purchasing products or the use of electronic computers and digital platforms".[324]

[323] Abstract from documents used for the OECD ECONOMIC SURVEY OF GREECE 2018-2020, provided by the Ministry of Development and Investments on February 21, 2020 via mail.
[324] Ministry of Environment and Energy of Greece, http://www.ypeka.gr/LinkClick.aspx?fileticket=pYSLQXgjjOU%3D&tabid=37&language=en-US

7.2 Review of the national Industry 4.0 strategies

In response to the European Initiative on digitising industry, Governments all over Europe have already adopted initiatives to support the uptake of digital technologies and strengthen their industries. Every country's plan differs significantly with regards to its strategic focus, key audience, policy design, implementation approach, and funding approaches. This section will take a close look at different EU member states' Industry 4.0 strategies and identify the key differences amongst them.

Sixteen national strategies & initiatives for digitising industry have been collected, reviewed and analysed across different dimensions. The development of these national initiatives consists also an important element of DEI Pillar 1: The European Platform of National Initiatives on Digitising Industry (see Figure 64).[325]

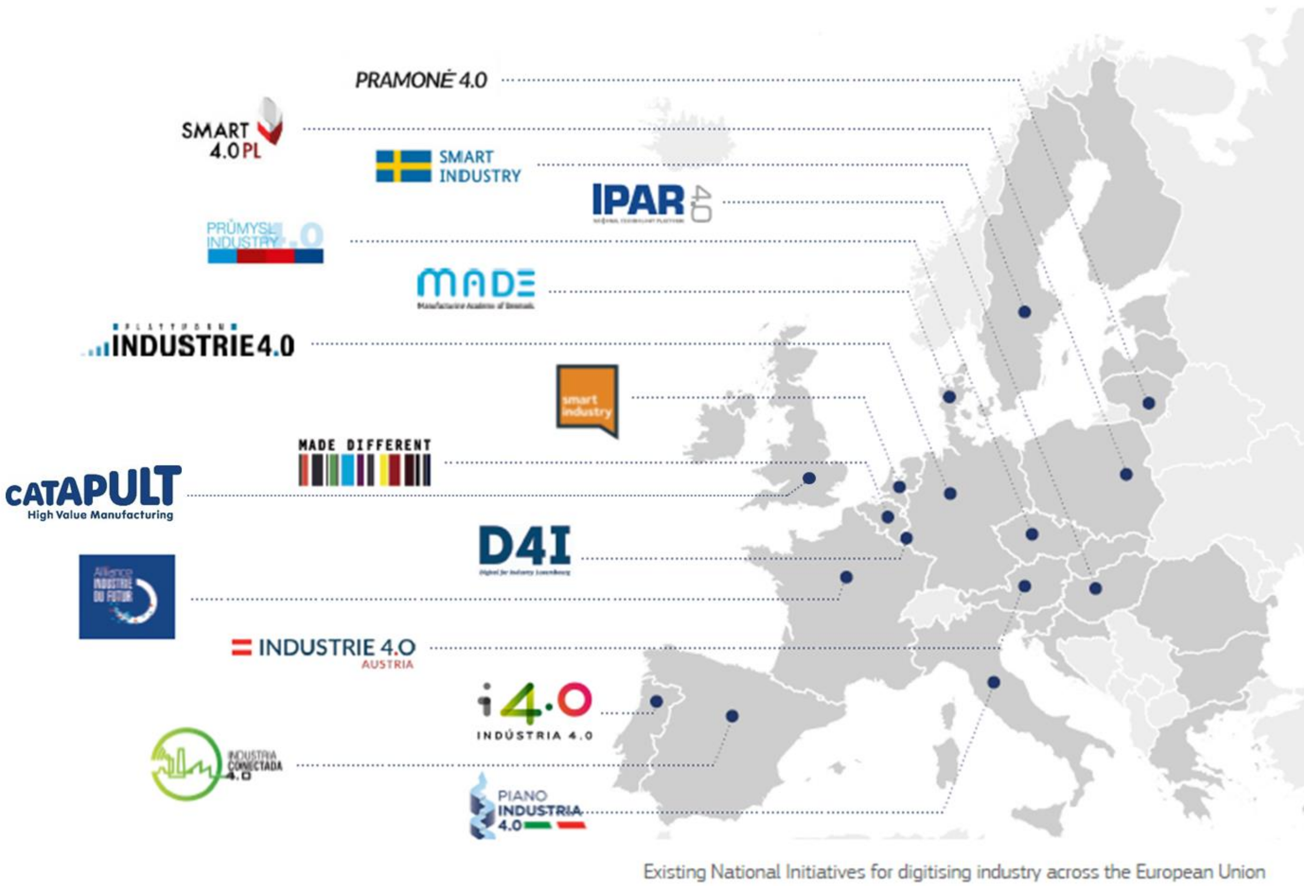

Figure 64: Mapping of National Industry 4.0 initiatives (non-exhaustive) – Source: EU Report, "Digital transformation scoreboard 2018"

[325] Note: Not all initiatives that will be presented below consist national Industry 4.0 strategies. Some initiatives are private-led and although were later supported by the countries' Public Administration, they had a narrower scope and did not horizontaly cover the digitisation of national industries end-to-end.

A snapshot of all reviewed Industry 4.0 initiatives and strategies is presented below, along with their descriptions, and strategic focus.

Country	Industry 4.0 Strategy/ Initiative	Year of Launch	Description	Key Concepts/ Focus Areas	Target Audience
1. Austria	**"Plattform Industrie 4.0"[326]**	2014	Austria's national Plattform Industrie 4.0 (PI4.0) serves as an observatory, network and strategic advisory entity. It also designs working groups, strategies, focus topics and case studies on industry 4.0 topics	Six thematic working groups: (1) Norms and standards; (2) Research, development and innovation; (3) Qualification and skills for Industry 4.0; (4) Regional strategies; (5) The human in the digital factory;(6) Smart logistics.	Companies; research organisations; universities; policy-makers at national and regional level; trade unions; employees' associations
2. Belgium	**"Made Different"[327]**	2013	"Made Different" is an industry-driven strategy and is tasked with organizing events to raise awareness and with delivering custom and long-term counsel services for the transformation of the production processes of businesses	Made Different defines the concept of´Factory of the Future´based on seven key transformations including both technology and social innovation dimensions	Belgian manufacturing companies from all economic sectors, in particular SMEs

[326]Platform Industrie, https://plattformindustrie40.at/?lang=en
[327] Made Different, https://www.abh-ace.be/sites/default/files/Economic_studies/country_study/belgium_made_different_-_industry_4.0.pdf

Country	Industry 4.0 Strategy/ Initiative	Year of Launch	Description	Key Concepts/ Focus Areas	Target Audience
3. Czech Republic	**"Průmysl 4.0"[328]**	2016	A national initiative that aims to strengthen the competitiveness of the Czech Republic utilizing the new opportunities that arise from the Fourth Industrial Revolution	Timely response to the market and industry changes by creating a flexible education system; adapting the labour market and regulatory framework.	Policy makers, private sector, R&D organisations, industry associations, academia
4. Denmark	**"Manufacturing Academy of Denmark (MADE)"[329]**	2014	A national initiative across industries that aims to apply research, empower innovation and enhance education to make Danish manufacturing more competitive	MADE's research and innovation themes are focused on developing and implementing advanced manufacturing and Industry 4.0 solutions in the Danish industry	Danish manufacturing SMEs and larger companies; stakeholders from research / academia. The general focus is on companies, universities and organisations seeking to advance their capabilities and strengthen the Danish manufacturing ecosystem
5. France	**"Industrie du futur"[330]**	2015	"Industrie du Futur" aims to enable businesses to utilize digital technologies, to support transformation of companies and business models and to modernise production practices	Supporting the use of digital technologies, modernising production tools and transforming business models	French industry and production base and in particular SMEs and mid-caps
6. Germany	**"Industrie 4.0"[331]**	2011	Industrie 4.0 aims to strengthen digital	Digital innovation and ICT market;	Manufacturers/producers, SMEs and policy-makers

[328] Průmysl 4.0, http://ricaip.eu/wp-content/uploads/2018/11/Industry-4-0_The-Initiative-for-the-Czech-Republic.pdf
[329] Manufacturing Academy of Denmark (MADE), https://en.made.dk/
[330] Industrie du futur, http://www.industrie-dufutur.org/
[331] Platform Industrie 4.0, https://www.plattform-i40.de/PI40/Navigation/EN/Home/home.html

Country	Industry 4.0 Strategy/ Initiative	Year of Launch	Description	Key Concepts/ Focus Areas	Target Audience
			manufacturing by increasing digitisation and the interconnection of products, value chains and business models. It also works to enhance research, encourage industry networking and increase standardisation	transformation of business models and product/service delivery	
7. Hungary	**"IPAR 4.0 National Technology Platform"[332]**	2016	A national initiative aiming to encourage Hungarian manufacturing and industry transformation by promoting Industry 4.0 technologies and practices	Implementation of the knowledge-economy elements for the digitisation of the industry	Policy makers, private sector, R&D organisations, industry associations, universities, social circles, business
8. Italy	**"Industria 4.0"[333]**	2017	Industria 4.0 introduces uniform measures available to any business, in order to increase investment in new technologies, research and development, and fortify the	Take full advantage of opportunities related to the fourth industrial revolution, promoting investments in innovation, intangible assets and R&D, spreading the culture related to "Industria 4.0"and developing skills	Companies and entrepreneurs, regardless of the size, sector or location

[332] IPAR 4.0 National Technology Platform, https://www.i40platform.hu/
[333] Industria 4.0, https://www.mise.gov.it/index.php/en/202-news-english/2036690-national-industry-4-0-plan

Country	Industry 4.0 Strategy/ Initiative	Year of Launch	Description	Key Concepts/ Focus Areas	Target Audience
			competitiveness of Italian businesses		
9. Lithuania	**"Pramonė 4.0"[334]**	2019	Pramonė 4.0 aims to boost the competitiveness and productivity of industry and to encourage the adoption of digital applications and new technologies	Pramonė 4.0 supports the digitisation of industry, new technologies and standardisation in key strategic sectors of the Lithuanian economy	Industrial companies, enterprises and universities interested in digital solutions and new technologies
10. Luxembourg	**"Third Industrial Revolution Strategy (TIR)"[335]**	2015	The Third Industrial Revolution strategy (TIR) aims to strengthen the country's existing digital capabilities and cement Luxembourg position as a Digital Leader in Europe through a series of strategic collaborations and partnerships.	Develop the data economy through high performance computer capacity, competency centre and pre-emptive workforce skills planning	Public and private stakeholders, particularly industries with significant computational requirements and high numbers of processes/roles suited to automation
11. Netherlands	**"Smart Industry"[336]**	2014	The objectives of the Smart Industry are to strengthen the Dutch manufacturing industry position and increase industrial productivity	Promotion of a network-centric approach to production, building on intelligent and flexible network approaches	Business community in general

[334] Pramone 4.0, https://eimin.lrv.lt/uploads/eimin/documents/files/EN%20versija/Lithuanian%20Industry%20Digitisation%20Roadmap%202019-2030_final.pdf
[335] Third Industrial Revolution (TIR), https://www.troisiemerevolutionindustrielle.lu/wp-content/uploads/2016/11/TIR-Strategy-Study_Short.pdf
[336] Smart Industry, https://smartindustry.nl/wp-content/uploads/2019/04/opmaak-smart-industry.pdf

Country	Industry 4.0 Strategy/ Initiative	Year of Launch	Description	Key Concepts/ Focus Areas	Target Audience
12. Poland	**"Initiative for Polish Industry 4.0 – The Future Industry Platform"**[337]	2016	The Future Industry Platform provides long-term financing to industry initiatives, in order to drive reindustrialisation in Poland. It also provides partnerships, export-oriented support measures and a comprehensive regional development plan.	Raising awareness, competence building, infrastructure development, SME support, actions focused across the manufacturing sector	Public and private stakeholders interested in the field of industrial transformation: mostly SMEs as well as domestic 4.0 solutions suppliers, academia, research organisations etc
13. Portugal	**"Indústria 4.0"**[338]	2017	The Portuguese strategy aims to put Portugal at the forefront of the 4th Industrial Revolution by focusing on 3 axes: digitalisation, innovation and training	Indústria 4.0 supports the development of skills, new methods and digital applications for the Portuguese economy	SMEs
14. Spain	**"Industria Conectada 4.0"**[339]	2014	Connected Industry 4.0 aims to digitise and boost competitiveness of the industrial sector. It identifies eight major obstacles and prerequisites of	Focus on digital enablers, in particular intra and inter-enterprise enablers, with impact areas in employment and competitiveness settings	Enterprises with industrial activity, in particular SMEs and micro-enterprises

[337] Polish Industry 4.0 Platform (PIAP), https://piap.pl/en/2016/10/26/polish-industry-4-0-platform/
[338] Indústria 4.0, https://www.industria4-0.cotec.pt/en/industry-4-0-program/action-plan/
[339] Industria Conectada 4.0, https://www.industriaconectada40.gob.es/estrategias-informes/estrategia-nacional-IC40/Paginas/descripcion-estrategia-IC40.aspx

Country	Industry 4.0 Strategy/ Initiative	Year of Launch	Description	Key Concepts/ Focus Areas	Target Audience
			Industry 4.0 that can be addressed by using digital enablers		
15. Sweden	**"Produktion 2030"[340]**	2013	"Produktion2030" (P2030) was established in 2013 as a strategic research and innovation programme	Sustainable production and delivery as well as flexible, integrated and human-centred production development	Research institutes, universities and companies/ SMEs from industry and service fields
16. United Kingdom	**"HVM Catapult"[341]**	2011	The High Value Manufacturing Catapult (HVMC) aims to increase the competitiveness and value added of UK's manufacturing industry. As the first and largest of eleven national catapults under the programme, the HVMC is composed of seven technology centres. Through these, UK businesses have access to industrial scale technology to accelerate and de-risk new concepts to commercial reality	Enabling innovation and commercialisation. It is focused across multiple industrial sectors and 27 key technology areas	Business, industry and research organisations

[340] Produktion 2030, https://produktion2030.se/en/
[341] HVM Catapult, https://hvm.catapult.org.uk/

The following table presents information on the type of Industry 4.0 initiative (i.e. strategy, funding mechanism, collaborative platform) that each country has introduced, as well as on the responsible party in each country for designing and running the Industry 4.0 initiative.

Country	Industry 4.0 Strategy/ Initiative	Responsible Parties	Strategy	Collaborative Platform	Funding Mechanism
1. Austria	**"Plattform Industrie 4.0"[342]**	Austrian Ministry of Transport, Innovation and Technology		√	√
2. Belgium	**"Made Different"[343]**	Government of Flanders	√	√	
3. Czech Republic	**"Průmysl 4.0"[344]**	Ministry of Industry and Trade	√	√	√
4. Denmark	**"Manufacturing Academy of Denmark (MADE)"[345]**	Danish companies, universities, RTOs, various associations and public and private funds		√	√
5. France	**"Industrie du futur"[346]**	French Government	√	√	√
6. Germany	**"Industrie 4.0"[347]**	Ministry of Education and Research, Ministry of Economic Affairs and Energy	√	√	√
7. Hungary	**"IPAR 4.0 National Technology Platform"[348]**	Ministry of National Economy	√	√	√
8. Italy	**"Industria 4.0"[349]**	Italian Ministry of Economic Development	√	√	√

[342]Platform Industrie, https://plattformindustrie40.at/?lang=en
[343] Made Different, https://www.abh-ace.be/sites/default/files/Economic_studies/country_study/belgium_made_different_-_industry_4.0.pdf
[344] Průmysl 4.0, http://ricaip.eu/wp-content/uploads/2018/11/Industry-4-0_The-Initiative-for-the-Czech-Republic.pdf
[345] Manufacturing Academy of Denmark (MADE), https://en.made.dk/
[346] Industrie du futur, http://www.industrie-dufutur.org/
[347] Platform Industrie 4.0, https://www.plattform-i40.de/PI40/Navigation/EN/Home/home.html
[348] IPAR 4.0 National Technology Platform, https://www.i40platform.hu/
[349] Industria 4.0, https://www.mise.gov.it/index.php/en/202-news-english/2036690-national-industry-4-0-plan

Country	Industry 4.0 Strategy/ Initiative	Responsible Parties	Strategy	Collaborative Platform	Funding Mechanism
9. Lithuania	**“Pramonė 4.0”[350]**	Ministry of Economy, Private Sector, Public Sector	√	√	√
10. Luxembourg	**“Third Industrial Revolution Strategy (TIR)”[351]**	Government of Luxembourg, Public Sector, Private Sector	√	√	√
11. Netherlands	**“Smart Industry”[352]**	Dutch Government, Dutch Industry	√		
12. Poland	**“Initiative for Polish Industry 4.0 – The Future Industry Platform”[353]**	Ministry of Finance and Development, Private Sector, Transformation Team (Ministries Representatives, Agencies, Private Sector & ICT Leaders)		√	√
13. Portugal	**“Indústria 4.0”[354]**	Ministry of Economy, COTEC	√	√	√
14. Spain	**“Industria Conectada 4.0”[355]**	General Secretariat of Industry & SMEs, Private Sector, Public Sector	√		√
15. Sweden	**“Produktion 2030”[356]**	Teknikforetagen, Association of Swedish Engineering Industries, VINNOVA		√	√
16. United Kingdom	**“HVM Catapult”[357]**	UK Government, Innovate UK		√	√

[350] Pramone 4.0, https://eimin.lrv.lt/uploads/eimin/documents/files/EN%20versija/Lithuanian%20Industry%20Digitisation%20Roadmap%202019-2030_final.pdf
[351] Third Industrial Revolution (TIR), https://www.troisiemerevolutionindustrielle.lu/wp-content/uploads/2016/11/TIR-Strategy-Study_Short.pdf
[352] Smart Industry, https://smartindustry.nl/wp-content/uploads/2019/04/opmaak-smart-industry.pdf
[353] Polish Industry 4.0 Platform (PIAP), https://piap.pl/en/2016/10/26/polish-industry-4-0-platform/
[354] Indústria 4.0, https://www.industria4-0.cotec.pt/en/industry-4-0-program/action-plan/
[355] Industria Conectada 4.0, https://www.industriaconectada40.gob.es/estrategias-informes/estrategia-nacional-IC40/Paginas/descripcion-estrategia-IC40.aspx
[356] Produktion 2030, https://produktion2030.se/en/
[357] HVM Catapult, https://hvm.catapult.org.uk/

7.2.1 Key Outcomes from the review of the national Industry 4.0 strategies

The review of the 16 national Industry 4.0 strategies, enables us to derive a set of key outcomes with regards to how these countries have architected their Industry 4.0 strategies. These outcomes shall be used as the guiding principles that will underpin the design of the Greek Industry 4.0 strategy.

1. Countries' Industry 4.0 vision and targets demonstrate significant overlaps. The majority of the Industry 4.0 strategies aim to strengthen the country's industrial competitiveness and accelerate its digitisation, in order to ensure higher growth of their manufacturing sector. In addition, some of the countries have identified additional social and environmental targets that their Industry 4.0 strategy shall aim to achieve (i.e. France aims to enhance sustainability and digital trust through the implementation of their Industry 4.0 strategy).

2. Albeit their common vision, each country appears to have followed a different approach in architecting, implementing and funding their Industry 4.0 strategies. Pre-existing strategies (like the German one) may have been used as the basis for the design of more recent national strategies. Nevertheless, all countries have avoided the single country imitation in designing their strategy.

3. The focus of the designed national Industry 4.0 strategies significantly varies. In more detail, in terms of sectoral focus, almost none of the national strategies focuses on specific sectors of their economy. For example, France, Italy, Belgium and Sweden address their strategies to their entire industry, without specifying any specific sector. Germany narrows down its strategy to the broader field of "industrial manufacturing and engineering" that includes the sectors of logistics, automotive, manufacturing of machinery, etc. Nevertheless, the concept of enhancing wider areas of economic activity and relevant value chains is highlighted in some of those. Portugal declares that sectors of first focus for their strategy shall be the Automotive, Fashion & Retail, Agri-industry and Tourism sectors and the Netherlands suggests that besides their horizontal approach, their strategy shall focus on the High-Tech, the Chemical, Agri-food and Logistics sectors. Nevertheless, both countries propose no targeted initiatives for their select sectors.

4. A set of strategies focus their efforts on the implementation and integration of specific Industry 4.0 technologies. For example, France aims to undertake specific initiatives for the development of their Data Economy and the implementation of the IoT technology within their industry.

5. In terms of the audience to which national Industry 4.0 strategies refer to, it is worth mentioning that all countries have designed dedicated incentives for the digitisation of their SMEs.

6. The facilitation of collaboration between industry, research, and public authorities is another major theme met with different approaches by each member state. France's strategy outlines the creation of a platform that facilitates the collaboration between public and private industry and technology stakeholders, while the Dutch Smart Industry (SI) is grounded on the Triple Helix principle, according to which industry, academia and research partners with the public sector in the agenda setting and the execution of core activities.

7. While all EU member policies designed so far give a clear priority to the deployment and application of Industry 4.0 technologies, the Italian policy plan differs in its focus on using R&D for the development of new technologies to meet the challenges of manufacturing innovation.

8. Moreover, Industry 4.0 strategies tend to focus equivalently on the design of digital infrastructure and the implementation of digital technologies as well as on skills development. For instance, the Swedish initiative introduced the National Graduate School in Production.

9. In terms of governance and implementation of their designed Industry 4.0 strategies most I4.0 EU member state policies adopt a top-down approach. Thus, despite the significance of other stakeholders in most I4.0 initiatives, national governments are clearly in the driver's seat. There are two exceptions to this rule: Sweden and the Netherlands. Sweden's Industry 4.0 initiative places the primary responsibility for its own design and operation on industry, academia, and research groups. The latter are, in turn assisted by significant industrial co-financing. Likewise, the Industry 4.0 initiative adopted by the Netherlands places the responsibility of agenda setting and execution on the public sector, industry, universities and research partners. Nevertheless, both initiatives cannot be considered national Industry 4.0 strategies, as their design have not been initiated by the respective Government and do not provide an overall vision of the path these countries shall follow in the Industry 4.0 era.

10. While the major national Industry 4.0 strategies significantly rely on public funding, complementary private investments are also important with the leverage effect being considerable. However, the volume of the multiplying leverage effect on investment among the examined initiatives is not clearly identified.

11. Most of the Industry 4.0 strategies have been designed recently, therefore no outcomes have been provided yet, with regards to the progress of their implementation and the enhancement of innovation and integration of Industry 4.0 technologies. Nevertheless, some of the countries have recorded thus far quantifiable outcomes. For instance, within IdF in France, more than 800 company loans were provided, whereas the Swedish P2030 funded 30 projects with the participation of over 150 businesses. Meanwhile, Spain has set up an Industry 4.0 innovation and research programme in June 2016, as well as the pilot of an enterprise support programme. It is worth mentioning here, that all outcomes are measured at a national, and not at a sectoral level.

7.3 Best practices on Industry 4.0 within the EU

Having reviewed 16 national Industry 4.0 strategies/ initiatives, our next step was to identify three EU countries that shall be used as best practices for the design of Greece's national Industry 4.0 strategy. The selection of the countries was based on a structured, stepped approach as presented and was agreed with the Ministry of Development and Investments during a dedicated workshop, held on February 4, 2020 (see Figure 65).

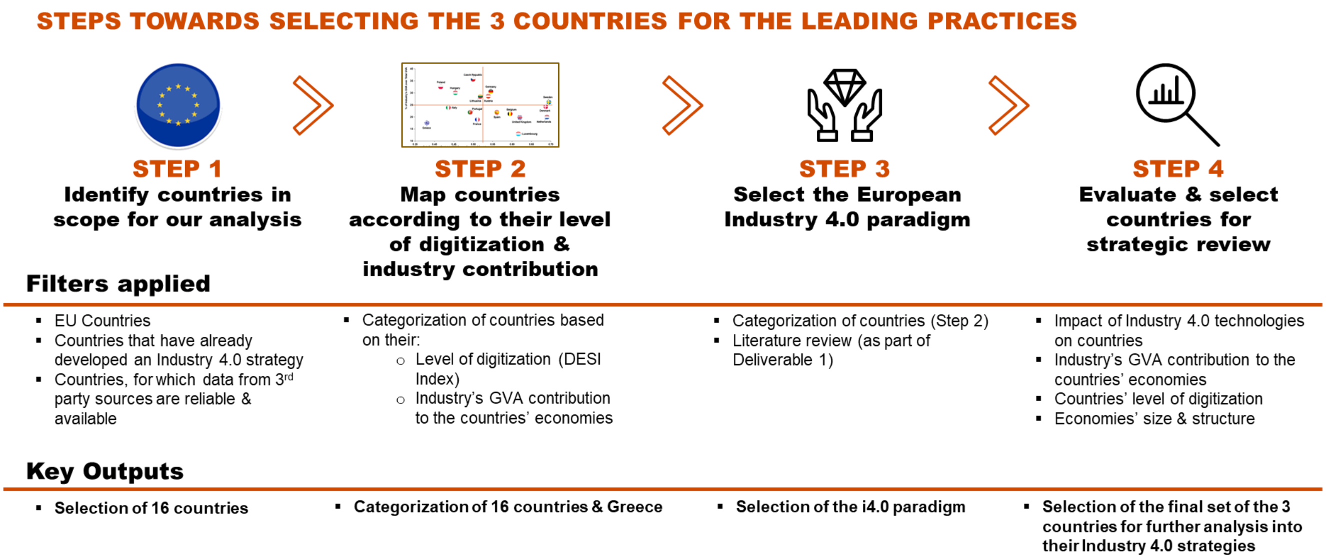

Figure 65: Approach for selecting the three EU countries to be used as leading practices – Source: Accenture Analysis

As a first step, we identified the countries in scope for our analysis. These were the EU countries that have already developed Industry 4.0 strategies/ initiatives and for which 3rd party sources are available and reliable. These countries are indeed the 16 countries that we presented and analysed in the previous paragraph 7.2.

As a second step, we categorized the 16 countries according to their current level of digitisation (countries' DESI score 2019 was used as a proxy for this) and according to their Industry's contribution to their economies (Gross Value Added contribution (%) to the overall Gross Value Added was used as a proxy for this) (see Figure 66).[358, 359]

[358] Eurostat, National accounts aggregates by industry (up to NACE A*64), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_a64&lang=en
[359] The Digital Economy and Society Index 2019, https://ec.europa.eu/digital-single-market/en/desi

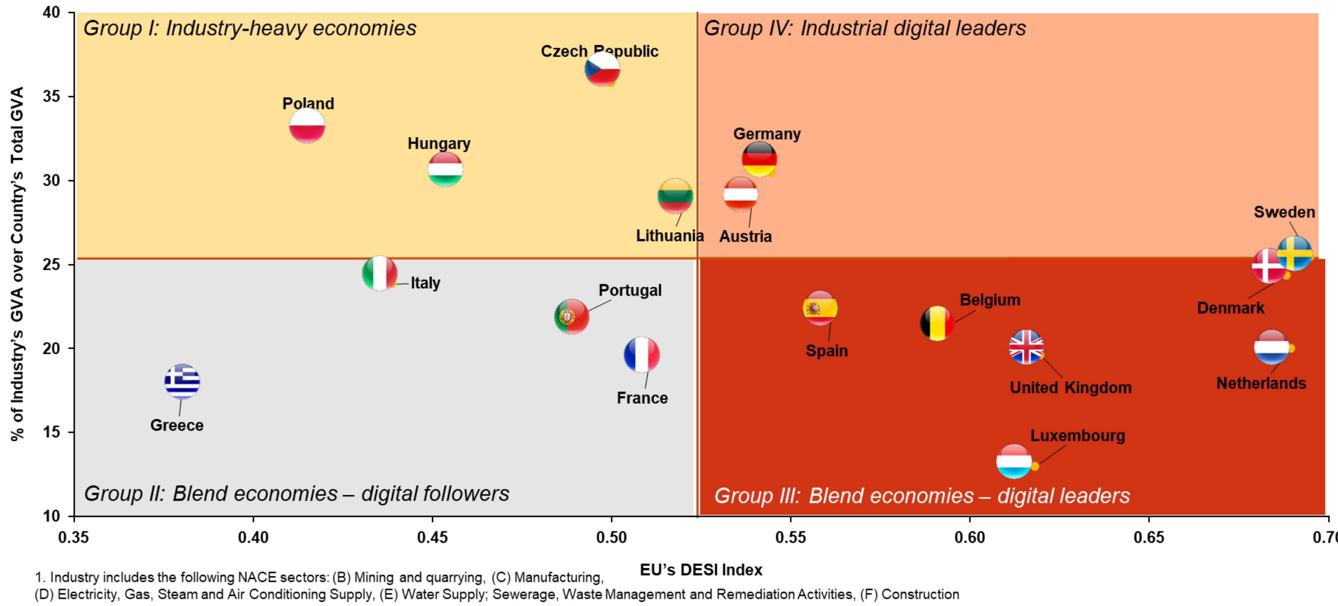

Figure 66: Classification of 17 EU countries according to their level of digitisation and their Industry's contribution to their national GVAs, 2019 (#, %) – Source: Eurostat, DESI Index 2019, Accenture Analysis

Out of this categorisation, four distinct clusters of countries emerge:

- **The Industry-heavy economies:** Countries with industry-heavy economies that demonstrate nevertheless low digital maturity at a national level (Poland, Hungary, Czech Republic, Lithuania).
- **The blend economies – digital followers:** Countries with blend economies (i.e. economies based both on the production of services and goods) that demonstrate low digital maturity at a national level (Greece, Italy, Portugal, France).
- **The blend economies – digital leaders:** Countries with blend economies (i.e. economies based both on the production of services and goods) that demonstrate low digital maturity at a national level (Austria, Germany).
- **The Industrial digital leaders:** Countries with blend economies (i.e. economies based both on the production of services and goods) that demonstrate high digital maturity at a national level (Spain, Belgium, United Kingdom, Luxembourg, Denmark, Netherlands, Sweden).

Having categorized the countries and based on the extensive literature review performed for countries' Industry 4.0 strategies/ initiatives, we first selected the EU country that consists the Industry 4.0 paradigm for all other countries. This is Germany. Germany developed early in 2011 a significant I4.0 initiative (Industrie 4.0), which was used as a guide for many other Industry 4.0 initiatives across Europe that were launched in recent years. It showcases the advantages of a top-down Industry 4.0 design approach, developed by the Government and embraced by stakeholders and actors of the wider business sector of the country.

Having selected Germany, we then co-evaluated a number of dimensions for the remaining countries (i.e. impact of industry 4.0 technologies on each country, countries' industry contribution to their overall economies, countries' economies' size & structure etc.) to identify the remaining two EU countries, that shall consist together with Germany the three leading practices for Greece. The selected countries were Portugal and France.

Portugal was selected due to the fact that it is also a small northern EU country, the structure of its economy is similar to Greece's, SMEs constitute the backbone of the Portuguese economy, and the country demonstrates also a low national digital maturity. Nevertheless, during the last years Portugal has implemented significant Industry 4.0 initiatives for its Industry's digitisation. This could consist a leading example for Greece and it could inspire the country on how it should structure its first digital steps towards Industry 4.0.

Although a much bigger economy, France could also be used as a leading practice for Greece's Industry 4.0 transformation. France's economy is also a blend one, based both on the production of services and goods. At the same time, similarly to Greece, France demonstrates a robust Public Administration, that acted as an enabler for France's accelerated digitisation. Finally, the country has designed and implemented a detailed national Industry 4.0 strategy since 2015 with specific emphasis given both at SMEs and mid-cap enterprises.

In the following chapters, a deeper elaboration and analysis of each of the above case-studies follows.

7.3.1 Germany – Industrie 4.0

Brief description of the initiative/ strategy

Image 1: Industrie 4.0 Logo

Germany was one of the first European countries to recognize the significance of Industry 4.0 as the country's driver for growth in the upcoming years. In fact, Germany's decision to invest in its industrial growth and digitalisation is only logical since it constitutes a global industrial powerhouse, ranking only 4th behind the USA, China and Japan[360].

For that reason, the German state developed and launched in 2011 the "Industrie 4.0" or "I40" initiative. The design and launch of the initiative were the result of the combined efforts of the Federal Ministry of Economic Affairs and Energy (BMWI) and the Ministry of Education and Research (BMBF) of Germany. It is important to note that I40 was also based on the German government's **High-Tech Strategy 2020**, which seeks to materialize innovative ideas and concepts into functional products and services, forging strong links between Industry, academia and the society. Industrie 4.0 has since set the stage for the launch of other many other i4.0 initiatives across the EU.

Key focus areas and main instruments

The initiative of Industrie 4.0 is focused at enhancing industrial knowledge as well as improving the financial and regulatory environment of the industry. The key focus areas are Cyber Physical Systems (CPS) and the Internet of Things (IoT) services. In that context, the strategy aims to integrate in the best way possible all those applications in the operations of Industrial businesses in order to ensure German manufacturing grows and evolves.

This target is pursued by developing recommendations and hands-on actions that can be implemented by businesses or institutionalized by policy makers. The main vehicle to achieve that goal is the "Platform Industrie 4.0" or "Platform I4.0", which seeks to serve as a central point of contact for policymakers and all other related parties. It was developed in 2015 and it "initiates, funds, and supports research and company-

[360] Deutschland.de, Is the industrial giant ready for the future?, https://www.deutschland.de/en/topic/business/is-the-industrial-giant-ready-for-the-future

led projects and test-beds and competence centres for the piloting of production systems", as indicated by the EU's Digital Transformation Monitor.

The platform essentially consists of six discrete working groups, that are comprised of experts from the business sector, various associations and work councils as well as academia members. Their role is to identify key areas for improvement within the German Industry as well as design i4.0 concepts and address them with recommendations and suggested actions. The 6 discrete working groups are presented below:

Working groups (WG) of the Platform Industrie 4.0	
Reference architectures, standards & norms	Technology and application scenarios
Security of networked detailed systems	Legal framework
Work, education and training	Digital Business models in Industrie 4.0

1. **WG1: Reference architectures, standards & norms**

This working group seeks to develop and establish uniform, well-designed and open industry standards, in order to promote interoperability and ultimately allow the ecosystem of businesses work as one.

Among others, the first milestone of the group was to develop the Reference Architecture Model Industrie 4.0 (**RAMI 4.0**). Through the RAMI 4.0 orientation framework, a common set of entrepreneurial and technical requirements in the Industrial internet are set out.

Adding to that, this group has also developed and seeks to roll out what is called "the **Administration shell**". This concept seeks to collect all the available and vital information of a product (physical properties, process values, configuration parameters etc.) acting as a communication interface that allows for true interoperability among the different parties.

2. **WG2: Technology and application scenarios**

This working group seeks to essentially "create the future" of the German Industry. This is mainly achieved by examining Industry 4.0 concepts that might seem far-fetched or "ahead-of-the-curve" in order to make them tangible. To achieve that, it keeps close to the business world and any gaps that may arise in order to research if new technological applications can effectively "fill" them. This ongoing dialogue and identification of relevant trends has helped the WG ten application scenarios relevant for the German Industrial future.

At the same time, it seeks to ensure the spillage of positive externalities among all other working groups through their horizontal networking.

3. **WG3: Security of networked detailed systems**

WG3 seeks to support IT security in all its dimensions (systems, data etc.) in order for companies to be able to safely and freely share their operational, production as well as other data in the context of a true Industry 4.0 environment. This group designs and proposes solutions as well as actionable recommendations that will lead to a secure and connected Industry. The key areas their actions focus at are the following:

- Secure data communications through the right mechanisms
- Identification and authentication
- Integrity and trustworthiness between the interested parties

Adding to their working group sessions held in the lines of the abovementioned, WG3 seeks to engage global experts in a discussion to identify elements for a global common approach regarding IT security. A landmark event of this effort was the "Securing Global Industrial Value Networks - Synchronising International Approaches" international conference held in Berlin in May 2018.

4. WG4: Legal framework

As the title of this working group indicates, it focuses on addressing the “grey areas” or gaps the current legal framework can present due to the rapid changes of the Industrial environment. The objectives of this working group are to maintain legal certainty within the current status quo and at the same time examine what implications/ particularities the industrial revolution can incur.

With regards to their actions, members of this working group are focused in the following key-areas:

- Civil law / civil procedure law
- IT security law / data protection law
- Product liability law / product safety law
- IP law
- Employment law
- Antitrust law

5. WG5: Work, education and training

This working group seeks to involve all players (from employers to employees and entrepreneurs) in the effort to improve proactively the working environment of the evolving Industry sector in Germany.

The epitome of their work was a guide named “Shaping the Digital Transformation Within Companies – Examples and Recommendations for Action Regarding Basic and Further Training”. This guide included recommendations on the acquisition of hard and soft skills from employees regarding i4.0 as well as specific actions for enterprises seeking to promote and boost in-house i4.0 related expertise.

This WG also seeks to create strong bonds and social partnerships among Industry players by inviting key individuals/ companies to “social dialogue” events (at Hannover Messe in 2016, 2017, 2018) in order to inform them of the latest developments and the actions they should take in that area.

6. WG6: Digital Business models in Industrie 4.0

Sixth’s Working Group’s role is to collectively study the direction the industry is moving and the changes that are taking place in order to identify the new business models that are a result of this evolution.

To achieve that, workshops with experts from manufacturing companies, trade unions, industry associations and research institutes are organized and conducted in order to discuss potential business models that will allow companies capture more value and become more efficient within the Digital age.

Implementation approach

As discussed earlier, Industrie 4.0 was initially designed and implemented by the German government the main stakeholders being the Ministry of Education and Research and the Ministry of Economic Affairs and Energy. That being said, the initiative consists a **top-down approach** case. This has allowed from the very beginning and up until today for strong governmental support in the form of policies, strategies and funding.

However, the initiative would have not been that successful had it not been for the active participation of partners from the German Industry, the science sector as well as other social partners. They have significantly helped with the collaboration of all key-actors among the German economy, building strong collaborations for a common way forward. In that sense, after the final report of the Strategy was delivered by the BMBF, the following organisations took the lead and designed Platform I40, which essentially became the main lever for the government designed Industrie 4.0 Strategy:

1. Bitkom, Germany's Digital Association
2. VDMA, Germany's Mechanical Engineering Industry Association and
3. ZVEI, the country's Electrical and Electronic Manufacturers' Association

Supported by various technology programmes, the platform sought to "bring on board" all the different stakeholders from the German Industry in order to achieve synergies. In that effort, although reluctant in joining the platform at the beginning, the German government played later on an active role through political leadership and agenda-setting. Today, the platform run by members of the German government, and directors from Industry, trade unions and scientific research centres, while an Industry-driven Steering Committee is responsible for the development of the initiative's strategy.

Funding mechanism

As far as funding is concerned, the German government has been the main contributor of financial aid towards this ambitious venture. Since 2011 and up until January 2017, the two founding Ministries involved (BMBF and BMWI) have invested cumulative € 200 million. More specifically, 60% of that money has been allocated to research activities and calls for proposals on CPS, IoT and i4.0 appliances as well as funding for testbeds for SMEs. The rest have been invested in work in the area of standardisation and regulation and in research.

Other than the public funding already mentioned, private financing and in-kind contributions do also exist in that scheme, with Industry partners providing an amount of in-kind and financial contributions depending on their status. For instance, it is typical for an SME to fund for (at most) up to 50% of a research project it participates in. The respective amount for larger firms is bigger, since they receive on average less funding than SMEs.

Achieved results

Up until January 2017 and according to the Digital Transformation Monitor of the European Commission, Industrie 4.0 has achieved significant results which are briefly summarized below:

- More than 500 projects have been funded, involving both SMEs and larger firms
- Close to 200 practical examples of I4.0 applications have been identified and implemented
- The Platform has amassed more than 250 members across Industry, academia, research institutions and governmental entities
- More than 100 companies have been engaged in the Platform and the overall effort of the Strategy
- Close to 200 participating experts have participated in thematic groups

7.3.2 France – Industrie du Futur

Brief description of the initiative/ strategy

France's manufacturing sector is the eighth (8th) largest in the world in terms of Manufacturing Value Added (MVA) and the third (3rd) largest in the EU and the country's industrial sector represents almost one fifth of the country's GDP. According to the PwC report "The Future of Manufacturing – France" that was presented in the Global Manufacturing and Industrialisation Summit of 2018, the French industry has undergone a downturn between 2010 and 2016 mainly due to the deterioration of its industrial competitiveness. This can be attributed to a number of factors, one of which has been the low government expenditures on R&D and industrial under-investment in general.

Image 2: Industrie du Future & Alliance Industrie du Futur, Logos

In order to reverse this situation and starting in 2015, the French government has taken important measures towards the digitisation of the Industry, under the umbrella of the ***Industrie du Futur (IdF)*** initiative. Industrie du Future is considered as the second phase of the "La Nouvelle France Industrielle" or "New Industrial France" (NFI) strategy, which consisted of 34 Industrial plans to reshape France's future Industrial policy.

Strategy's key focus areas

Industrie du Futur, being in line with the Digital Strategy of the Government for France, aims to support industrial companies to deploy digital technologies in order to transform their operations as well as their business models, modernising their production practices. It ultimately aims to prepare companies and employees for the Digital age. The initiative of is structured around five key pillars, which namely are the following and are presented in more detail below: Cutting edge technologies, business transformation, training of employees, international cooperation and promotion of IdF, and are briefly presented below:

- **Developing cutting edge technologies** refers to creating the right conditions that will allow companies to develop major projects with regards to Industry 4.0 technologies (i.e. Additive manufacturing, the Virtual plant and the Internet of things, Augmented reality etc.) in order to digitise their operations. Through a network of regional platforms companies have the ability, through test beds, to tinker with i4.0 technologies and train their workforce in how to utilise them.
- The **Business transformation** pillar prioritises industrial SMEs and mid-tier companies (mid-caps) in order to offer them tailored financial and tailored consultation support, offered by a group of

experts, in order to adapt to the new industrial paradigm. Since the beginning of the programme the target for this pillar was set quite high, as it opted to support more than 2.000 companies by the end of 2016. With regards to financial support, tax incentives as well as loans are offered to SMEs and mid-caps in order to urge them to invest in their production line.

- **Employees' training** refers to the upskilling of the industrial workforce in order for them to be ready with regards to the skillset that the Digital era comes along with. This is supported by the launch of interdisciplinary research programmes that seek to fully map what the role of the employee within the new industrial paradigm is. Based on this research, training programmes are designed and rolled out in order to prepare, to the best possible extent, employees with regards to modern ways of operation and interaction with new and advanced technologies.

- **Promoting the IdF programme** is an ongoing effort to build a strong and lasting brand around the French Industry, supported by the creation and launch of flagship projects. In the lines of this, the organisation of "Industry fairs" is pursued across the country with regards to Industry 4.0 and the Digital era, in order to bring together all industrial firms that are involved in this area.

- Through the **International cooperations** pillar, Industrie du Futur seeks to build strategic European and international partnerships with other countries that are advanced with regards to their Digital 4.0 initiatives and policies. This allows first and foremost to achieve cross-nation synergies that will boost the Industry of France in various areas as well as adequately prepare industrial firms for the project calls for "Horizon 2020".

<u>Implementation approach</u>

Although the initial development and roll-out of the IdF programme was led by the French government, this initiative consists a good example of a **bottom-up approach**. This essentially means that its steering relies now mainly on the involvement of key stakeholders coming from more than 33 organisations, being members of the French Industry, technology partners, academic partners and organisations for financing businesses (such as Bpifrance, the French development bank).

The "vehicle" towards IdF's implementation, that connects and helps all the aforementioned parties to cooperate, is the "Alliance Industrie du Future", or the "Industry of the Future Alliance" (IdFA). IdFA is the digital platform launched by IdF, its main objectives being the following:

- **Develop –** Supply technologies of the future to companies and achieve normalisation at an international level
- **Accompany –** Assist enterprises and the human capital of France to prepare optimally in terms of technologies and skills with regards to the new Industrial age
- **Diffuse –** Promote the concept of the "Industry of the Future" and highlight relevant best practices

A differentiating factor that significantly boosts the efforts of IdF and increases their success rate is the regional aspect of the initiative. By putting an emphasis on local communities, regional actors involved can have a tremendous impact and ensure that the pursued measures are implemented in a smooth and structured way, implementing IdF at a local level. IdFA is run by a working programme that comprises of six discrete Working Groups (WG), administered and run by the aforementioned stakeholders/ organisations. These are briefly analysed:

Working groups (WG) of the Alliance Industrie du Futur	
WG1: Development of technologies of the future	**WG4:** Normalisation at international level
WG2: Deployment in companies at regional level	**WG5:** Promotion of existing technology supply
WG3: Humans and Industry of the Future	**WG6:** Showcases of Industry of the Future

WG1 - Development of technologies of the future

Working group 1 consists of experts that seek to promote actions and measures with regards to the integration of modern production technologies in businesses. More specifically, WG1 has identified seven technological themes to focus on, as follows:

- Digitisation of the value chain
- Automation/ robotisation
- Additive manufacturing
- Monitoring and control
- Composites and new material
- Workers in the factory
- Energy efficiency and environmental footprint/ eco-system integration

By focusing on the above areas, the experts involved seek to upscale the operations and production base of industrial companies, modernising the way they perform on a daily basis.

WG2 – Deployment in companies at regional level

This working group seeks to help French companies "make the leap" and become digital, by endorsing and implementing Industry 4.0 applications in their everyday operations. The methodology to identify those companies that consist the target group for this initiative is a three stepped process.

At first, a "diagnostic" is run by the WG's experts in order to classify firms on the degree/ urgency at which they need to deploy such technologies. Next, the selected candidates proceed with experts' coaching in terms of technology identification and method of implementation and finally the financing support follows (more than often to be financed by loans of Bpifrance).

As mentioned earlier, IdF's target with regards to this dimension was 2.000 companies by the end of 2016. The efforts of WG1 were a big success since more than double the estimated number of companies were supported. This can be mainly attributed to the local presence of the Working group in many regions around France, through correspondents and ambassadors.

WG3 – Humans and Industry of the Future

WG3 focuses on the aspect of the Human Capital in the Digital age. This is pursued by developing training curricula on various industrial sectors based on the identified needs of the Digital age, creating specifications around essential skills and competences and also finding way on how to attract the younger generation to engage with and later work in the Industry of the Future.

WG4 – Normalisation at international level

Similar to Germany's working group on "Reference architectures, Standards & Norms", WG4 surfaced the need to focus on four different strategic domains of i4.0 and enhance/ change the current standards. These domains are those of robotic systems for collaboration, additive manufacturing, digitisation and multi-material assembly. This effort seeks to standardise various aspects of these areas in order to achieve interoperability of systems, establishing at the same time a standard way of conducting business in the ecosystem.

This working group joined forces with its German and Italian counterparts in an effort to co-shape and contribute as a common force towards the international industrial standards.

WG5 – Promotion of existing technology supply

This Working Group seeks to promote the French technology providers among all other international technology supplier options. This is pursued mainly through the creation of a special "repository" which contains all the active technology provider players in the French market. This way a "made-in-France" movement is built, resulting in the growth of the French industry to its own products.

This group of suppliers are labelled as "Creative Industry" suppliers and are further advertised and promoted in national exhibitions and international conferences. The companies within this group of suppliers focus on digitisation and control-command applications, production equipment and maintenance services.

WG6 – Show cases of Industry of the Future

Working group 6's main objective is to highlight those companies that constitute an industrial case study for France and should be looked upon by other companies of their field as "role-models". These companies have achieved to modernise their production and achieve digital transformation of their processes and operations, being attributed the title "Vitrines Industrie de Futur". Advertising these companies within the French industry will hopefully lead to the diffusion of good practices and push other companies to also improve and make a difference in their respective sector.

Funding mechanism

With regards to its funding mechanism, Industrie du Futur combines both public and private funds. As far as public funding is concerned, the French state has devoted a significant amount of funds throughout the years.

Up until January 2017, the French government has allocated the amount of approximately €10 billion towards the digitisation of the French industry. More specifically, €550 million have been allocated to the development of technological offerings through calls for projects, while an extra €100 million have been made available for the same purpose for the IdF programme (an extra €150 was programmed for this purpose after 2017). With regards to business transformation and more specifically industrial production, €2.2 billion was offered in the form of loans targeted at SMEs and Midcaps. Further to this amount, the government had budgeted an extra €2 billion to complement the aforementioned budget on business transformation.

Based on the 2017 report of the EC, during the period 2014-2020 €5 billion had been made available in the form of tax aid for investments. Through the Grand Investment Plan (Grand Plan d' Investissement), the French government recognises the importance of the human factor towards achieving industrial digitalisation. For that purpose, a total of €15 billion has been budgeted for the 2018-2020 period. Adding to that, the Grand Investment Plan has also provided new funding equal to €10 billion (€6 billion in the form of subsidies and €4 billion for financing) for the period 2017-2021 with regards to new priorities such as Artificial Intelligence.

Adding to the above, Bpifrance (the French development bank) has a crucial role in this whole process (and more specifically with regards to innovation aid), contributing towards that effort with a budget of approximately €21 billion.

It is crucial to point out that with aside public funding, IdF relies heavily on private funding as well. This essentially means that IdF's public financing tools rely on private funding at an equal, if not greater percentage of contribution (i.e. at least 50% of the investment is financed by the private partner.)

Achieved results

With regards to results achieved, the programme has achieved some initial significant milestones that have been measured in 2017 (by the European Commission as well as other sources), which indicates that measures and actions are on the right path and should continue towards the same direction:

- More than 4100 SMEs have been supported (initial goal was 2000) by 2016 in terms of consultations and financial support/ digitisation of their operations
- At a regional level more than 10 field labs have been developed
- More than 50 lecturers and 15 schools have included in their curricula subjects on Industry 4.0
- A solid network of more than 300 experts has been established, with the potential to increase this number significantly in the upcoming years.

7.3.3 Portugal – Industria 4.0

Brief description of the initiative/ strategy

Image 3: Industria 4.0 Logo

Portugal, same as Greece, has experienced a major economic downturn in recent years due to the global financial crisis. However, the country's overall effort to come out of this crisis spiral has been successful and Portugal's economic recovery is today a fact. Industry in Portugal accounts for almost one fourth of the country's GDP, employing also close to 25% of the country's employees. In an effort to invest in the Portuguese economy and in the lines of the "Portugal 2020" programme (a partnership agreement between Portugal and the European Commission) aiming at the Portugal's growth, its key officials have initiated a concrete and complete Industry 4.0 strategy, called "Industria 4.0".

Key focus areas and main instruments

Industria 4.0 is at its infant steps since it was only launched by the Portuguese government in 2017. The strategy is focused at three main axes, namely **digitalisation, innovation and people's training.** Through the prism of the aforementioned, through the strategy three board "goal categories" are pursued, which are presented below:

1. To encourage Portuguese businesses to become familiar with the concept of Industry 4.0 by providing the business community with the necessary information ultimately transforming the workforce and the way business is conducted within the Industry sector
2. To breed the next "Industrial champions", which essentially means to create a favourable and business friendly ecosystem that will provide favourable entrepreneurial conditions and help already existing businesses grow and improve
3. Turn Portugal into an Industry 4.0 innovation HUB, creating the right conditions and provide the motivation to attract foreign direct investment related to i4.0 applications.

To help these goals materialize, the Strategy is structured around six (6) strategic dimensions, as per below:

1. Human Capital qualification	4. Financing and investment incentive
2. Technological cooperation ecosystems	5. Internationalisation
3. Startup i4.0	6. Standards and regulation

- The "Human capital qualification" dimension seeks to introduce all the current and future i4.0 technologies and appliances within the Portuguese education system, educating the youth about the Industry world of the future. At the same time, it seeks to educate and make the current workforce more potent for the challenges of the future Industry, by effectively upskilling and reskilling them.
- The second dimension, "Technological cooperation ecosystems" seeks to create a strong and interdependent ecosystems of Industry 4.0 businesses. This effort will materialize through the diffusion of the different applications and Industry 4.0 technologies, innovative business models,

new and more efficient ways of operations etc. among companies of the same or different subsectors of the Portuguese Industry.

- “Start-up” i4.0 focuses on creating the right conditions to promote the creation and growth of startups within the Portuguese Industry, as a major driver for the growth of the sector and the economy in general for the future. This dimension is aligned with the National Strategy for Entrepreneurship of Startups for Portugal.
- The fourth dimension focuses on financial aspect of Industry 4.0 in the sense that it seeks to design, create and roll-out the financial instruments and financial support schemes through which Industry 4.0 solutions will be implemented from the businesses of the sector.
- The “Internationalisation” dimension seeks to “export” new Portuguese products, applications and services regarding Industry 4.0 in other countries. This way, investors will appreciate the uniqueness of the products/ applications/ services exported and will therefore be willing to invest in Portuguese companies, thus helping the sector grow exponentially.
- As mentioned earlier, Industry 4.0 brings along with its advantages a whole new set of changes and challenges for the Legal and Regulatory environment. Therefore, the sixth dimension is devoted in address those issues in order to ensure a well-defined and simple legal/ regulatory environment where businesses can operate flexibly and effectively.

For each one of the key dimensions, the Strategic Committee of the Industria 4.0 initiative has come up with discrete measures that will have to be implemented within the 2017-2021 period. In total, 64 measures were developed, which are expected to impact a total of 50.000 Portuguese companies. These measures are expected to result in the digital upskilling and reskilling of approximately 20.000 workers by 2020.

Another important aspect of the Industry 4.0 Strategy of Portugal is the fact that it in order for it to be meaningful and impactful for the economy as a whole, it focused on 4 strategic sectors, namely “Fashion and Retail”, “Automotive”, “Tourism and Agri-food”. Despite that prioritisation of sectors, it is important to note that all actions and initiatives related to Industry 4.0 are horizontal, targeting the Portuguese industry as a whole and do not aim at one specific sector.

According to the Small Business Act 2018 Report from the European Commission, “SMEs are the backbone of the ‘non-financial business economy’ in Portugal. They account for over two thirds (68.4 %) of overall value added and over three quarters (78.0 %) of employment, against an average of 56.8 % and 66.4 % respectively in the EU as a whole”. Based on that, the Industria 4.0 initiative gives a special emphasis on SMEs, providing them with the right tools, knowledge and resources in order to help them transition to the Digital age effectively. In the lines of Industria 4.0, 24 measures/ initiatives have been designed and will be implemented until 2021. Out of those, 10 stand out and are characterized as “Flagship” initiatives, presented below:

Flagship initiative	Description
1. Financing	Mobilizes EU funds to transform Industry enterprises and especially SMEs regarding applications and technologies. Two of its key tools are: ○ “Industria Vale 4.0” which supports SMEs through vouchers of € 7.500 to update and make their business model digital and ○ “PME Investimentos” which represents a line of credit to mitigate risk and support exporters of innovative technologies
2. Digital Skills programme	Addresses the I4.0 skills’ gap of the workforce and aims to upskill and reskill employees at a wide range of competence areas

Flagship initiative	Description
3. Technical courses Industry 4.0	Makes sure that the curriculum of professional technical courses is adequate. At the same time, it seeks to create a “bridge” between the workplace and the education system.
4. Learning factories	Create “digital spaces” that simulate real conditions in an Industry 4.0 factory to train and improve individuals with the needed skills
5. International missions	Develop “exporting committees” responsible for the promotion of the Industry 4.0 offerings developed in Portugal in foreign countries
6. ADIRA Industry 4.0	ADIRA is a national SME company with several projects that seek to develop i4.0 solutions around additive manufacturing (collaboration with other organisations, development of an R&D unit on additive manufacturing, incubator for additive manufacturing etc.)
7. Footure 2020	It combines multiple initiatives focused at the worldwide promotion and recognition of Portuguese products and services of the Footwear, Components, Fur products and Substitutes industry
8. Bosch Digital	This initiative revolves around investments of Bosch on Industry 4.0, and more specifically regarding the development of smart home solutions and digital equipment, safer cities, additive manufacturing of prototypes and tools etc.
9. 4AC Industria 4.0 – Accelerator, Incubator, Prototyping	Collaboration of many international firms (such as Mitsubishi, Siemens, Volkswagen and others) that seeks to assist technology startups to disrupt the status quo and come up with innovative solutions regarding both hardware and software, new products and services etc.
10. Consortium PSA Mangualde	It constitutes a consortium of 3 academic institutions and 5 individual entities (partners) that focus on developing and testing the following: ○ Intelligent robotic systems ○ Advanced inspection and traceability systems ○ Autonomous drive systems ○ Digital factories and “The factory of the future”

One of the main drivers of success for the Strategy is its online platform called “Plataforma Portugal i4.0”. Same as for all the aforementioned initiatives, the platform acts as the main vehicle to achieve all the aforementioned goals. More specifically, it seeks to act as a hub that promotes the cooperation and connection of all involved stakeholders in their respective areas of action. It also seeks to constantly disseminate information about the strategy to key national and international stakeholders and the wider public as well as track the strategy’s progress and achieved results.

Implementation approach

One of the key-success factors for the development of the Strategy was the fact that a “**bottom-up**” **approach** was followed by the Portuguese government. For the total duration of 10 months, the government invited into round-discussions and workshops 113 multinational companies and entities as well as associations, employees from different sectors, science and stakeholders from the political space in order to share their views and ideas to design a complete and realistic strategy to drive the growth of the country.

It is imperative to note that, due to the great collaboration during the design of Industria 4.0, the Portuguese government (and more specifically the Ministry of Economy) launched the digital platform that will support the initiative and passed on its management, a private entity that focuses on advanced technology solutions, cooperation of businesses on innovation issues and spread of technology-related knowledge. The overall re-adjustment/ calibration of the strategy is handled by Strategic Committee comprised by multinational firms that advise the Portuguese government.

Funding mechanism

With regards to funding the initiative is going to utilize a mixture of public and private funding. As far as public funding is concerned, the Portuguese government has planned to invest € 4,5 billion in the 2017-2020 period, that amount stemming from the country's 2020 European Regional Development Fund (ERDF) which "aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions".

It is estimated that approximately €2,25 billion will be allocated in the format of incentives to businesses in order to encourage them to make the leap to the new digital era through technologies, training of their workforce etc. For these incentives various financial instruments will be used, for instance tax deductions, loans, call for proposal, vouchers (as described in the previous chapter) etc.

As far as private funding is concerned, it is considered as a key-success element of the programme since half of the proposed measures under Industria 4.0 will be financed by the private sector. At the early stages of the strategy, a few private funds had already agreed to collaborate with the Portuguese government over this matter.

Achieved results

Due to the fact the Industria 4.0 is still being implemented, not official results have been published by the European Commission in terms of milestones achieved. However, according to the European Commission's "Digital Transformation Monitor 2017", the target goals of the Strategy in terms of results comprise in the following:

- To support 1500 SMEs through Industria Vale 4.0 and have an impact on approximately 500.000 companies across the economy
- Make a bold statement towards the international community regarding the country's goals and aspirations on its Industry 4.0 maturity and growth
- Disseminate i4.0 knowledge across all SMEs and enterprises of the Portuguese economy
- Adequately reskill and upskill the country's workforce.

7.4 Key points and important takeaways

At this chapter, the approaches of different countries regarding their Industry 4.0 strategy at all levels were studied. In order for the i4.0 strategy to be successful, it should encourage and enable enterprises to grow through digitisation and pursue new opportunities. In essence, it should focus on the modernisation of all current enterprises as well as breed the digital champions of tomorrow, enabling them to transition to the digital era and overcome its challenges to come ahead of the global competition. The key points that one should note as the most important takeaways in order to design, implement and govern an i4.0 initiative/ strategy are the following:

1. **Choose the right governance and implementation approach**

At first, one of the most significant European Industry 4.0 initiatives was analysed, that of Germany, which consists a "**top-down**" approach. It was made apparent that if the state strongly supports and takes the appropriate action and policy measures, this can lead to the initiative's success as it enables it to push i4.0 reforms at all levels. However, one could argue that following this approach, keeping the right balance to satisfy the both industrial and sectoral interest can prove difficult.

At the same time, the "**bottom-up**" approach was analysed, and it could prove equally effective, like in the cases of Portugal and Sweden. This approach allows for the initiative to be structured around the actual needs of the Industry and its participants, engaging members of the academic and research world as well. Another upside of this approach is the fact that increasing the interest and engagement of industry players can result in them assisting significantly with the co-financing activities of the initiative, allowing for financial flexibility on the Government's predefined budget. Despite that, in the case that the majority of participants are large corporates, there is always the risk to "overshadow" smaller and medium enterprises and their needs.

We suggest that one should pursue a **collaborative** governance and implementation approach, meaning a strong governmental involvement paired with adequate participation of actors from the industry, academia, research centres etc. is advisable. This will lead to considering all of the key players' needs within the Industry ecosystem, designing a concrete and complete Strategy. At all times, the government should keep the balance between larger and smaller companies' interests, keeping all stakeholders satisfied with the pursued approach.

2. **Setting up an Industry 4.0 Platform**

It is essential that regardless the implementation approach to be followed, the respective digital i4.0 platform is designed and rolled out. This platform will act as the central nod of the strategy and will seek to gather all measures, initiatives and actions in a central point for coordination between the stakeholders responsible for the strategy's implementation.

At the same time, the platform could act as a "knowledge hub" that will disseminate knowledge to businesses, the wider public as well as any other interested party regarding the strategy and its pursued goals as well as Industry 4.0 in general, raising awareness. It could also act as a beacon for attracting and engaging a continuously increasing numbers of businesses and other stakeholders, benefiting the ecosystem multifold.

3. Put emphasis on Digital Skills

A vital aspect of the strategy should be to focus on upskilling and reskilling the workforce of the country to meet the standards of the digital age workplace. Defining what skills are needed in today's digital market should be followed by identifying the digital skills gap that exists for the workforce of the Industry. Doing so, the next action would be to create a series of trainings' curricula as well as engage the right experts to help companies retrain their employees.

At the same time, digital literacy should be added to the education curriculum of the country, allowing for the younger generation to get familiar with digital applications and technologies from a young age. This way, they will be better prepared and equipped with the right knowledge to address the complex needs of the digital age in the future.

4. Financing mechanisms are vital

Having considered the aforementioned, the appropriate financial instruments should be designed in order to assist the implementation of the strategy from a financial point of view. Doing so will allow for optimal allocation of financial resources, making the best use of public and private funds as well as any financing aid stemming from the European Union in the lines of supporting the digitisation of the country.

5. Additional key elements to be pursued

Pursuing all the points made above will set the foundations for the strategy, however they alone cannot guarantee its success. The core team that will ultimately design the strategy will have to consider the particularities of the country's Industry and its overall business environment and economy structure, proposing initiatives and actions that will address them effectively and in a short period of time.

Moreover, a well-designed time plan for the strategy's implementation should be set out, defining each time the responsible party/ parties for the initiative's/ action's implementation. This will create a feeling of ownership and accountability among the key stakeholders, resulting in them acting at the top of their capabilities.

Last but not least, the collaboration with other Industry 4.0 initiatives or digitally mature countries should be pursued. Such a strategic alliance could potentially have a major impact in the overall effort since it would allow for diffusion of expertise and "best-practices", adjusting them to the country's reality and needs, from experts that have already achieved to make a similar initiative succeed.

7.5 The "Digitising European Industry" (DEI) Initiative in the EU and Greece

Industry 4.0 and digitisation open up tremendous new opportunities for the European industry. Approximately a third of the growth of the overall industrial European output can be attributed to digital technologies.[361] Moreover, according to a PwC report, the digitisation of the European Industry will offer benefits that could generate additional annual revenues of € 110 billion for industry in Europe.[362]

In this context, the European Commission launched the Digitising European Industry initiative (DEI) in April 2016.[363] Its goal is to reinforce the EU's competitiveness in digital technologies and ensure that all European businesses can draw the full benefits from digital innovation. The DEI initiative introduces a framework for the effective coordination between national and EU-level initiatives and promotes relevant policy actions including investments in digital innovation capabilities. In addition, it focuses on the development of ICT standards, explores the creation of favourable regulatory conditions and promotes specific initiatives for the upskilling and reskilling of the human capital, to get prepared for the digital transformation. DEI actions are structured around five key pillars, presented below (see Figure 67).

Figure 67: DEI Key Pillars – Source: Digitising European Industry (DEI) Initiative

DEI Pillars	Description
1. European platform of national initiatives on digitising industry	Launched by the European Commission in March 2017, this forum aims to build a critical mass of initiatives and investments for digitising industry, and to ensure the commitment of Member States, regions and private sector to achieve the Digitising European Industry goals.

[361] Estimates by LIFE + series of studies 2016, referred to in COM(2016) 180 final
[362] PWC, Industry 4.0, http://www.strategyand.pwc.com/media/file/Industry-4-0.pdf
[363] European Commission, Digitising European Industry, https://ec.europa.eu/digital-single-market/en/policies/digitising-european-industry

DEI Pillars	Description
2. Digital innovations for all: Digital Innovation Hubs	A Digital Innovation Hub is a place where companies –especially SMEs, start-ups and mid-caps– can get help to improve their business, production processes, products and services by means of digital innovations.
3. Strengthening leadership through partnerships & industrial platforms	To reinforce the EU's competitiveness in digital technologies, the Digitising European Industry strategy (DEI) supports Public-Private Partnerships (PPPs) that develop future digital technology building blocks. At the same time, the European Commission supports partnerships and EU-wide collaborations that foster digital innovation and promote the creation of industry platforms in specific sectors.
4. Preparing Europeans for the digital future	Adapting the workforce and our education and learning systems is a key priority of the Digitising European Industry (DEI) strategy and more broadly of the Digital Single Market strategy.
5. A regulatory framework fit for the digital age	A digital-friendly regulatory framework is important for EU's industry and economy to strive. The Digital Single Market strategy adopted in May 2015 paves the way in this direction with the goal of opening up new opportunities and enhancing Europe's position as a world leader in the digital economy.

In the paragraphs below we will dissect the DEI pillars, present the state of play for EU and Greece, analyse good practices implemented by EU countries and present key initiatives that Greece has already implemented in this space.

7.5.1 DEI Pillar 1: The European platform of national initiatives on digitising industry

The first pillar is the European platform of national initiatives on digitising industry. In March 2017, the European Union launched this platform and the EU coordination forum, in order to build a critical mass of initiatives and investments for the digitisation of European industry, and to ensure the commitment of Member States to the Digitising European Industry goals.

The forum's objective is to add value at a European scale, rather than simply duplicate actions already taken by Member state initiatives. At the moment, the platform builds on and complements the 15 national initiatives currently being implemented across the EU and plans to expand so as to welcome new initiatives as they are being launched. The cross-national coordination between initiatives is at the core of Digitising European Industry.

The main actions undertaken by the forum include identifying challenges that need to be addressed at EU level, sharing experiences and best practices, triggering collaboration and boosting co-investments and exploring common approaches to regulation, skills and jobs.

To facilitate the forum's success, the European Commission has secured the commitment from several groups of Member States towards significant co-investments in EU-wide projects strategic for Europe's competitiveness, such as High-Performance Computing and micro- and Nano-electronics. The DEI strategy facilitates strong stakeholder engagement through high level governance meetings of the European Platform that are held twice per year. These meetings offer a forum for representatives of national governments and initiatives to meet with European Public Private Partnerships, European federations of business, and social associations in order to take stock of progress and identify areas of actions where the EU can add value.

Although every Industry 4.0 strategy is shaped based on each country's own policy challenges, and there is no-size-fits-all approach, it appears that all countries have taken measures in the context of their Industry 4.0 strategies, in order to address the five DEI pillars (see Figure 68).

		AT	BE	CZ	DE	DK	ES	FR	HU	IT	LT	LU	NL	PL	PT	SE	UK
DIGITAL INNOVATIONS FOR ALL	Test – beds				●		●	●	●		●		●	●	●	●	●
	R&I Infrastructure	●	●		●		●	●	●	●		●		●	●	●	●
	DIH	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Clusters		●		●	●	●	●		●	●	●	●		●		●
R&D&I PROGRAMMES	Basic Technology research	●	●			●		●	●	●			●	●	●		●
	Industrial/ Applied Research	●	●	●	●	●	●	●				●	●	●		●	●
	Pilot & Demonstrations	●	●		●	●			●			●	●		●	●	●
	Standardization	●			●		●	●		●	●	●	●	●	●		
	International cooperation	●	●	●	●			●	●	●	●					●	
	R&I PPPs					●				●		●	●			●	●
	Regional level		●		●	●	●	●					●			●	●
REGULATION			●	●	●	●	●	●	●		●	●	●	●	●	●	
DIGITAL SKILLS		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Figure 68: National Actions along the DEI strategy – Source: National Industry 4.0 initiatives, Accenture analysis

Overall the 16 member states have implemented a set of diverse financial measures to promote investments in research, development and innovation. In addition, a different set of financial incentives facilitated the access to capital for organisations across these countries (see Figure 69).

		AT	BE	CZ	DE	DK	ES	FR	HU	IT	LT	LU	NL	PL	PT	SE	UK
INCENTIVES TO INVEST IN R&D&I	Innovation vouchers		●	●	●			●	●		●			●	●		
	Amortization schemes					●		●		●							
	Foreign direct investments measures	●		●											●	●	
	Tax relief	●	●			●	●	●		●	●		●	●		●	●
ACCESS TO FINANCE	Guarantee/ Loan fund						●	●	●	●			●	●	●		
	National innovation fund		●	●	●	●	●	●				●	●	●		●	●
	Venture capital Start-ups support	●			●	●	●	●		●			●	●		●	
PATENTS & IPR INCENTIVES		●	●		●					●	●	●		●			●

Figure 69: National Financial Measures – Source: National Industry 4.0 initiatives, Accenture analysis

A detailed list of financial incentives adopted by Governments to encourage companies' CapEx investments is also presented below.[364]

Measures Incentivizing CapEx investment	
Belgium (Wallonia)	50 measures from Digital Agency for Digital Innovation Grants. €500 million (2015-2020)
Belgium (Flanders)	I4.0-related investment financing (mainly by the government agency Flanders Innovation & Entrepreneurship and strategic research organisations and subsequently by companies). €50million a year.
France	Partial funding through subsidies and sub-loans under the PIAVE (€305m) and SPI (€425 million) initiatives
France	Bpifrance Loans for SMEs over the next two years for companies investing in IdF projects. €2,1 billion
France	"Loans for Industry of the Future", loans to SMEs, from €500,000 to €5m, with at least equal private participation, for a period of 7 years (including two-year deferred capital deferral). €1,2 billion
France	"Projets structurants des poles de competitivite" (PSPC) - Subsidies or advances of 25% to 40% of project costs.
Denmark	Enterprise Partnership for Advanced Production (SME Automation and Digitisation). €5,6 million (2016-2019)
Denmark	Robot Technology Transfer Network - ROBOTT-NET (Dissemination of technology by robotics companies to manufacturing companies). €7,5million (2016-2019) (Horizon 2020)
Spain	Industria Conectada 4.0 Initiative Program (call for €97,5 million in 2016). 0% interest for up to 80% of the project budget, with a minimum project size of €150.000.

364 For a detailed list of sources with regards to national Industry 4.0 strategies/ initiatives please refer to paragraph 7.2.

Measures Incentivizing CapEx investment	
Spain	Subsidized loans under the ENISA credit line for the development of new digital actions. The credit provided requires no guarantees, ranging from €25.000 to €1,5 million and is long-term (4-9 years).
Italy	Coverage of up to 80% of the loan, with a maximum contribution of €2,5 million per company (Public Guarantee Fund).
Italy	Interest payment contribution from 2,75% to 3,57%, for loans of €20.000 to €2 million ("Nuova Sabatini", investment in machinery, equipment and capital goods used in production and digital technologies).
Lithuania	Digitisation of Industry LT, €79,8million (€38,9million from EU investment funds and €40,9million from private equity). 2017-2020
Lithuania	Baltic Innovation Fund: Private equity investment in SMEs with growth prospects (EIF funds and Lithuanian, Estonian and Latvian governments). 2013-2017. €130million (€52million from the EIF and €26million from each of the 3 Baltic countries)
Netherlands	IoF2020: IoT Solutions for Agriculture. €300,000 per project.
Netherlands	Data Pitch: Open, Shared and Closed Data Set. €100,000 per project.
Netherlands	MIT (SME Innovation Stimulation Region and Top Sectors): Supporting SME innovation locally. €16,2 million
Netherlands	VFF: Loans for SMEs and start-ups for initial financing (interest rate: 4,82%).
Poland	Polish Development Fund PFR ventures: Investing in start-ups. Funds the "Start in Poland" program for new, innovative businesses. Project funding: from €50,000 to €15 million.
Portugal	Specific alerts I4.0: Announcements for I4.0 projects, with mobilisation of funds up to €2,26 billion through various incentives
Sweden	ESIF: Investment in ICT (rural areas, high-speed broadband, eProcurement, open data, etc.). €278,5 million Period depending on project duration and total investment.
Sweden	Venture capital to finance start-ups and high-risk projects through Almi Invest and SamInvest tools

The State of Play in Greece

Contrary to the 16 EU countries that have already implemented Industry 4.0 strategies, Greece has not designed yet a national initiative, dedicated to the digitisation of industry.

In fact, a structured approach for Greece's digital transformation was introduced in 2016 by the Ministry for Digital Policy, Telecommunications, and Media and the design of the Greek National Digital Strategy (NDS) (2016-2021).[365] As also confirmed by the Ministry of Digital Governance through the performed meetings[366], although the establishment of this Ministry and the design of the National Digital Strategy was a first step towards the right direction, it did not provide the expected outcomes. This was mainly due to the fact that the National Digital Strategy 2016 – 2021 set a high level a set of guiding principles that should govern Greece's digital transformation, instead of proposing a concrete strategy and a structured action

[365] Ministry o Digital Governance, Digital Strategy 2016-2021, http://www.mindigital.gr/index.php/κείμενα-στρατηγικής/220-digital-strategy-2016-2021
[366] As per the interview that the project team held with the Ministry of Digital Governance on Monday, 13 January 2020

plan that would engage all responsible stakeholders for the country's digital transformation. In addition, the National Digital Strategy did not address the digitisation needs of Greece's economic sectors; therefore, provided limited digital initiatives towards this direction. Finally, the lack of a structured governance mechanism, with clear and allocated set of accountabilities and responsibilities amongst the different parties, led to a weak level of coordination between the various ministries and stakeholders.

In summer 2019, with the change of the Greek Government the Ministry for Digital Policy, Telecommunications, and Media was transformed into the Ministry of Digital Governance. The Ministry of Digital Governance is now coordinating activities with all other ministries, government agencies, and bodies, to ensure interoperability at all levels e.g. devices, networks, data repositories, services, people, sectors, authorities, communities. Its strategic target is to develop the necessary framework in order to contribute to the establishment of the inclusive Digital Single Market at European level and enable citizens and businesses in Greece to truly benefit from interlinked and multi-lingual e-services. In addition, the new Ministerial team, acknowledging the deficiencies of the National Digital Strategy 2016 – 2021, is currently in the process of re-writing Greece's national digital strategy.[367] The "Bible of Digital Transformation", expected to be published in the spring of 2020 will include:

- A clear national digital vision as well as the guiding principles that should underpin all national digital initiatives and will align the national strategy with the EU requirements and guidelines
- The introduction of a set of strategic pillars accompanied by structured digital initiatives that will aim at operationalizing the Greek digital vision. The suggested digital initiatives will address both horizontal needs (i.e. digital infrastructure and digital skills), as well as vertical requirements across specific economic areas (i.e. Agri-Food, Justice, Transportation, etc.)
- The introduction of a clear Governance Model. This model will require Government representation at the highest level. It will introduce robust accountabilities and clear segregation of duties. This will ensure clarity on execution and an uninterrupted flow of information across the Governance structure.

Besides Greece's national digital strategy, the country participates in several European digital initiatives, since cross-border collaborations are crucial for the digital transformation of the Greek economy. The key initiatives that Greece participates in or has announced its participation are the following:

- Greece's participation in November 2017, as the 12th country member in the European effort for building the next generation of computing and data infrastructures by signing the High-Performance Computing declaration (the EuroHPC declaration).[368]
- The Declaration for the European Blockchain Partnership (EBP) signed by Greece in May 2018.[369] This is a European Commission initiative, with the aim to ensure the active participation of all Member States in the fields of ICT, Blockchain, Distributed Ledger Technologies.
- The Declaration of cooperation on Artificial Intelligence, signed by Greece in May 2018. This is a European Commission initiative, with the aim to ensure the active participation of all Member

[367] As per the interview that the project team held with the Ministry of Digital Governance on Monday, 13 January 2020
[368] European Commission, Greece signs the European declaration on high-performance computing, https://ec.europa.eu/digital-single-market/en/news/greece-signs-european-declaration-high-performance-computing
[369] European Commission, European countries join Blockchain Partnership, https://ec.europa.eu/digital-single-market/en/news/european-countries-join-blockchain-partnership

States, in a key technology that is expected to become a key driver for economic growth through the digitisation of industry and for society as a whole.[370]

- Also, in May 2018, Greece signed with Bulgaria and Serbia the 5G cross-border corridor initiative. This collaborative network between the countries will enable a better environment for the testing and deployment of the 5G technology, allowing connected automated driving to be tested across borders.[371]
- During December 2018, Greece signed with Cyprus, France, Italy, Malta, Portugal and Spain the Southern European Countries Ministerial Declaration on Distributed Ledger Technologies, that is expected to lead to enhancement of eGovernment services but also increase transparency and reduce administrative burdens and lead to better customs collection and better access to public information.[372]
- Greece is also a member of European Space Agency (ESA). The Greek government, in order to fully exploit the benefits of its participation to ESA and potential spill overs to many sectors of the economy (ICT infrastructure, medical applications, environmental monitoring etc.) established during 2018 the Hellenic Space Agency (HSA), with the mission to shape the country's space strategy and to promote the participation of Greece in space programs.[373]

Although it is too early to assess the benefits of the country's participation in the above initiatives, it is expected that they will enhance the digital capabilities of the public and private sectors and will lead to the dissemination of advanced digital technologies across many sectors of the economy, creating new business opportunities. Additional information on the policy measures undertaken by the Greek Public Administration is presented in Chapter 8.

[370] European Commission, EU Member States sign up to cooperate on Artificial Intelligence, https://ec.europa.eu/digital-single-market/en/news/eu-member-states-sign-cooperate-artificial-intelligence
[371] European Commission, New 5G cross-border corridor for connected and automated mobility announced at the Digital Assembly 2018, https://ec.europa.eu/digital-single-market/en/news/new-5g-cross-border-corridor-connected-and-automated-mobility-announced-digital-assembly-2018
[372] Lexology, Seven EU countries gather force to push blockchain adoption, https://www.lexology.com/library/detail.aspx?g=3dc1e580-862c-4a4d-81ae-7f32bb24b5e5
[373] European Space Agency, https://www.esa.int/Space_in_Member_States/Greece/Kalosorhisate

7.5.2 DEI Pillar 2: Digital innovations for all: Digital Innovation Hubs

The second pillar of the DEI strategy refers to the promotion of innovation through Digital Innovation Hubs (DIHs). Their role is to help ensure that every company, regardless of size or level of digital maturity, can grasp the emerging digital opportunities. DIHs have research centres and universities at their core. SMEs, start-ups and mid-caps can take advantage of Digital Innovation Hubs to improve their business, production processes, products and services through digital innovations. The research and technology centres or innovation-oriented university departments focus on the main needs of the region in which they operate, while collaborating with DIHs from other regions when required.[374]

DIHs can act as one-stop-shops where companies can get the following services:

- Access to digital technologies and competences
- Infrastructure and training to test digital innovations
- Financing advice
- Market intelligence
- Networking opportunities

A total investment of €100 million per year within the Horizon 2020 programme will continue supporting DIHs until 2020.[375] Through this funding for the last five years (2016-2020) major accomplishments have been achieved. Namely:

- Support was provided to more than 2000 Start-ups, SMEs and mid-caps to test digital innovations in collaboration with more than 200 Digital Innovation Hubs networked across the European Union. Five flagship DIHs are presented in the vignette on the right
- 13 EU countries included Digital Innovation Hubs in their national digitalisation strategies. More are preparing to do so.
- Coaching was provided to more than 60 potential Digital Innovation Hubs in regions with slower adoption of digital technologies, with focus on Central and Eastern Europe.

In order to create a strong network of Digital Innovation Hubs the EU has also published the European catalogue of DIHs that includes more than 200 existing operational hubs.[376] In the future,

Indicative Networking Digital Innovation Hubs

ICT Innovation for Manufacturing SMEs

ICT Innovation for Manufacturing SMEs (I4MS) is an initiative designed to support the adaption of innovative ICT in Europe's manufacturing SMEs.

Smart Anything Everywhere (SAE)

SAE is an initiative aiming to accelerate the design, development and uptake of advanced digital technologies by European industry, SMEs and mid-caps.

European Coordination Hub for Open Robotics Development (ECHORD++)

The robotics research project ECHORD++ will promote the interaction between robot manufacturers, researchers and users by facilitating the cooperation between academia and industry.

Access Centre for Photonics Innovation Solutions and Technology Support (ACTPHAST 4.0)

ACTPHAST is an initiative supporting cross border collaborations to support photonics innovation

Supercomputing Exercise for SMEs (SESAME NET)

SESAME NET is an initiative aimed at facilitating access to and the utilisation of High-Performance Computing (HPC) services by industrial players especially the SMEs.

Source: https://www.effra.eu/i4ms-ict-innovation-manufacturing-smes , https://diatomic.eu/index.php/sae/, http://echord.eu/, https://www.actphast.eu/en, https://grnet.gr/en/grnet_projects/sesame-net/
[1] https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs
https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-catalogue

[374] European Commission, Digital Innovation Hubs in Europe, https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs
[375] European Commission, Digital Innovation Hubs in Europe, https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs
[376] European Commission, Digital Innovation Hubs Catalogue, https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-catalogue

this catalogue could also be used for sharing best practices and gather information about the expertise and support facilities offered across Europe.

The Digital Innovation Hubs pillar is expected to continue having a pivotal role in the European Multiannual Financial Framework for 2021-2027, in order to ensure the wide accessibility of Industry 4.0 technologies across all key stakeholders of the EU member states.

In more detail, the following countries have undertaken the following measures for supporting and enhancing their national Digital Innovation Hubs.[377]

Digital Innovation Hub Measures	
Austria	Operation of innovation hubs, consisting of research centres (Salzburg Research, Know Centre Graz, etc.). Part of them is funded by the COMET program.
Germany	Development of nodes to enhance business collaboration and start-ups. Since the launch of the initiative in 2016 to date, nodes have been operating in 12 areas.
UK	Implementing the High Value Manufacturing Catapult (HVMC) program, based on the operation of the Catapult Centres network. The network, being a public-private partnership, has been set up, supervised and funded by the Government Innovation Agency (Innovate UK). There are currently 7 Catapult Centres in operation.
Spain	As part of the national cluster strategy (annual investment of €11m), the work of the relevant Working Group was launched in May 2017. Intention to create nodes through public-private investment.
Italy	100 node network development
Lithuania	“Advanced Manufacturing Digital Innovation Hub Initiative” and “Virtual Engineering Industry Competition Centre” (VIPKC) under the direction of LINPRA - Node in IIoT, 5G and SMART SA under the direction of INFOBALT - Node in Digital Robotics Systems under the direction of Lithuanian Robotics Association.
Netherlands	Future Fund: a funding tool for the development of the Field Labs network of laboratories and innovative SMEs, since 2018 it grants €5 million a year (initial capital: €200m).
Poland	3 Innovation Nodes - 5 additional nodes have been designated by the Ministry of Economic Development.
Sweden	Operation of competence centres, e.g. CENIIT, FindIT, ProcessIT Innovations et al.

Over and above the Digital Innovation Hubs, additional actions taken by EU member states enable the applied Research & Development and facilitate strong ties between business, research institutes and academia (“triple helix”). Some of these are presented in the table below.[378]

Measures to foster investment in Innovation and R&D	
Austria	R&D tax deduction from 10% to 12% in 2016 (€628 million) and 14% from 2018.
Austria	Public funding of research €185 million / year.
Austria	Production of the Future €20-25 million / year.
Belgium	Tax reduction from 30% to 45% for start-up investments, up to €100.000.
France	Tax incentives for companies investing in the production line over the next 12 months. €2,5 billion
France	Tax rebates (30%) for R&D projects up to €100 million
France	Accelerated depreciation for IdF investments at 140% of value, or reduced depreciation period of 2 instead of 5 years.
Denmark	22% tax reduction on investment in R&D activities.
Denmark	Financing Strategic Research, Technology Development and Innovation Activities €215 million (2015)

[377] For a detailed list of sources with regards to national Industry 4.0 strategies/ initiatives please refer to paragraph 7.2.
[378] For a detailed list of sources with regards to national Industry 4.0 strategies/ initiatives please refer to paragraph 7.2.

Measures to foster investment in Innovation and R&D	
Denmark	Development and sale of new technologies intended for businesses, mainly SMEs. Danish Technological Institute: €54,5 million (€8,5 million for I4.0 projects) - Force Technology and DELTA: €16,5 million and €12,63 million respectively (€7,4 million overall for projects with I4.0) - Alexandra Institute: €6,8 million (€4,5 million for projects with I4.0)
UK	Tax deduction of 12% from 1.1.2018 for large companies engaged in R&D, or for SMEs and large companies that have been subcontracted by large companies.
UK	Opportunity for SMEs to deduct an additional 130% of their eligible costs from their annual profit, as well as the normal 100% deduction, to receive a 230% total deduction.
Spain	€100 million R&D Investment Program in I4.0 - €80million Supplemental Program by AEESD to develop projects in the areas of IoT, big data, cloud, HPC, additive manufacturing etc.
Italy	50% tax deduction (from 25% today) for additional R&D spending, with a maximum of €20 million per beneficiary per year (from €5 million today).
Italy	Over-depreciation: Increases depreciation rate for investments in I4.0 technologies from 140% to 250%. Super-depreciation: 1-year extension with a fixed rate of 140% for investment in I4.0 technologies (tangible and intangible).
Italy	50% tax deduction on income derived from the use of intangible assets.
Italy	10% tax rate on productivity bonuses (maximum amount: €4.000).
Italy	30% tax deduction for investments up to €1million in innovative start-ups and SMEs.
Lithuania	National R&D Program, Subsidizing Business Investment for New Product Development (2015-present). Two programs: a) New, innovative businesses: maximum funding €400.000. b) Mature, innovative enterprises: maximum funding €4,4 million. Total budget: €100 million (30 million for start-ups, 70 million for mature businesses).
Lithuania	R & D investment assets depreciated at 200% since 2008.
Netherlands	WBSO Tool (implemented since 1994), with a budget of €1,2 billion per year (2/3 of which are SMEs). Exemptions: a) 32% for labour costs up to €350.000 per year and 16% for a higher amount, b) for start-ups: 40% up to €350.000 per year and 16% for a larger amount.
Netherlands	Eurostars Netherlands: SME Grants for International R&D. €19million per year.
Poland	R&D tax deduction: at least €1,2million of annual project allocation come from sales of goods, products and financial services, at least 20% of which come from R&D services or industrial property rights. In this case: exemption from real estate taxes levied on R&D, set up by the innovation fund company with a monthly reduction of no more than 20% of revenue.
Poland	Since 1.1.2017, taxes on intellectual and industrial property have been permanently abolished
Poland	The maximum reduction in eligible R&D spending has increased. For small businesses and SMEs, reductions are up to 50%, while for large businesses up to 50% for employee expenses and 30% for other R&D spending.
Sweden	Reduced contributions for employees engaged in R&D work, amounting to 10% of their salary.

The State of Play in Greece

In order to better evaluate Greece's performance across the 2nd DEI Pillar, we will review Greece's innovation landscape, its R&D state of play, the as-is situation of its start-up ecosystem and we will conclude with actions performed with regards to fostering Digital Innovation Hubs in Greece.

Greece's innovation landscape

The European Commission's Innovation Scoreboard 2019 provides a granular view of Greece's innovation landscape. In fact, the European innovation scoreboard assesses relative strengths and weaknesses of national innovation systems and helps countries identify areas they need to address.[379]

According to the EU's Innovation Scoreboard 2019, Greece ranks 20th out of EU's 28 countries and is classified as a "Moderate Innovator" (see Figure 70).[380]

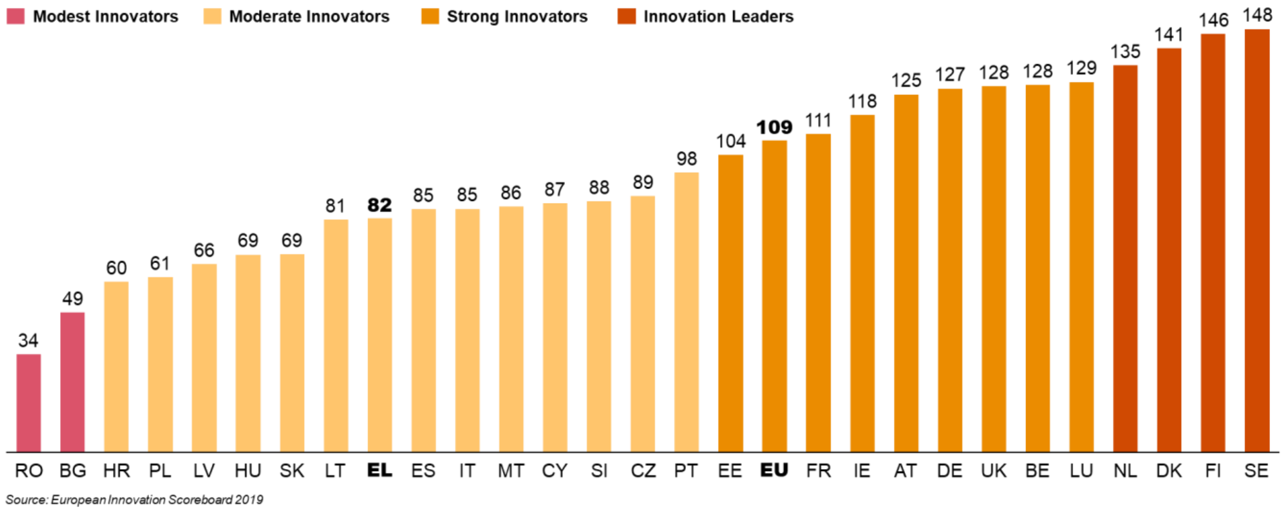

Figure 70: Performance of EU member states' in innovation systems, 2018, relative to that of the EU in 2011 – Source: European Commission, European Innovation Scoreboard 2019

The EU's Innovation Scoreboard (EIS) ranks countries' innovation landscape across four main types of indicators – Framework conditions, Investments, Innovation activities and Impacts, as presented below (see Figure 71).[381]

[379] European Commission, European Innovation Scoreboard 2019, https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en
[380] European Commission, European Innovation Scoreboard 2019, https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en
[381] European Commission, European Innovation Scoreboard 2019, https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en

Framework Conditions	**Framework conditions** captures the main drivers of innovation performance external to the firm and differentiates between three innovation dimensions: • The *Human resources* dimension includes three indicators and measures the availability of a high-skilled and educated workforce. Human resources captures New doctorate graduates, Population aged 25-34 with completed tertiary education, and Population aged 25-64 involved in education and training. • *Attractive research* systems includes three indicators and measures the international competitiveness of the science base by focusing on International scientific co-publications, Most cited publications, and Foreign doctorate students. • *Innovation-friendly environment* captures the environment in which enterprises operate and includes two indicators - Broadband penetration among enterprises and Opportunity-driven entrepreneurship - measuring the degree to which individuals pursue entrepreneurial activities as they see new opportunities, for example resulting from innovation.
Investments	**Investments** captures investments made in both the public and business sector and differentiates between two innovation dimensions: • *Finance and support* includes two indicators and measures the availability of finance for innovation projects by Venture capital expenditures, and the support of governments for research and innovation activities by R&D expenditures in universities and government research organizations. • *Firm investments* includes three indicators of both R&D and non-R&D investments that firms make to generate innovations, and the efforts enterprises make to upgrade the ICT skills of their personnel.
Innovation activities	**Innovation activities** captures different aspects of innovation in the business sector and differentiates between three dimensions: • *Innovators* includes three indicators measuring the share of firms that have introduced innovations onto the market or within their organizations, covering both product and process innovators, marketing and organizational innovators, and SMEs that innovate in-house. • *Linkages* includes three indicators measuring innovation capabilities by looking at collaboration efforts between innovating firms, research collaboration between the private and public sector, and the extent to which the private sector finances public R&D activities. • *Intellectual assets* captures different forms of Intellectual Property Rights (IPR) generated in the innovation process, including PCT patent applications, Trademark applications, and Design applications.
Impacts	**Impacts** captures the effects of firms' innovation activities and differentiates between two innovation dimensions: • *Employment impacts* measures the impact of innovation on employment and includes two indicators measuring Employment in knowledge-intensive activities and Employment in fastgrowing firms in innovative sectors. • *Sales impacts* measures the economic impact of innovation and includes three indicators measuring Exports of medium and high-tech products, Exports of knowledge-intensive services, and Sales due to innovation activities.

Figure 71: EIS 2019 – Four types of indicators: Framework conditions, Investments, Innovation activities and Impacts – Source: European Commission, European Innovation Scoreboard 2019

Greece		Score (out of 100)
SUMMARY INNOVATION INDEX		**82**
Framework Conditions	**Human Resources**	**78,2**
	New doctorate graduates	70,9
	Population with tertiary education	120,0
	Lifelong learning	34,7
	Attractive research systems	**59,2**
	International scientific co-publications	77,6
	Most cited publications	78,4
	Foreign doctorate students	5,9
	Innovation-friendly environment	40,9
	Broadband penetration	22,2
	Opportunity-driven entrepreneurship	60,5
Investments	**Finance and support**	**44,4**
	R&D expenditure in the public sector	77,8
	Venture capital expenditure	16,0
	Firm investments	**66,0**
	R&D expenditure in the business sector	39,3
	Non-R&D innovation expenditures	103,6
	Enterprises providing ICT training	52,6
Innovation Activities	**Innovators**	**145,7**
	SMEs product/ process innovations	137,8
	SMEs marketing/ organisational innovations	142,5
	SMEs innovating in-house	157,5
	Linkages	**111,5**
	Innovative SMEs collaborating with others	201,6
	Public-private co-publications	41,1
	Private co-funding of public R&D exp.	75,3
	Intellectual assets	**36,0**
	PCT patent applications	16,1
	Trademark applications	67,6
	Design applications	25,0
Impacts	**Employment impacts**	**84,2**
	Employment in knowledge-intensive activities	75,3
	Employment fast-growing enterprises	91,0
	Sales impacts	**66,3**
	Medium and high-tech product exports	8,3
	Knowledge-intensive services exports	69,4
	Sales of new-to-market/ firm innovations	138,8

Greece's strongest innovation sub-dimensions are Innovators, Linkages, and Employment impacts. Notably, Greece ranks above the EU average in the **Innovators** sub-dimension, which consists of product and process innovations, marketing and organisational innovations, and in-house innovations with regards to SMEs. Furthermore, Greece is approximately on par with the EU average with regards to the Employment Impacts sub-dimension, which is derived by the percentage of employment in knowledge-intensive activities and in fast-growing enterprises.

Additionally, Greece scores above the EU average across the Linkages sub-dimension, which relates to the collaboration between SMEs, number of public-private co-publications, and the private co-funding of public R&D expenditures.

Figure 72: The colours show normalised performance relative to that of the EU in 2018. Dark green: above 120%, light green: between 90% and 120%, yellow: between 50% and 90%, orange: below 50% - Source: The EU Innovation Scoreboard 2019

Despite Greece's relatively strong performance across the aforementioned sub-dimensions, the country ranks poorly on the Intellectual Assets, Innovation-friendly environment, and Finance and Support sub-dimensions. In fact, Greece ranks at the lower end against its EU member states on the Intellectual Assets sub-dimension, with a low share of PCT patent applications, trademark applications, and design applications. On the Innovation-friendly environment sub-dimension, which is made up of broadband penetration and an indicator of opportunity-driven entrepreneurship, Greece ranks last among all 28 EU member states.

Finally, Greece's score along the Finance and Support sub-dimension is relatively fairer yet still trailing behind the EU average. Zooming further into this sub-dimension, Greece's performance appears on par with the EU average regarding the public R&D expenditures, but it ranks close-to-last on the venture capital sub-indicator. In addition, Greece scores the lowest in terms Foreign doctorate students, and Medium and high-tech product exports (see Figure 65).[382]

Greece's Research & Development (R&D) state of play

R&D is a key requirement for innovation. The output of R&D is measured in patents and publications, and more importantly, in increases of the stock of knowledge in organisations that lead to innovation, and eventually improve the output of firms. R&D activities can be differentiated into basic research (aiming to increase the understanding of fundamental principles) and applied research (aiming to achieve technical solutions to specific commercial problems). Public research institutions and university-based institutes often focus on basic research and the early stages of applied research, whereas the private sector is often focused on applied research at later stages of innovation.

The economic crisis had a limited impact on research and development (R&D) expenditure, but the overall levels remain low, negatively affecting Greece's growth potential. In terms of R&D intensity, defined as the gross domestic spending on R&D as a percentage of GDP, Greece ranked significantly below its peers, at 1,18% in 2018, compared to an EU average of 2,12% in the same year. European frontrunners, Germany, Denmark, Austria and Sweden, all allocate more than 3% of their GDP in R&D (see Figure 73).[383]

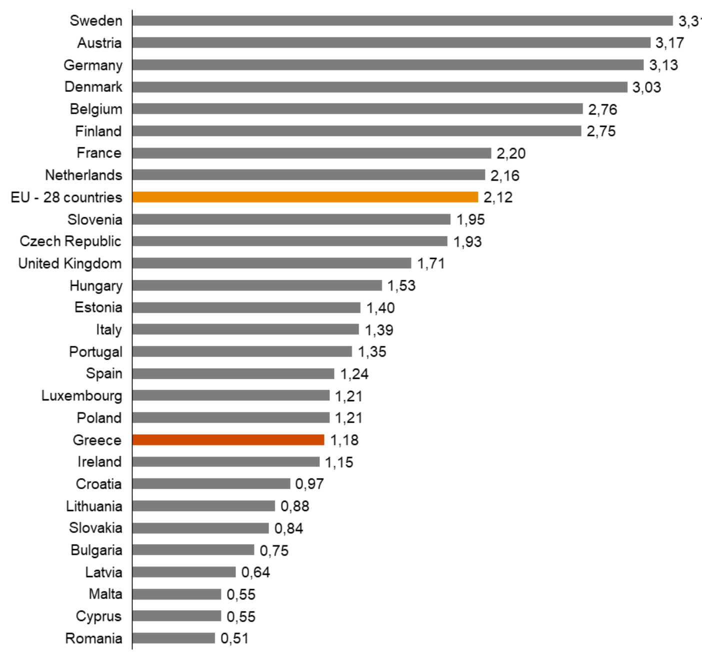

Figure 73: Gross Domestic Expenditure in R&D in the EU, % of GDP – Source: OECD, Gross domestic spending on R&D

[382] European Commission, European Innovation Scoreboard 2019, https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en
[383] OECD, Gross domestic spending on R&D, https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm

In addition, overall technological development remains low as also reflected in the very low number of patents compared with other countries. Greece ranks low in Europe with regards to the patent applications submitted by Greek residents to the European Patent Office per million inhabitants. While the EU-28 average was 107 patents in 2017, Greece reports 8 patent applications per million inhabitants, 97% less patents than Sweden, the European leader (283 patents).[384] Therefore, investments are necessary in the short and medium term to tackle these problems (see Figure 74).

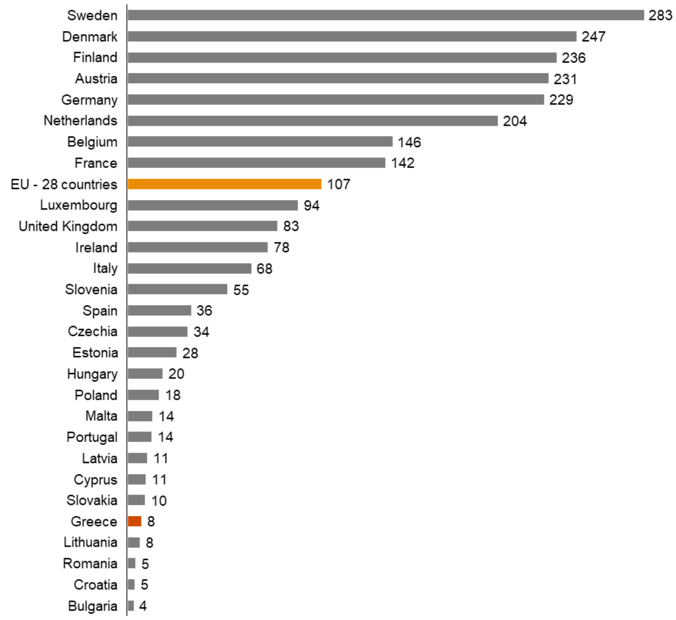

Figure 74: Patent applications to the EPO per million inhabitants, EU, 2017 – Source: Eurostat, Patent applications to the European Patent Office

Nevertheless, Greece's overall R&D in FTE units has been growing at a rate of 38%, compared to the average of 25% across EU countries, demonstrating that the country is on a path to increasing its innovative capabilities (see Figure 75).[385]

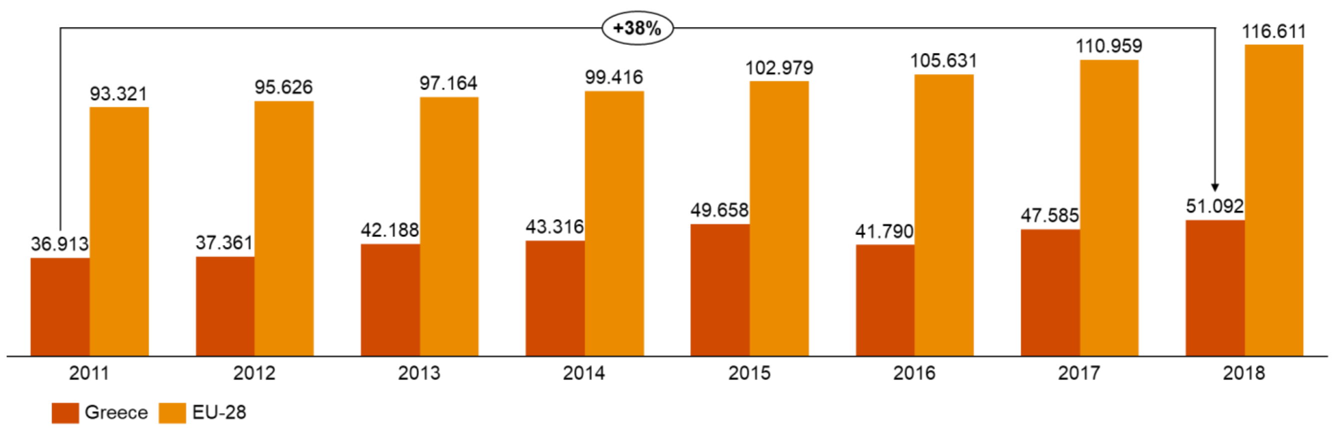

Figure 75: Evolution of Total R&D by FTE, Greece and EU-28 average, 2011-2018 – Source: Eurostat, Total researchers by sectors of performance - full time equivalent

384 Eurostat, Patent applications to the European Patent Office, https://ec.europa.eu/eurostat/web/products-datasets/product?code=sdg_09_40
385 Eurostat, Total researchers by sectors of performance - full time equivalent, https://ec.europa.eu/eurostat/web/products-datasets/product?code=tsc00004

Interestingly enough, the resource allocation for Greece's R&D varies significantly from the European average. Contrary to the EU average, where the business sector appears highly involved in R&D (58% FTE), the Greek R&D is mainly dominated by the higher education sector (46% FTE). This highlights an important finding: Greek organisations appear hesitant to invest in research of new technologies, as well as in active experimentation of how these could be implemented to drive new sources of revenues (see Figure 76). [386]

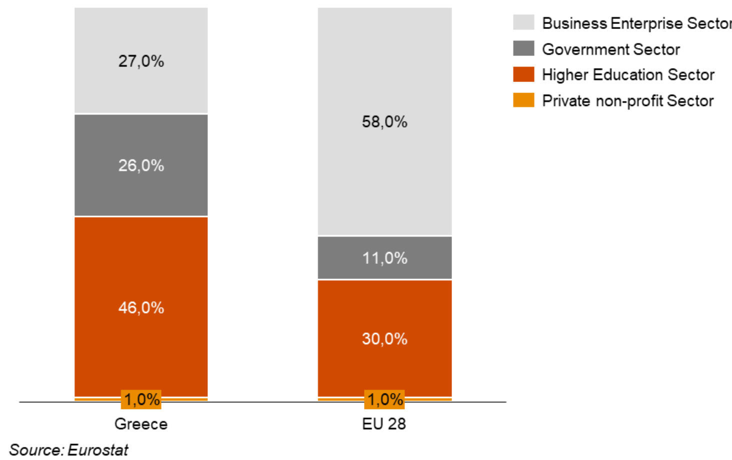

Figure 76: % of total R&D FTE per sector Greece and EU-28, 2018 – Source: Eurostat, Total researchers by sectors of performance - full time equivalent

Research & Development (R&D) state of play for the Greek Industry

Greece's industry, much like the overall economy, is far behind the European average when it comes to industrial R&D. Greece's total business R&D expenditure in the manufacturing sector was €290 million in 2017, among the lowest in the EU. In comparison, Germany's business R&D in the manufacturing sector in 2017 was €58 billion, while France and the UK's business sectors spent approximately €16 and €11 billion in industrial R&D respectively (see Figure 77).[387]

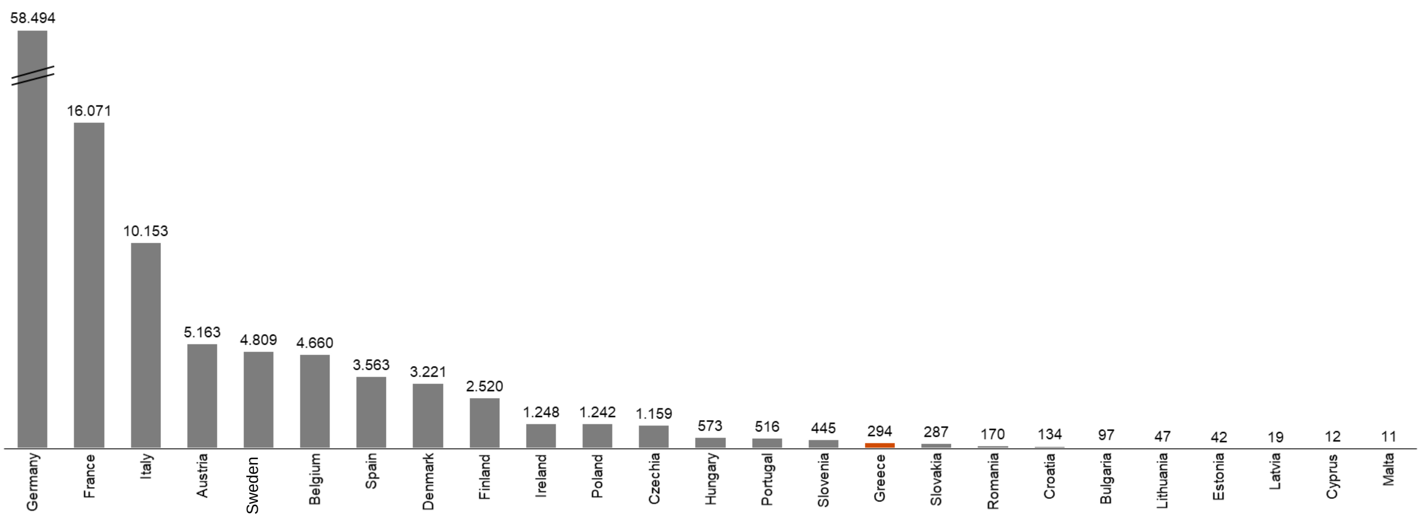

Figure 77: Business R&D Expenditure in the manufacturing sector, € Billion (2017) – Source: Eurostat, Business expenditure on R&D (BERD) by NACE Rev. 2 activity

[386] Eurostat, Total researchers by sectors of performance - full time equivalent, https://ec.europa.eu/eurostat/web/products-datasets/product?code=tsc00004
[387] Eurostat, Business expenditure on R&D (BERD) by NACE Rev. 2 activity, https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

Nevertheless, the share of capital allocated to R&D expenditures by European manufacturers vary significantly as a percentage of each country's manufacturing gross value added. For instance, most Scandinavian, German and Austrian manufactures choose to allocate significantly more funds into research and development (above 6% of their sector's GVA), when compared to other European countries, i.e. Italy, Spain, the United Kingdom, etc. Greek manufacturers score significantly low, in terms of their relative R&D spending, amounting to 2% of the Greek manufacturing sector's GVA (see Figure 78).[388]

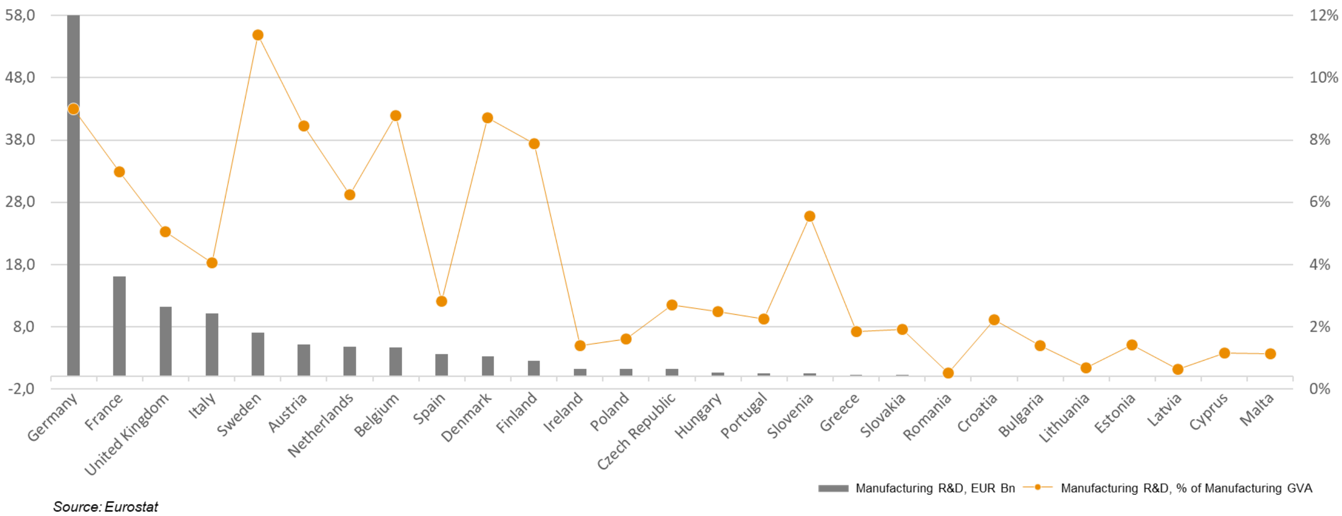

Figure 78: Manufacturing R&D (in Billion €) and Manufacturing R&D as a percentage of Manufacturing GVA, EU, 2017 – Source: Eurostat

Greece's Start-up Ecosystem State of Play

Greece is home to a burgeoning start-up scene. From 2012 to 2016, investment in Greek Start-ups grew by a factor of 18, from 5 to 90 million Euros in annual start-up funding per year in 2012 and 2016 respectively, totalling 250 million in the span of five years (see Figure 79). A significant portion of this growth is due to Equifund, an investment platform developed by the ministry of Economy and Development and the European Investment Fund. Equifund have invested a total of €1 billion into Greek start-ups through intermediary Venture Capital (VC) and private equity funds. [389]

[388] Eurostat, Business expenditure on R&D (BERD) by NACE Rev. 2 activity, https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
[389] BCG, The Greek startup Ecosystem - http://www.sev.org.gr/Uploads/Documents/50906/BCG_Greeces_Startup_Ecosystem_Apr_2018.pdf

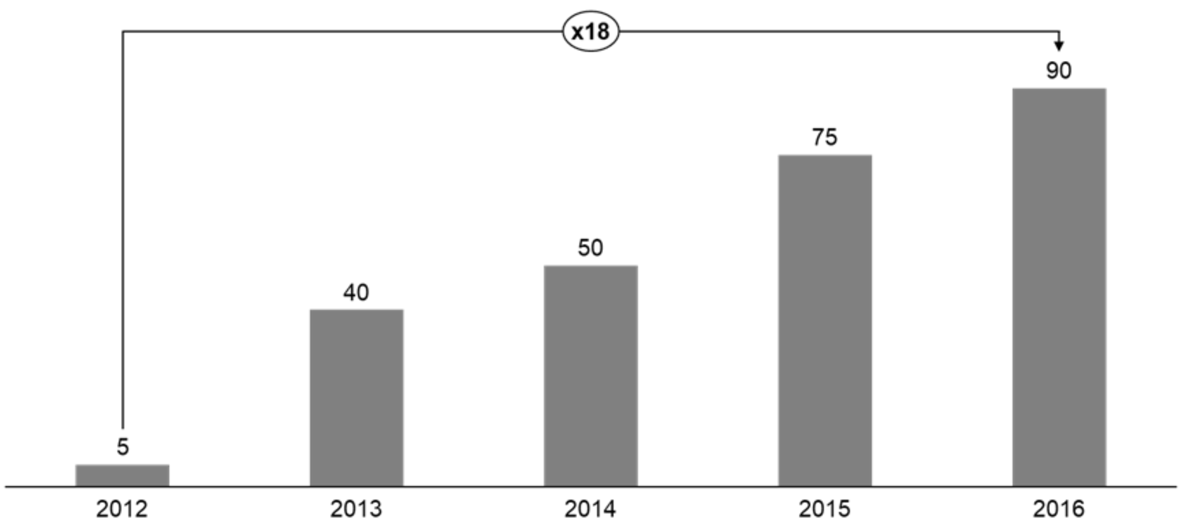

Figure 79: Annual start-up funding in Greece, € Millions, 2012-2016 – Source: StarTech Ventures, Marathon Venture Capital, OECD, ECVA/ Invest Europe, BCG Analysis

Another portion of growth comes through the acquisition of majority stakes in start-ups - with notable examples including Delivery Hero's investment in Efood, Daimler's investment in Taxibeat, and Samsung's investment in Innoetics. In addition, the last few years have seen a strong growth in incubators, with the likes of Corallia, the EGG, iQbility, and Orange Grove supporting start-ups through seed funding and the facilitation of strategic partnerships. Coupled with the growth of VC groups like Venture Friends and Marathon Venture Capital and the increasing presence of co-working spaces, these developments signify that the Greek Start-up ecosystem withholds significant potential.[390]

When it comes to sectoral focus, most Greek start-ups are operating within the Life Sciences (9,25%), Lifestyle/Social/Entertainment (8,22%), Tourism/Hospitality (7,93%), ICT (7,05%), Energy/Infrastructure (6,31%) sectors. Finally, the vast majority of start-ups are in the pre-seed stage (77,6%), indicating the need to expand the amount of capital allocated to the ecosystem's growth. Below we present the breakdown of the Greek start-up ecosystem by sector of focus.[391]

Sector	%
Life sciences (HealthTech. Biotechnology, Medical Devices)	9,25%
Lifestyle/Social/Entertainment (Fashion, sports. Gaming, Media, Social Networks)	8,22%
Tourism/Hospitality	7,93%
ICT (Software, Security, Networking. Services)	7,05%
Energy/Infrastructure (industrial, Cleantech, SmartCities, Telecommunications)	6,31%
Deep tech (Aerospace, Automation. Robotics. Semiconductors. Nanotechnology)	6,02%

[390] BCG, The Greek startup Ecosystem - http://www.sev.org.gr/Uploads/Documents/50906/BCG_Greeces_Startup_Ecosystem_Apr_2018.pdf
[391] Found.ation : technology breakdown of Greek Startup Sector - http://thefoundation.gr/wp-content/uploads/2018/12/Startups-in-Greece-2018-by-EIT-Digital-and-Foundation.pdf

Sector	%
Fintech	5,87%
Agri/Food	5,73%
Retail/eCommerce	5,43%
Logistics/Transportation	4,41%
Big Data/Analytics	3,96%
AdTech/MarTech	3,67%
EdTech	3,38%
MaritimeTech	3,23%
HRtech	2,94%
Business Services	2,94%
RegTech/InsureTech	2,64%
IoT	2,64%
AR/VR	1,76%
Other	6,61%

The Greek start-up ecosystem can play a significant role towards the digitisation of the Greek economy. Start-ups can attract additional foreign investment and digitally skilled talent and support the creation of centres of innovation across Greece. Start-ups can also increase the global competitiveness of Greek industries by forming strong partnerships both with the Greek academia, but most importantly with Greek established companies. Start-ups are able to design new, innovative products, while large organisations can scale operations for mass product manufacturing and distribution. This can lead to the design of digital innovation hubs and clusters that will boost the Greek industries' competitiveness and will accelerate their digital transformation.

Greece's Digital Innovation Hubs

With regards to Digital Innovation Hubs, as of January 2020, on a national level Greece has 14 of them (9 fully operational and 5 in preparation status[Error! Bookmark not defined.]) covering various market domains (agriculture, fishing, construction, manufacturing (food products, textiles, chemicals, basic and fabricated metal products, electrical and optical equipment, machinery, electrical equipment), transport, electricity, public administration, education and health) through a large spectrum of technology areas presented as follows[392]:

- Additive manufacturing (3D printing)
- Advanced or High-performance computing
- Artificial Intelligence and cognitive systems
- Augmented and virtual reality, visualisation
- Broadband and other communication networks (e.g. 5G)
- Cloud computing
- Cyber physical systems (e.g. embedded systems)
- Cyber security (including biometrics)
- Data mining, big data, database management
- Gamification
- ICT management, logistics and business systems

[392] Information was provided by the Ministry of Development and Investments working team via mail on February 21, 2020

- Interaction technologies (e.g. human-machine Interaction, motion recognition and language technologies)
- Internet of Things (e.g. connected devices, sensors and actuators networks)
- Internet services (e.g. web development, web production, design, networking, and e-commerce)
- Laser based manufacturing
- Location based technologies (e.g. GPS, GIS, in-house localisation)
- Micro and nano electronics, smart system integration
- New Media technologies
- Organic and Large Area Electronics (OLAE)
- Photonics, electronic and optical functional materials
- Robotics and autonomous systems
- Screens and display technologies
- Sensors, actuators, MEMS, NEMS, RF
- Simulation and modelling
- Software as a service and service architectures

A concise list of all hubs on national and regional level is presented as follows:

Fully Operational Digital Innovation Hubs:

DIH Name	Location	City	Website	Contact	NUTS2 Name
ATHENA Research and Innovation Center	Artemidos 6 & Epidavrou	Maroussi, Athens	http://www.athena-innovation.gr	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/2094/view	Attiki
Attica Hub for the Economy of Data and Devices (AHEDD)	Patr. Gregoriou E & 27 Neapoleos Str, Agia Paraskevi	Athens	http://ahedd.demokritos.gr/	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/2092/view	Attiki
Center for Research and Technology Hellas	6th km Harilaou - Thermi Rd	Thermi - Thessaloniki	https://www.certh.gr/	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/3085/view	Kentriki Makedonia
Embedded System Design & Application Laboratory	Megalou Alexandrou 1	Patra	http://esda-lab.cied.teiwest.gr	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/12382/view	Dytiki Ellada
Foundation for Research and Technology – Hellas (FORTH) / PRAXI Network	Kolokotroni 8	Athens	https://www.praxinetwork.gr	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/5967/view	Attiki
Internet of Things, Intelligent Systems, Data Engineering and Media DIH [National Technical University of Athens - Institute	Heroon Polytechneiou 9	Athens	https://www.dih-ntua.gr/services/	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1980/view	Attiki

of Communication and Computer Systems]					
Nanotechnology Lab LTFN (Lab for Thin Films - Nanobiomaterials - Nanosystems - Nanometrology)	University Campus	Thessaloniki	http://www.ltfn.gr/	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1784/view	Kentriki Makedonia
National Documentation Centre / National Hellenic Research Foundation	48, Vas. Constantinou Ave.	Athens	http://www.ekt.gr/en	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/5806/view	Attiki
nZEB Smart House	CERTH/ITI, 6th km Charilaou-Thermi Road	Thessaloniki	https://smarthome.iti.gr	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1521/view	Kentriki Makedonia

In addition, below we present the Digital Innovation Hubs in Preparation:

DIH Name	Location	City	Website	Contact	NUTS2 Name
Piraeus Blue Growth Digital Innovation Hub (BG-DIH)	91, Iroon Polytechniou Ave	Piraeus	http://www.bluegrowth.gr/	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/2491/view	Attiki
OK!Thess (Οικοσύστημα Καινοτομίας Θεσσαλονίκης)	2 Komotinis Street	Thessaloniki	https://okthess.gr/en/	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/2872/view	Kentriki Makedonia
ManuHub@WG	Archimidous 7	Patras	http://lms.mech.upatras.gr	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1559/view	Dytiki Ellada
Central Macedonia Digital Innovation Hub on Agrofood	Dioikitirio	Thessaloniki	http://www.thessinnozone.gr/	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1361/view	Kentriki Makedonia
Institute of Entrepreneurship Development (iED)	169 Iroon Politechniou str	Larissa	https://ied.eu/	https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/12716/view	Thessalia

Indicative Initiatives that Greece has undertaken for DEI Pillar 2

The Greek Government has adopted already a series of measures to tackle persistent weaknesses and some of the most pressing challenges in the research and innovation system. Various co-financed projects have recently been set up to boost research and innovation activities, such as the Research-Create-

Innovate initiative[393] with an allocated budget of EUR 543 million. In addition, Equifund, the equity fund supported by EU funds has been set up to inject liquidity in start-ups and innovative businesses.[394] These initiatives are also presented in chapter 8.

Research and innovation strategies for 'smart specialisation' have also been developed in line with international practice. These have led to the identification of key growth sectors such as agri-food, tourism, health, information and communication technology, energy and sustainable development, transport and logistics.[395] A detailed analysis of the Greek "Smart Specialisation" strategy is presented as part of Deliverable 2.

Finally, Greece has also launched the two actions that promote the digital transformation of enterprises and organisations. The "Digital Step"[396] that aims at the digital upgrading of very small, small and medium sized enterprises with business plans from €5.000 to €50.000 and the "Digital Jump"[397] that aims at the digital transformation of very small, small and medium sized enterprises with business plans from €55.000 to €400.000. More information on policy mechanism and the funding schemes that Greece has implemented to support Innovation and R&D are presented in chapter 8.

A non-exhaustive list of the key initiatives undertaken to boost Greece's innovation capacity is also briefly presented below.

Name of Initiative	**Strategy of Smart Specialisation**
Type	National Strategy
Starting date	2016
Short description	The National RIS3 provides for the transformation of the productive sectors through research, technological development and innovation while mitigating regional disparities and creating sustainable employment. ICT technologies play a fundamental dual role, both as an economic domain and as an enabler in other domains in the context of RIS3.
Sectors targeted	Agrofood; Life Sciences & Health – Pharma; Information and Communication Technologies; Energy; Environment and Sustainable Development; Transport and Logistics; Materials – Construction; Culture - Tourism - Cultural & Creative Industries
Technologies targeted	ICT technologies
Funding	N/A
Additional information	http://www.gsrt.gr/Financing/Files/ProPeFiles19/Executive%20Summary-2015-09-17-v04.pdf

Name of Initiative	**Research-Create-Innovate**
Type	Research & innovation support
Starting date	2017
Short description	Promote Research & Innovation projects and collaborations through a) funding research activities in enterprises and collaboration between firms and public research organisations, b) Integrating mature research results into the production process and c) fostering patenting of innovative products and services.

393 Source : http://www.antagonistikotita.gr/epanek_en/news.asp?id=7
394 Equifund, https://equifund.gr/
395 GSRT, National Research and Innovation Strategy For Smart Specialisation 2014-2020, http://www.gsrt.gr/News/Files/New1034/Executive%20Summary-2015-09-17-v04.pdf
396 EPANEK, http://www.antagonistikotita.gr/epanek_en/prokirixeis.asp?id=25&cs=
397 EPANEK, http://www.antagonistikotita.gr/epanek_en/prokirixeis.asp?id=26&cs=

Granting organisation	General Secretariat for Research & Technology (GSRT), Managing and Implementation Authority for Research, Technological Development and Innovation (MIA-RTDI)
Participating organisations	N/A
Sectors targeted	ICT, Agriculture, Health, Energy, Transport, Culture tourism, Environment, Materials
Technologies targeted	Robotics and Automation Machinery, Big Data and Data Analytics, 3D-Printing, AI, Cloud, IoT
Funding	EUR 75.5 million. Co-financed by ERDF and by national funds
Additional Information	http://www.antagonistikotita.gr/epanek/prokirixeis.asp?id=47&cs=

Name of Initiative	**Digital Step**
Type	Investment subsidy
Starting date	2018
Short description	Upgrade SMEs' digital competences. Focus on small interventions with the aim to familiarise SMEs with digital technologies.
Granting organisation	Ministry of Economy and Development
Participating organisations	N/A
Sectors targeted	All sectors
Technologies targeted	Social Media, Mobile Services, Cloud, IoT, Cyber Security
Funding	EUR 50 million. Co-financed by ERDF and by national funds
Additional Information	http://www.antagonistikotita.gr/epanek/prokirixeis.asp?id=39&cs=

Name of Initiative	**Digital Jump**
Type	Investment subsidy
Starting date	2018
Short description	Upgrade SMEs' digital competences. (More extensive and ambitious investments compared to digital step measure, aiming at SMEs already acquainted with digital technologies)
Granting organisation	Ministry of Economy and Development
Participating organisations	N/A
Sectors targeted	All sectors
Technologies targeted	Social Media, Mobile Services, Cloud, IoT, Cyber Security
Funding	EUR 50 million. Co-financed by ERDF and by national funds
Additional Information	https://www.espa.gr/el/Pages/ProclamationsFS.aspx?item=3886

7.5.3 DEI Pillar 3: Strengthening leadership through partnership & industrial platforms

Cooperation and interaction between universities, research institutions, firms and other agents of the economy and society provide economic advantages for all stakeholders. The regional proximity of stakeholders facilitates networking activities, e.g. by building up a critical mass of talent, while contextual proximity between public funded researchers and private entrepreneurs facilitate communication and accelerate the innovation process.

Towards this direction, EU supports the establishment of Public-Private Partnerships (PPPs) that develop future digital technology building blocks and focus on developing strategic research and innovation agendas across a set of digital technologies, i.e. big data analytics, high performance computing, robotics, photonics, cybersecurity, 5G and electronic components & systems. The EU supports partnerships and collaborations will focus on the applications of specific technologies and on the creation of industrial platforms across different industrial sectors. In fact, the EU has secured around €1 billion in funds over the past years for the establishment of strategic next-generation industrial platforms. Currently, the EU is investing more than €3 billion in these areas, roughly 2/3 on the development of PPPs for digital building blocks and 1/3 on platform building, large-scale piloting, pilot lines and related actions. [398]

It has been observed that the partnerships and PPPs are increasingly cooperating for developing new digital industrial platforms. For instance, the Big Data Value PPP, the Alliance for Internet of Things Innovation, and the High-Performance Computing PPP have agreed to join forces in the development of next-generation digital industrial platforms, including AI platforms.[399]

For the period 2018-20, the EU focuses on the development of next-generation platform building and piloting through large scale federating projects. The aim is to foster Member States' cooperation to achieve the following EU-wide digital strategies (see Figure 80):

[398] European Commission, Industrial platforms and large scale pilots, https://ec.europa.eu/digital-single-market/en/industrial-platforms-and-large-scale-pilots
[399] Digitising European Strategy: Progress so Far, 2 Years after the Launch, March 2018

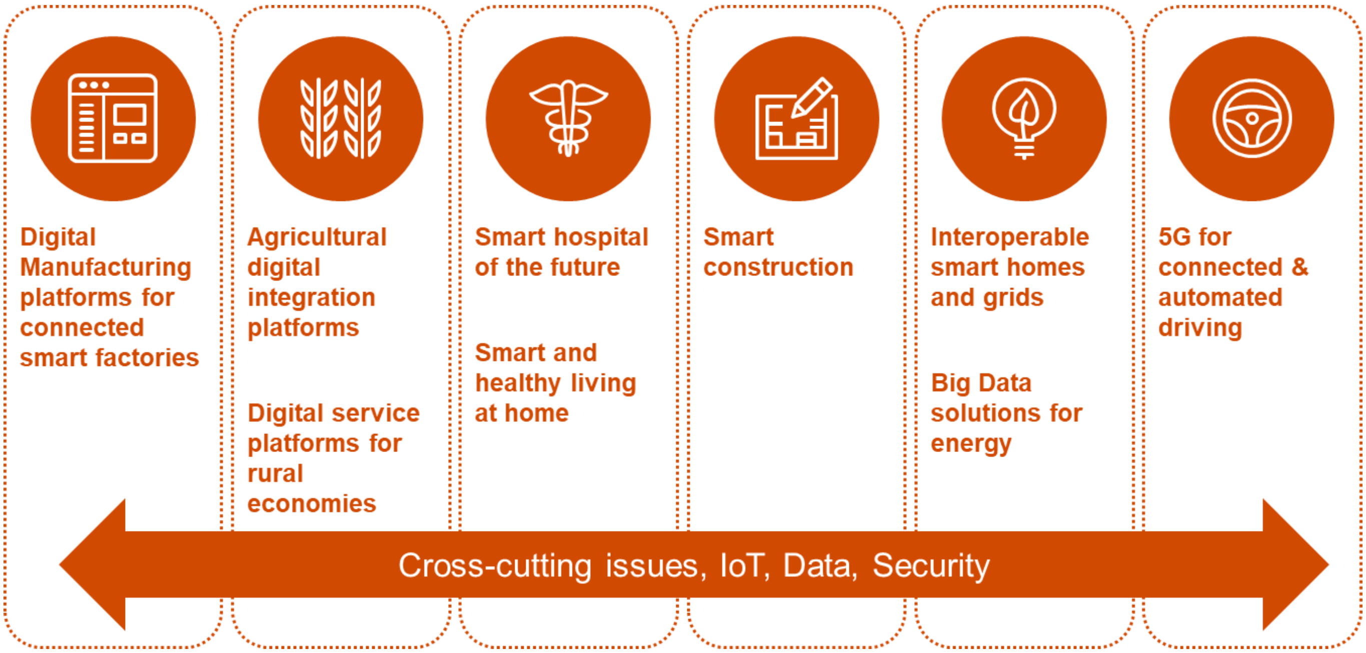

Figure 80: Cross-EU Strategic Themes – Source: Accenture Analysis

In addition, the review of the 16 Industry 4.0 strategies & initiatives have surfaced the following coordination platforms that have been developed to enable the coordination between the private and public sector, as well as the academia and research institutes.[400]

Coordination Platforms	
Austria – Industrie 4.0	Administered by a Board of 10. Its 44 members are paying the following contributions: €300.000 per year for the 6 founding members (50% from the Ministry + 50% from the other members) + €200.000 per annum from other members' contributions
Belgium – Made Different	235 enterprises participate (2/3 are SMEs). No specific budget has been allocated through public funding, because the platform is managed mainly through the Industry, while various other aids are used
France – Industrie du Futur (IdF)	Implementation of (IdF) is carried out from the non-profit, cooperative platform Alliance Industrie du Futur (AIF). It is comprised by 35 members. Budget: €10 billion from public funding
Germany – Industrie 4.0	Budget: €200 million from Ministries of Finance & Economy, Ministry of Energy and Education & Research, supplemented by cash and in-kind contributions from Industry
Denmark – MADE 4.0	Administered by the independent homonymous association, which consists of 170 members. Total budget: €50 million for the period 2014-2019. The funds come from companies, universities, organisations, private institutions and public bodies.

[400] For a detailed list of sources with regards to national Industry 4.0 strategies/ initiatives please refer to paragraph 7.2.

Coordination Platforms	
United Kingdom - Catapult	This is a network of 7 Catapult Centres (research centres of applied research). The network is funded equally by public sector (Innovate UK), enterprises and co-financing of public-private sector. Government budget: €164 million for the period 2012-2018.
Spain – Industria Connectada 4.0	Budget: €97,5 million from government for loans to Industry in 2016 (Calls for Innovation & Research Projects). Related Projects provide additionally €68 million (loans and direct payments) for ICT companies and €10 million for innovative clusters
Italy – Industria 4.0	The financing model is based on public funding of over €18 billion in the period 2017-2020 (mainly tax incentives)
Lithuania – Pramone 4.0	Estimated investments of €79,8 million for the period 2017-2020 (€38,9 million from EU investment funding and €40,9 million from private funding)
Netherlands – Smart Industry	Budget of €25 million that comes from national resources (€15 million) and European regional funds (€10 million). In addition, private financing is offered along with contributions in kind
Hungary – IPAR 4.0	Publicly funded, with Horizon2020 being the main source with €10,8 million, while significant is the contribution of the National Development & Innovation Bureau (NRDI Office) with €3.6 million and the contribution of the OP Economic Development & Innovation (GINOP). A private funding mechanism is not applied (except for low, voluntary contributions).
Poland – Future Industry	As part of the Responsible Development Industry Roadmap Plan, investments of €235 billion are foreseen by 2040 (about 50% will come from European funding)
Portugal – Industria 4.0	Funding comes from both public and private resources, with the total budget set at €4,5 billion during the next 4 years.
Sweden – Produktion2030	Over 150 companies are involved. Budget: €50 million overall: €25 million from VINNOVA for the period 2013-2018 and approximately €25 million complemented from Industry

Greece's networking landscape

In order to evaluate Greece's networking ecosystem and PPP partnerships, we shall review data regarding the cooperation of innovative firms[401] with research institutes and identify the number and scope of existing cluster in Greece.

In Greece, research networks are rare and cooperation between the public research, academia and industry has been initiated but remains weak. Nevertheless, a considerable part of innovative companies in Greece have reported to collaborate with others (i.e. research institutes or other enterprises), clarifying

[401] Innovative enterprises are product and/or process innovative enterprises, regardless of organisational or marketing innovation (including enterprises with abandoned/suspended or on-going innovation activities

that this small number of companies is able to create a network and to build a digital ecosystem around it (see Figure 81). [402]

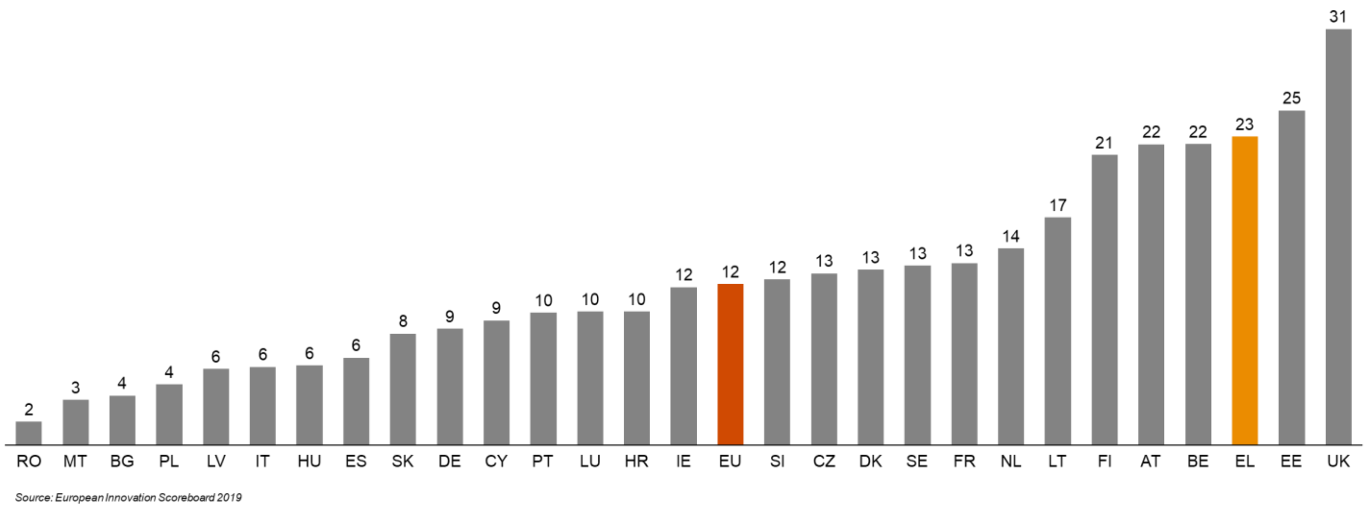

Figure 81: Innovative SMEs collaborating with others (% of SMEs), 2016 – Source: European Commission, European Innovation Scoreboard 2019

It is important to state here, that given the disproportionally small percentage of large enterprises (0,04%) in the Greek economy and the percentage of total innovative SMEs (44% of the total number of Greek SMEs), the relatively high percentage of innovative companies that cooperate with research institutes does not indicate that Greek enterprises are performing significantly well in terms of innovative output. For this reason, Greece needs large innovative enterprises that can make use of economies of scale to generate significant levels of innovation. For this to be achieved, the networks among basic research, applied research and business need to be further extended in number and quality towards the creation of regional clusters.

With regards to clusters[403], limited actions have been undertaken in Greece. According to the European Cluster Collaboration Platform[404], currently in Greece there are three clusters. Unfortunately, no assessment is currently available regarding their effectiveness and key outcomes. Nevertheless, judging from the total number of enterprises that participate in these and their percentage of SMEs, it is evident that these clusters currently have limited scale. More information on these clusters is provided in the tables below.

Name of Cluster	**Hellenic Photonics Cluster-HPhos**
Establishment date	Tuesday, 3 March, 2015
Legal form of the cluster organisation	Non-Profit
Region	Attiki
Sectoral Industries	Aerospace Vehicles and Defence Communications, Equipment, and Services
Technology Fields	Jointing (soldering, welding, sticking), Optical Materials
EU Priority Areas	Photonics, Basic metals & of fabricated metals products
Emerging Industries	Digital Industries, Experience Industries

[402] European Commission, European innovation scoreboard, https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en
[403] Groups of firms, related economic actors, and institutions that are located near each other and have reached a sufficient scale to develop specialised expertise, services, resources, suppliers and skills. Clusters are referred to both as a concept and a real economic phenomenon, such as the Silicon Valley, the effects of which, such as employment concentration, can be measured.
[404] European Commission, European Cluster Collaboration Platform, https://www.clustercollaboration.eu/

Name of Cluster	**Hellenic Photonics Cluster-HPhos**
Total number of members	18
Number of SME members	13
Number of larger company members	0
Number of research organisations/universities/technology centers	5
Cluster Strategy	• To promote the contribution and role of the Greek Photonic industry on the global scene. • To foster collaborations between HPhos members and international players. • To support members in their export orientation and international business development. • To foster the exchange of knowledge between HPhos members and the international photonic community. • To encourage and support entrepreneurship and innovation in the photonic technology space.
Services Provided	Access to public support (regional/national programs, innovation vouchers, etc.) Facilitation of collaboration between members Facilitation of cross-sectoral cooperation Support of technology transfer Innovation Management / Support of innovation processes (internal, external)
Participation in Funded Support Programs	Horizon 2020
Additional Information	http://www.hphos.gr/

Name of Cluster	**ITS Hellas**
Establishment date	Monday, 31 March, 2008
Legal form of the cluster organisation	Registered Association
Region	Attiki
Sectoral Industries	Transportation and Logistics
Technology Fields	Applications for Transport and Logistics
EU Priority Areas	Intelligent inter-modal & sustainable urban areas (e.g. smart cities), Smart green & integrated transport systems
Emerging Industries	Digital Industries, Logistical Services
Total number of members	31
Number of SME members	16
Number of larger company members	8
Number of research organisations/universities/technology centers	5
Cluster Strategy	• Supporting integration of Intelligent Transportation Systems and cooperation among stakeholders • Supporting the development of a national Intelligent Transportation Systems strategy • Promoting the wide deployment of Intelligent Transportation Systems • Promoting the use of standards and developing new standards and regulations when needed • Assessing new and existing deployments of Intelligent Transportation Systems in Greece and publishing the assessment results • Co-creating policies and strategies with stakeholders

Services Provided	Internationalisation support (i.e. access to international markets), access to public support (regional/national programs, innovation vouchers, etc.), access to technology services, facilitation of collaboration between members
Participation in Funded Support Programs	• SEE-ITS: Intelligent Transportation Systems in South-East Europe CAPITAL: Collaborative capacity program on ITS Training-education and liaison
Additional Information	http://itsnetwork.org/

Name of Cluster	**TECHNOLOGICAL RESEARCH CENTRE OF WESTERN MACEDONIA**
Establishment date	Thursday, 8 January, 2009
Legal form of the cluster organisation	Non-Profit
Region	Western Macedonia
Sectoral Industries	Metalworking Technology
Technology Fields	Energy management, Metals and Alloys
EU Priority Areas	Bio fuels & energy efficiency, Basic metals & of fabricated metals products
Emerging Industries	Blue Growth Industries, Experience Industries
Total number of members	48
Number of SME members	37
Number of larger company members	3
Number of research organisations/universities/technology centres	8
Cluster Strategy	Information for all, raising awareness on metal issues (magazines, internet, seminars, conferences) • Better Prices in raw materials, energy, services and products • Strategic marketing plans for the promotion in new markets and exports • Common research and co-operation with universities and research institutes • Scientific and organisational support • Representation with prestige • Certification of enterprises (ISO, CE, etc) • Promotion of new products and patents • Counselling on funding programs
Services Provided	• Access to technology services • Direct advisory services • Facilitation of collaboration between members • Periodic Information dissemination • Support of knowledge transfer
Participation in Funded Support Programs	Regional West Macedonia Development Fund
Additional Information	N/A

The abovementioned findings allow to identify the current situation of the present Greek networking and clustering system. Even though some elements of an effective networking system are present in Greece, crucial factors are still missing. Networks among basic research, applied research and business need to be further extended in number and quality towards the creation of regional clusters, in order to act as the catalyst for the Greek economy's digitisation.

7.5.4 DEI Pillar 4: Preparing Europeans for the digital future

The 4th DEI pillar concerns the preparation of Europeans for the digital future. As Industry 4.0 changes the workforce, it is important to provide digital skills and reskilling programs that will enable all Europeans to find opportunities in the digital workplace.

The current state of Europe with regards to digital skills and human capital has been presented in full detail in paragraph 6.5.3 as well as in Appendix I. In this section, we only mention a few emblematic initiatives that the EU has undertaken for the acceleration of the digital upskilling and reskilling of the European human capital.

Key Initiative	Description	Outcome
The Digital Skills and Jobs Coalition[405]	The Digital Skills and Jobs Coalition brings together Member States, companies, social partners, non-profit organisations and education providers to act to improve digital skills of all types in Europe.	The activities of the Coalition provided 3.7 million trainings in digital skills, over 1 million digital skills certifications, 4000 events, over 9000 job placements, and around 200 internships by March 2018. More than 320 members (companies, non-profit organisations and educational institutions) have already joined the initiative, with 90 making concrete pledges.
The Digital Opportunity Scheme[406]	The Digital Opportunity Scheme aims to boost EU digital skills through internship opportunities for students of all disciplines residing in the EU.	Starting in the fall of 2018, the initiative aims to offer 4-5 month paid internship, at a €500/month stipend to 5000-6000 graduate students across all disciplines until the year 2020.
The Digital Education Action Plan[407]	The Action Plan focuses on initial education and training systems (including schools, vocational education and training (VET) and higher education), prioritizing digital technologies for teaching and learning, digital competences and skills, and the improvement of education through data analysis and foresight.	The Plan has no specific outcomes. Nevertheless, it identifies 11 actions in 3 main categories that shall be implemented by the end of 2020: a) Making better use of digital technology for teaching and learning: (1) Connectivity in Schools, (2) SELFIE self-reflection tool & mentoring scheme for schools, (3) Digitally Signed Qualifications b) Developing digital competences and skills: (4) Higher Education Hub, (5) Open Science Skills, (6) EU Code Week in schools, (7) Cybersecurity in Education, (8) Training in digital and entrepreneurial skills for girls c) Improving education through better data analysis and foresight: (9) Studies on ICT in education, (10) Artificial Intelligence and analytics, (11) Strategic foresight

On top of the EU initiatives for digital skills, our analysis of the 16 national Industry 4.0 strategies indicated a number of countries have undertaken a set of initiatives to accelerate the digital up-skilling and reskilling of their human capital.[408]

Digital Skills Development	
Belgium	Enhancing the digital skills of children and young people. €18 million for 3 years.

[405] European Commission, The Digital Skills and Jobs Coalition, https://ec.europa.eu/digital-single-market/en/digital-skills-jobs-coalition
[406] European Commission, Pilot project to boost digital skills through internships, https://ec.europa.eu/digital-single-market/en/news/commission-announces-pilot-project-boost-digital-skills-through-internships
[407] Digitising European Strategy: Progress so Far, 2 Years after the Launch, March 2018
[408] For a detailed list of sources with regards to national Industry 4.0 strategies/ initiatives please refer to paragraph 7.2.

Belgium	Belgium Skills development (digital education in schools, businesses and organisations, free ICT education for the unemployed). This is the first axis of the Marshall Plan 4.0. €305 million
Belgium	Centre "BeCentral": A 2.000 square metre training centre where young people and adults improve their digital skills (launched: October 2017).
Belgium	"Digital Champions.be": Collaboration bringing together stakeholders from governments, the education community and the private sector to enhance citizens' digital skills.
Germany	"Future of the German Mittelstand" program for SMEs: an initiative to enhance vocational education, provide advice to SMEs, modernise vocational education.
Germany	"Berufsbildung 4.0" (vocational training 4.0): action to restructure vocational training.
Denmark	Improved Postgraduate.dk and Better Adult and Continuing Education - WEU programs for adult education.
Spain	Long-distance digital education program, with an annual budget of €45 million.
Italy	Dissemination of I4.0 culture through the programs "Scuola Digitale" and "Alternanza Scuola Lavoro".
Italy	I4.0 Skills Development through Vocational Training, with the Support of "Instituti Tecnici Superiori".
Italy	Financing Technological Clusters I4.0 and Industrial PhDs.
Lithuania	I4.0 training in InTechCentras, in collaboration with LINPRA.
UK	£400 million investment in math as well as digital and technology education.
UK	Creation of National Re-Education Plan: £64 million investment in digital technologies and construction is included.
Poland	"Broad Alliance on Digital Skills in Poland": a voluntary association of ICT training institutes, organisations and companies. "Air 4.0": automation and robotics training.
Portugal	22 measures for the development and enhancement of digital skills, which are structured into 4 objectives: (a) primary, secondary and vocational education, (b) higher education, (c) upgrading of human resources skills, (d) industry attractiveness.
Sweden	Awarded to the Swedish Development Directorate in October 2016: (a) a three-year pilot project to strengthen cooperation between schools, industry and industrial services companies (€313.000 per year), (b) a skills development plan for industrial SMEs (€313.000 per year). Period: 2017-2019.

The State of Play in Greece

The current state of Greece with regards to digital skills and human capital has been presented in full detail in paragraph 6.5.3 as well as in Appendix I. In this section, it is worth nevertheless mentioning some emblematic initiatives that Greece has undertaken for the acceleration of the digital upskilling and reskilling of the Greek human capital.

During the last years, the Greek Government has undertaken some key initiatives for the digital upskilling and reskilling of the Greek human capital. In June 2018, the Greek National Coalition for Digital Skills and

Jobs was launched.[409] The Greek Coalition was led by the Ministry of Administrative Reconstruction and included Central Government agencies, Local Government agencies, businesses, social partners and NGOs as its members. In this context, the national coalition 2018 Action Plan was designed. This plan included 54 actions that covered the following areas:

- design and development of accessible digital educational material
- upgrade education infrastructures
- subsidise job positions in ICT enterprises
- train in digital marketing for SMEs in the tourism industry
- launch vocational training programmes in the field of ICT etc.

Some of the most emblematic initiatives included in the action plan were:

- The training in digital marketing for SMEs to enhance the extension of tourist season in regions of Greece (with the support of Google).
- The creation of job positions in ICT enterprises for 12 months. The total number of beneficiaries would be 500 young unemployed aged 25 to 29 years old. The budget for the programme was be EUR 7,000,000.
- The introduction of measures regarding training, certification and up-skilling in the field of ICT at Regional Level, for 3000 unemployed for the 18-24 group age and 1250 already employed.
- The "Digital Skills for All" initiative: Short Learning Programmes (SLPs) developing digital skills to encourage people to be active in the context of the digital society. The initiative was launched in Cooperation with the Ministry of Digital Policy, with the support of the Hellenic Open University (HOU), targeting 150,000 people.

In addition, in 2017 the "Alliance for Digital Employability (AFDEmp)" initiative[410] provided a 12 or 24- week intensive training course to previously unemployed candidates with no ICT background, in order to reskill and certify them as full stack developers in Java or C#. Candidates. Until today, 97% are hired as entry-level, full-stack developers by top companies.

Although the abovementioned initiatives are considered positive steps, the digital skills gap appears to be a key structural inhibitor for the Greek Industry. In fact according to a latest EU report, software engineering, data science and machine learning seem to be the top three digital skills in demand in Greece.[411] This is explained by the fact that all initiatives undertaken by the Public Administration, academia, federations and private businesses were fragmented, dispersed and were not underpinned by any common digital skills vision and strategic guidelines. In addition, it appears that there is no structured mechanism in place to measure the effectiveness of the undertaken digital skills initiatives. This leads to lack of and/or wrong information with regards to the real level of digital skills across the Greek society and workforce.

[409] European Commission, Greek Digital Skills and Jobs Coallition, http://www.nationalcoalition.gov.gr/
[410] Alliance for Digital Employability, https://www.afdemp.org/
[411] European Commision, Digital Skills New Professions, New Educational Methods, New Jobs, https://ec.europa.eu/digital-single-market/en/news/digital-skills-training-blueprints-upskilling-sme-employees-and-unemployed-persons

To address these issues, the Ministry of Digital Governance aims to design a new digital skills initiative, the “Digital Academy”. Digital Academy will act as the platform that will interconnect all digital skills initiatives, will enable collaboration between the various bodies that provide ICT training and certification, will eliminate overlaps and replications, will provide global expertise and best practices and will enable international collaboration.[412]

7.5.5 DEI Pillar 5: A regulatory framework fit for the digital age

The fifth pillar focuses on designing a regulatory framework fit for the digital age. The European Commission has proposed several measures for the update of regulatory frameworks in fields such as cybersecurity and the free flow of data, which are key for the development of Industry 4.0.

The business practice transformations brought about by Industry 4.0 technology adoption will require a diligent and proactive regulatory preparation, not just as a means of minimizing risk, but as a key facilitator of Industry 4.0’s growth potential. As data sources and data-transmitting devices grow exponentially, so do the opportunities for cyber-attacks. As such, cyber resilience will be central to national industries’ transition to the fourth industrial revolution.

Furthermore, the ability to share data quickly and seamlessly across corporate and national borders is vital to the growth of vibrant industrial ecosystems. As such, national laws will need to be refined to overcome obstacles such as data localisation restrictions, vendor-lock-in of data by IT service providers, and legal uncertainty around data storage and processing. In the same way that red tape discourages the investment of capital, untrustworthy or unclear legal regulations around data are likely to dissuade the sharing of data with organisations operating within a loosely regulated national framework.

In addition, the upcoming surge of artificial intelligence applications in industry will require targeted legislative actions to address ethical, legal and societal issues and to facilitate a thriving platform economy. As such, regulations safeguarding business users against harmful trading practices while protecting platform operators from emerging fragmentation work to ensure a fair, predictable, and trusted business environment.[413]

Finally, the transition towards a circular economy, that will boost global competitiveness and foster sustainable economic growth, requires a new set of regulations at a European level that will monitor and adjust the overall production and consumption, waste management, use of secondary raw materials and will bring on the table a revised legislative proposal on waste.

For these reasons, the European Commission identifies five key areas of regulatory focus:

1. Cybersecurity: The following cybersecurity initiatives have been undertaken by the EU during the last years:[414]
    1.1. The NIS directive is the first piece of EU-wide legislation on cybersecurity. It provides legal measures to boost the overall level of cybersecurity in the EU[415]

[412] As per interview with the Ministry of Digital Governance held on Monday, 13 January 2020.
[413] Digitising European Strategy: Progress so Far, 2 Years after the Launch, March 2018
[414] European Commission, Cybersecurity, https://ec.europa.eu/digital-single-market/en/policies/cybersecurity
[415] The Directive on security of network and information systems, https://ec.europa.eu/digital-single-market/en/network-and-information-security-nis-directive

1.2. The Cybersecurity Act, that consists of two initiatives to promote cybersecurity, a comprehensive reform of ENISA and the creation of a cybersecurity certification framework recognised across the EU[416]
1.3. The blueprint for rapid emergency response provides a plan in case of a large-scale cross-border cyber incident or crisis[417]
1.4. Measures for free and fair European elections, including recommendations on election cooperation networks, online transparency, protection against cybersecurity incidents and fighting disinformation campaigns[418]
1.5. A Network of Cybersecurity Competence Centres and a new European Cybersecurity Industrial, Technology and Research Competence Centre proposed by the Commission with the goal of robust and innovative cybersecurity in the EU[419]
1.6. A set of operational steps and measures to ensure a high level of cybersecurity of 5G networks across the EU, recommended by the Commission[420]
1.7. The framework for a joint EU diplomatic response to malicious cyber activities under the Common Foreign and Security Policy for Cyber-defence, including restrictive measures which can be used to strengthen the EU's response to activities that harm its political, security and economic interests[421]

2. The free flow of non-personal data: The EU has proposed a regulation on free flow of non-personal to enable the abolishment of localisation restrictions. This combined with the General Data Protection Regulation (GDPR) will facilitate the creation of a common European data space.[422] The Regulation ensures:
2.1. The free movement of non-personal data across borders: every organisation should be able to store and process data anywhere in the European Union,
2.2. The availability of data for regulatory control: public authorities will retain access to data, also when it is in another Member State or when it is stored or processed in the cloud,
2.3. The easier switching of cloud service providers for professional users. The Commission has started facilitating self-regulation in this area, encouraging providers to develop codes of conduct regarding the conditions under which users can port data between cloud service providers and back into their own IT environments,
2.4. The full consistency and synergies with the cybersecurity package, and clarification that any security requirements that already apply to businesses storing and processing data will continue to do so when they store or process data across borders in the EU or in the cloud.

416 European Commission, The EU Cybersecurity Act, https://ec.europa.eu/digital-single-market/en/eu-cybersecurity-act
417 European Commission, Recommendation on Cybersecurity, https://eur-lex.europa.eu/eli/reco/2017/1584/oj
418 European Commission, Recommendation on election cooperation networks, online transparency, protection against cybersecurity incidents and fighting disinformation campaigns in the context of elections to the European Parliament, https://ec.europa.eu/commission/sites/beta-political/files/soteu2018-cybersecurity-elections-recommendation-5949_en.pdf
419 European Commission, Proposal for a European Cybersecurity Competence Network and Centre, https://ec.europa.eu/digital-single-market/en/proposal-european-cybersecurity-competence-network-and-centre
420 European Commission, Secure 5G deployment in the EU: Implementing the EU toolbox - Communication from the Commission, https://ec.europa.eu/digital-single-market/en/news/secure-5g-deployment-eu-implementing-eu-toolbox-communication-commission
421 European Council, Cyber attacks: EU ready to respond with a range of measures, including sanctions, https://www.consilium.europa.eu/en/press/press-releases/2017/06/19/cyber-diplomacy-toolbox/
422 European Commission, Free flow of non-personal data, https://ec.europa.eu/digital-single-market/en/free-flow-non-personal-data

3. The European Data Strategy: The goal of the European Data Strategy is to create a single market for data where data can flow within the EU and across sectors, where EU-wide rules of privacy, data protection, and competition law are fully respected, while rules for access and use of data are fair, practical and straightforward. [423] To make the EU an attractive, secure, and dynamic data economy, the EU Data Strategy aims at:
    - Setting clear and fair rules on access and re-use of data;
    - Investing in next generation standards, tools and infrastructures to store and process data
    - Facilitating the coordination of Member States in joining forces in European cloud capacity
    - Pooling European data in key sectors, with EU-wide common and interoperable data spaces
    - Giving users rights, tools and skills to stay in full control of their data

4. AI-regulations: EU has proposed a set of regulations and guidance for defining the benefits of AI and coordinating citizens, businesses, and the public interest within the EU in order to maximize the potential benefits that AI has to offer along various dimensions.
    4.1. Ethics Guidelines for Trustworthy Artificial Intelligence: The European Commission welcomed the final Ethics Guidelines for Trustworthy Artificial Intelligence prepared by the High-Level Group on Artificial. The European Commission also welcomed the Report on liability for Artificial Intelligence and other emerging technologies prepared by the Expert Group on Liability and New Technologies – New Technologies Formation.[424]
    4.2. EU AI Strategic Framework: In order to fully leverage AI in the EU, the European Commission has aligned its efforts toward the creation of an ‘ecosystem of excellence’ and an ‘ecosystem of trust’. Excellence in AI can be achieved through the effective mobilisation and incorporation of the public and private sector along the entire value chain. The ‘ecosystem of trust’, as it is referred to by the European Commission, is defined as the close cooperation between regional authorities, industry stakeholders, and EU policymakers to ensure that legal frameworks and compliance measures create the right incentives for the accelerated adoption of AI technologies. To foster growth in the field of AI, the European Commission aims at coordinating Member States, industry, academia and civil society through concrete proposals for boosting investments in R&D, enhancing the development of AI skills, and supporting the uptake of AI by SMEs. In this context the European Commission has issued the “White Paper on AI: a European approach to excellence and trust”[425] the “Artificial Intelligence for Europe”[426] and the “Coordinated Plan on Artificial Intelligence”[427] that chart the roadmap for Member States towards the aforementioned direction. In more detail, the “White Paper on AI: a European approach to excellence and trust” introduces a coordinated European approach on the human and ethical implications of AI as well as a reflection on the better use of big data for innovation. The “Artificial Intelligence for Europe” sets out a European initiative on AI which aims to boost the EU's technological and industrial capacity and AI uptake across the economy, both by the private and public sectors, prepare for socio-economic changes brought about by AI and ensure an appropriate ethical and legal

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[423] European Commission, The European Data Strategy, https://ec.europa.eu/commission/presscorner/detail/en/fs_20_283
[424] European Commission, Artificial Intelligence, https://ec.europa.eu/digital-single-market/en/artificial-intelligence
[425] European Commission, Artificial Intelligence - A European approach to excellence and trust, https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf
[426] European Commission, Artifical Intelligence for Europe, https://ec.europa.eu/transparency/regdoc/rep/1/2018/EN/COM-2018-237-F1-EN-MAIN-PART-1.PDF
[427] European Commision, Coordinated Plan on Artificial Intelligence, https://ec.europa.eu/knowledge4policy/publication/coordinated-plan-artificial-intelligence-com2018-795-final_en

framework, based on the Union's values and in line with the Charter of Fundamental Rights of the EU. Finally, the "Coordinated Plan on Artificial Intelligence" introduces a coordinated plan that incorporates joint actions for closer and more efficient cooperation between Member States, Norway, Switzerland and the Commission in four key areas: increasing investment, making more data available, fostering talent and ensuring trust.

5. <u>Business relations to online platforms:</u> The regulation on online platform-to-business relationships provides a framework for minimum transparency and redress rights. The regulation protects companies dependent on online platforms for marketing their products and safeguards the innovation capacity of platforms. The online platform economy Observatory, monitors and analyses the latest trends and issues regarding online platform economy.[428]

6. <u>Regulations on Circular Economy:</u> The European Commission has adopted several measures and regulations throughout the years to promote the circular economy. Namely:
   6.1. In 2015, the European Commission adopted the EU Circular Economy Action Plan. The plan introduced several measures to help stimulate the European transition towards a circular economy, in order to boost global competitiveness, foster sustainable economic growth and generate new jobs. The EU's action plan for the Circular Economy includes goals related to overall production and consumption, waste management, use of secondary raw materials and the revised legislative proposal on waste. Indicatively, common EU targets include recycling 65% of municipal waste by 2035, 70% of packaging waste by 2030, and a number of minimum requirements for extended producer responsibility schemes to improve cost efficiency and governance.[429]
   6.2. The Green Deal: In order to support the sustainable growth and promote advances in the circular economy, the European Commission also introduced the European Green Deal in 2019. This is a set of policy initiatives with the overarching aim of making the European Union climate neutral by 2050. The initiatives incorporated in the European Green New deal aim at decarbonizing the energy sector, incentivizing building renovation to achieve greater energy efficiency, supporting industry to innovate and become leaders in the green economy globally, and rolling out cleaner, cheaper and healthier forms of public and private transportation. [430]
   6.3. The EU Plastics Strategy: In an effort to minimize the amount of plastics used in the European economy, the European Commission has devised the "European Strategy for Plastics in a Circular Economy". The strategy consists of a set of measures aimed at improving the economics and quality of plastics recycling, at curbing plastic waste and littering, at driving investment and innovation towards circular solutions and at harnessing global action through the cooperation with industries and governments outside European borders. To achieve this, the strategy incorporates a wide set of initiatives, from product design measures and recycling regulations (to increase monitoring and policymaking with regards to pollution and waste management), to investment incentivisation for plastic and waste-reduction initiatives in the private sector.[431]

[428] European Commission, EU Observatory on the Online Platform Economy, https://ec.europa.eu/digital-single-market/en/eu-observatory-online-platform-economy
[429] European Commission, EU Circular Economy Action Plan, https://ec.europa.eu/environment/circular-economy/
[430] European Commission, Communication on The European Green Deal, https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf
[431] European Commission, European strategy for plastics, https://ec.europa.eu/environment/waste/plastic_waste.htm

Finally, before we move to the Greek state of play with regards to the regulatory framework, it is important to mention that in March 2020, the European Commission introduced the EU Industrial Strategy and the EU SMEs Strategy.

7. European Industrial Strategy: The EU Industrial Strategy which aims at facilitating transition of European industry into the Industry 4.0 paradigm. The Strategy is predicated around three key strategic priorities: maintaining the EU industry's competitiveness at home and globally, making Europe climate neutral by 2050, and shaping the continent's digital future. The EU's Industrial Strategy includes actions to accelerate competition globally and locally, such as an Intellectual Property Action Plan, the comprehensive review of current EU competition rules, a white paper to address the distorted effects caused by foreign subsidies and an action plan on Critical Raw Materials, to secure their steady supply to EU industrial companies. Furthermore, the Strategy includes a significant number of initiatives focusing to promote the modernisation and decarbonisation of energy intensive industries such as the Clean Hydrogen Alliance and new green public procurement legislations. Sector specific actions have also been introduced, such as new EU Pharmaceutical Strategy while innovation, investment and skills are supported on a cross-sectoral level within the Strategy. The EU Industrial Strategy also places weight on the support of industrial ecosystems, indicating that the Commission understands their centrality to Industry 4.0. In this context, the Strategy devises is the creation of an industry forum aimed at analysing the risks and needs of different industrial ecosystems[432]. Moreover, a significant segment of the Industrial Strategy is dedicated to the removal of entrenched barriers in the European single market. The Single Market Enforcement Action Plan aims at removing structural barriers to the single market such as lack of access to information, burdensome administrative procedures, uneven access to public procurement, and market access denial due to complicated standard requirements, geo-blocking, language barriers, and different tax regimes.[433]

8. EU SME Strategy: With SMEs in Europe being the backbone of EU's economy, counting 25 million enterprises and employing around 100 million people (67% of jobs in EU), they are essential for Europe's economic and technological prosperity and hence, a core component in the achievement of the EU's Industrial Strategy. [434] In this context, the newly introduced EU SME Strategy, aims at supporting SMEs as they undergo the twin transitions of digital and green transformation. Its main priorities include removing regulatory and practical obstacles to SME growth, supporting SME initial public offerings through the InvestEU SME window, and introducing the EU Start-up Nations Standard, which will share and adopt best practices to accelerate growth of high-tech SMEs and start-ups.[435] Prerequisite for a robust implementation is the effective collaboration between the EU and the Member States (including regional and local authorities), as well as the active involvement of the SME community and companies alike. The ultimate goal is to make Europe the most attractive place to start a small business and set the right foundations for it to grow and scale up in the single market.[436]

[432] European Commission, A new Industrial Strategy for a globally competitive, green and digital Europe, https://ec.europa.eu/commission/presscorner/detail/en/fs_20_425
[433] European Commission, A single market that delivers for businesses and consumers, https://ec.europa.eu/commission/presscorner/detail/en/fs_20_427
[434] European Commision, An SME Strategy for a sustainable and digital Europe, https://ec.europa.eu/info/sites/info/files/communication-sme-strategy-march-2020_en.pdf
[435] European Commission, Unleashing the full potential of European SMEs, https://ec.europa.eu/commission/presscorner/detail/en/fs_20_426
[436] European Commision, An SME Strategy for a sustainable and digital Europe, https://ec.europa.eu/info/sites/info/files/communication-sme-strategy-march-2020_en.pdf

The State of Play in Greece

Key enabler for industry's digitisation consists the establishment of a friendly and flexible regulatory system that will encourage investors, managers and entrepreneurs. This appears not to be the case for Greece. According to a set of third-party indexes, companies in Greece face an adverse regulatory system, which can be considered as a critical reason for continuous exodus of capital, labour and entrepreneurship from Greece. Greek businesses, both start-ups and larger ones, face a multitude of regulatory hurdles, restrictions, and red tape. Complicated regulations in different areas as well as time- and cost-intensive procedures create uncertainty and hinder business activity, and in particular innovation and entrepreneurship.

The annual "Doing Business" report of the World Bank assesses economies with regard to underlying factors relevant to their economic performance, such as the regulatory system, the functioning of the bureaucracy and business governance. For 2020, Greece ranks 79th amongst 190 economies, falling 19 places since 2016 (in 2016, Greece scored on the 60th position amongst 189 countries) (see Figure 82).[437]

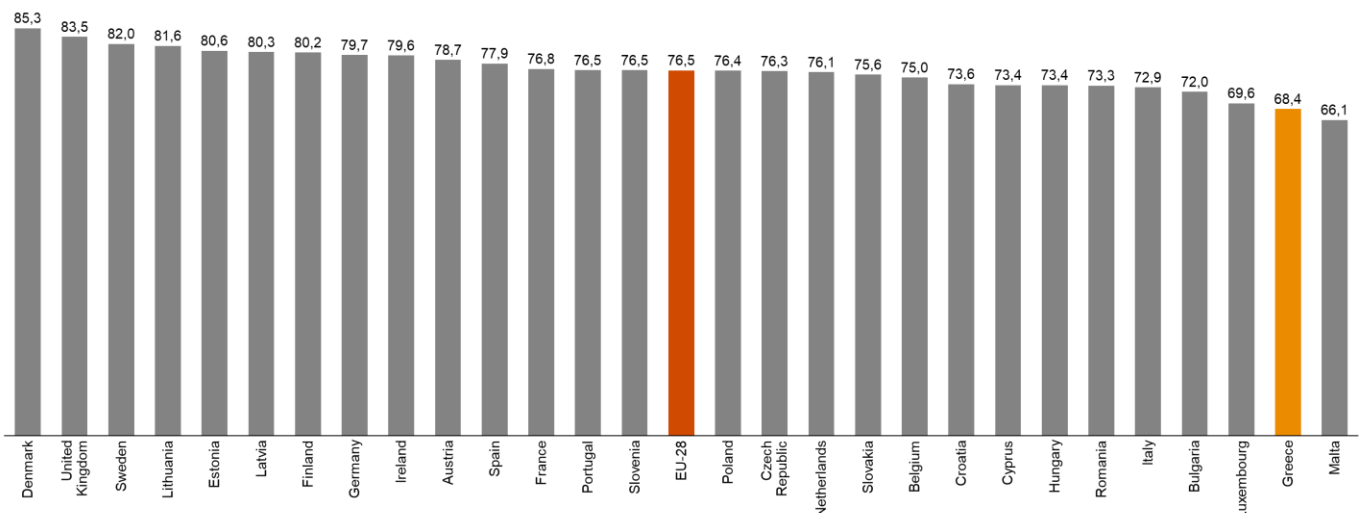

Figure 82: Ease of Doing Business Scores 2020 – EU28 – Source: World Bank Group, Ease of Doing Business 2020

[437] World Bank Group, Ease of Doing Business, https://www.doingbusiness.org/

In 2020, Greece demonstrates its best score across the "starting a business" (rank 11), "trading across borders" (rank 34) and "protecting minority investors" (rank 37). Nevertheless, Greece's performance is still extremely poor in some areas: "registering property" (rank 156), "enforcing contracts" (rank 146) (see Figure 83). [438]

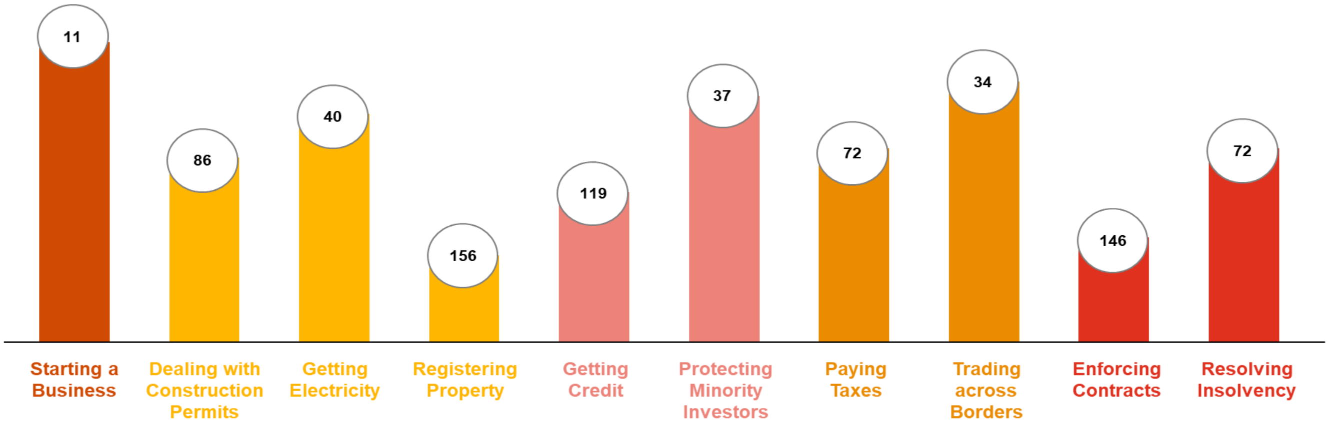

Figure 83: Ranking on Doing Business topics - Greece – Source: World Bank Group, Ease of Doing Business 2020

In addition, according to WEF's Global Competitiveness Index 2018, Greece's legal framework ranks last among the 28 EU member states and 124th out of 141 economies in terms of its adaptability to digital business models. This reflects Greece's legal framework's lack of adaptability and overall weakness when it comes to accommodating business interests in newly emerging digital fields, such as e-commerce, sharing economy, and FinTech (see Figure 84).[439]

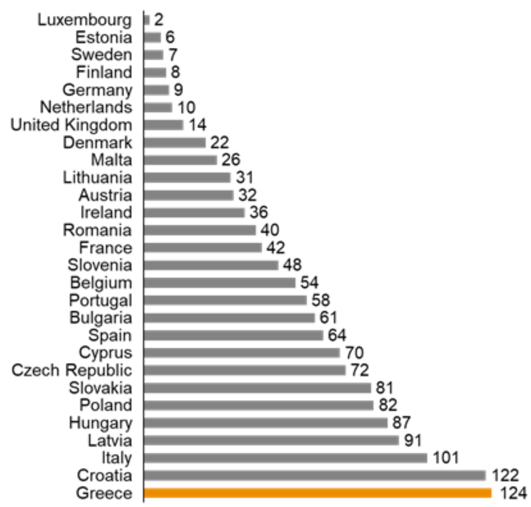

Figure 84: Global Competitiveness Index 2018 – Legal framework's adaptability to digital business models – Source: WEF, Global Competitiveness Index, EU28 by WEF Global Rank

[438] World Bank Group, Ease of Doing Business, https://www.doingbusiness.org/content/dam/doingBusiness/country/g/greece/GRC.pdf
[439] Global Competitiveness Index 2018 - http://www3.weforum.org/docs/GCR2018/05FullReport/TheGlobalCompetitivenessReport2018.pdf

Furthermore, the need for modernising Greece's legal framework to accommodate the growth new technologies is echoed in the World Economic Forum's Networked Readiness Index 'Laws Relating to ICTs' dimension. The latter assesses the development level of a country's ICT-related laws in fields such as e-commerce, digital signatures, and consumer protection. According to the NRI index, Greece ranks last among all EU countries, and 94th out of 139 countries globally (see Figure 85). [440]

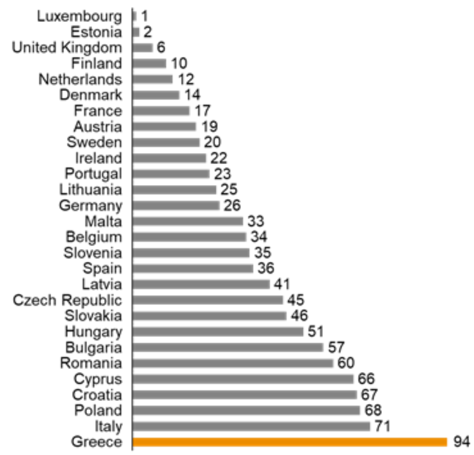

Figure 85: Networked Readiness Index 2016 – Laws Relating to ICTs – Source: WEF, Global Competitiveness Index, EU28 by WEF Global Rank

Indicative Initiatives that Greece has undertaken for DEI Pillar 5

In the previous years the Greek authorities have undertaken a limited number of initiatives to transform Greece's regulatory environment and facilitate the Greek digital economy. These initiatives included the Directive (EU) 2016/1148 for Cybersecurity[441] and the national cloud policy.[442] In the latest months, two initiatives have been taken up by the Greek government in order to simplify and promote the regulatory environment of the country:

- Law 4622/2019: This new law practically seeks to re-organize the way the country's public administration is conducted, by simplifying the process of decision making (which from now on will be operated centrally from the Government). This will allow for clarity and coordination of actions among all respective Ministries, resulting in turn in a more efficient and less time-consuming policy making procedure.
- The new multibill that seeks to address the growth of the economy and the country at multiple levels. With respect to the Greek Industry, the multibill seeks to simplify the issuing of licenses for businesses in the Industry sector as well as offer financial incentives to businesses that seek to operate in the context of business clusters. This latter provision can drastically create value chains among business, leading to greater synergies and better results.

In addition, during the last years, a set of horizontal efforts have been implemented to boost and assist the business environment of Greece. Specifically, laws L. 4442/2016 & 4512/2018 have been pursued. Furthermore, in 2019, law L.4442/2016 was supplemented and extended by law 4635/2019, introducing simplification of the standardisation, licensing and supervision processes as well as by Law 4512/2018, which establishes a new framework for the supervision of economic activities and the product markets.

Also, since early 2018, the "Better Regulation Delivery Directorate" of the General Secretariat for Industry has been established in order to act towards the successful implementation of the aforementioned laws.

[440] WEF, Networked Readiness Index, https://reports.weforum.org/global-information-technology-report-2016/networked-readiness-index/?doing_wp_cron=1578844630.9907069206237792968750
[441] European Commission, Instruction on the security of wireless networks and information in Europe, https://eur-lex.europa.eu/legal-content/EL/TXT/PDF/?uri=CELEX:32016L1148&from=EN
[442] Ministry of Digital Governance, G-Cloud, https://www.gsis.gr/dimosia-dioikisi/G-Cloud

As stated in the OECD Economic Survey of Greece 2018-2020, "the digitisation of licensing and inspection procedures through an Integrated Licensing Information Management System (ILIMS)" is pursued. "The development of the ILIMS has been approved for funding under the structural funds programme and will be key to the implementation of reforms through the digitisation of processes that enhance the transparency and efficiency of public administration". Further to that, since June 2017, the electronic licensing platform "Notify business – notifybusiness.gov.gr" was established. Lastly, in a significant effort to reduce the administrative burdens of enterprises, the new law for electronic one-stop shops (e-OSS) was developed (Law 4441/2016 and MD 63577/2018). As per OECD's report "E-OSS has been extremely successful and user-friendly, making the minimum time for creating a company just 6 minutes. Since July 2018, 8.838[443] companies have been created with e-OSS."

7.6 Global developments affecting the European Industrial landscape

On another note, the recent COVID-19 pandemic leads to an economic downturn and necessitates countries' rapid digitisation.

This report was finalised during the outbreak of the global COVID-19 pandemic, which, apart from the worldwide top-priority health and social implications, is expected to severely impact the global and the Greek economy. While the economic aftermath of the COVID-19 pandemic cannot be forecasted with certainty due to a vast number of unknowns, an imminent economic shock appears inevitable. It uniquely produces a dual shock felt at once by the financial system and the real economy. As financial markets collapse, businesses are in a standstill, with social distancing measures halting a sizeable portion of the economy's productive capabilities. Moreover, the interrelated relationship between the real economy and the financial markets further complicates the situation, as issues in one could affect the other. A recent OECD report on the evaluation of the initial impact of COVID-19 containment measures on the global economic activity, suggests that the initial direct impact of the business shutdowns could lead to a decline in the level of output of between one-fifth to one-quarter in many economies, with consumers' expenditure potentially dropping by around one-third. Rough estimates indicate that all major forces, like Germany, France, the United Kingdom, Italy and the USA may lose up to 30% of their annual GDP due to the potential impact of partial or complete shutdowns on activity, while Greece, a country that is heavily dependent on retail and tourist and leisure services this decrease may come up to 35% of its annual GDP.

In this context, the European Union thoroughly coordinates a common European response to the coronavirus outbreak and is currently examining measures to help the Member States respond to the apparent unprecedented crisis by taking actions to reinforce their public health sectors and mitigate the socio-economic impact of the pandemic. From supporting research on vaccines, diagnostics and treatment, to ensuring the flow of goods and workers' mobility in the EU single market, as well as putting in place flexible state rules to save jobs and companies, the European Commission does its best to tackle the crisis. Thus far EU has mobilized around 3,4 trillion euros with 2,5 trillion euros being national liquidity measures and the rest coming from multiple sources at an EU-level such as the European Investment bank group financing for businesses, the SURE-EU funding for short time work schemes, the European Stability Mechanism, direct EU budget support, etc.

[443] Data received from Greek Business Register dated 4th December 2019

The European Commission published on 15 April 2020[444] a document reflecting on the need for the EU to act swiftly on the COVID-19 pandemic in order to form "a comprehensive recovery plan and unprecedented investment to help the economies across the EU relaunch and transform". The document places an emphasis on the need to "achieve strategic autonomy of the EU" by supporting to the utmost extent the European industrial sector, and more specifically the SMEs and startups within it, through a solid Industrial policy, investing in strategic value chains. In the lines of this, the IndustriAll Europe organisation, on April 28th 2020[445] (representing employees in the manufacturing, mining and energy sectors) sparked a discussion that highlighted the need for a Recovery plan for Europe and more specifically the European Industry. Highly impacted by COVID-19, the European Industry, having its workforce at the epicentre, should be highly supported as one of the main pillars that will assist the EU overcome this crisis. For that reason, the key areas/ initiatives highlighted by IndustriAll Europe are the following:

- Assisting viable companies to cope with the crisis and remain competitive, at the same time assisting their human capital to grow and become more competent in this challenging environment.
- Map out the impact of COVID 19 across the Industrial sectors, designing tailored strategic initiatives for their recovery, investing in a sustainable Industry for the future and pursuing the simultaneous transition of the EU industry with regards to digitalisation and a low-carbon footprint.
- Enhance strategic industrial value chain across the EU, aiming at the autonomy of EU Industry.
- Introduce and utilise innovative instruments (i.e., as mentioned by IndustriAll EU, the "**Carbon Border Adjustment Mechanism** or the **Instrument on Foreign Subsidies")** as well as dedicated funds in order to assist in this overall boost of the European Industry.

On the Greek forefront and with regards to the COVID 19 pandemic, on May 20th 2020, the Greek Prime Minister announced a reboot plan to the tune of 24 billion euros that will serve as a three-pillar bridge from "from today's uncertainty to tomorrow's security" aiming primarily to revive the Greek tourism and other Greek economic sectors hit by the coronavirus pandemic. These three pillars will focus on job support, targeted tax cuts and the boosting of entrepreneurship. In addition, all unemployment benefits shall be extended and the government will also subsidize salaries and social security contributions for workers in the tourism sector. It will also pay unemployment benefits to seasonal employees, who will not be hired this year. Moreover, there will be a five-month reduction (from June 1 until October 31) of VAT from 24% to 13% for travel by ship, bus and airplanes, so that those who go on vacation in the summer "can do so at the lowest possible cost."

Despite the severely negative economic effects of the pandemic, it is worth mentioning, that COVID-19 "forces" businesses around the world and within Greece to deploy digital technologies immediately and at a large-scale to deal with such an emergency. Social distancing has enforced the Greek Public Sector to accelerate the digitisation of the public services provided, schools have started providing remote learning capabilities, while the majority of the Greek enterprises have adopted digital technologies that enable their employees to work remotely from home. This shall potentially lead to an abrupt, nevertheless much needed digital upskilling of the Greek society and workforce.

[444] https://www.consilium.europa.eu/media/43384/roadmap-for-recovery-final-21-04-2020.pdf
[445] https://news.industriall-europe.eu/content/documents/upload/2020/4/637238495414024176_Letter%20to%20Commissioner%20Breton.pdf

For further implications, threats and opportunities imposed by the COVID-19 outbreak, please refer to Deliverable 2: National Strategy for the 4th Industrial Revolution (Greece i4.0) (2021 -2027) for the Greek industry and manufacturing.

Strategic review of the present mechanisms, the policy mix and measures governing the digital transformation of the Greek Industry

7.7 Chapter's Summary

Greece is only at the beginning of a long and demanding effort, in order to achieve Digital Transformation in the Industry sector. Up until today, there has been no official policy or action in the form of a strategy/ initiative etc. from the side of the Greek state in order to support the transition of the Greek industry to the new digital era, i.e. towards Industry 4.0. Nevertheless, a set of measures have already been taken towards the right direction.

- The establishment of the Ministry of Digital Policy, Telecommunications and Media in 2016 was a first positive step towards assisting the digitalisation of the country and the economy overall. On the 8th of July 2019, the Ministry of Digital Governance was established in the place of the former Ministry of Digital Policy, Telecommunications and Media. The new Ministry currently updates the National Digital Strategy 2016-2021, in order to produce an enhanced and improved version that will be officially published within the first half of 2020.
- At the same time, an important step has also been taken by the signing of a memorandum of cooperation (in May 2019) regarding the setup of a digital Industry 4.0 platform, between the General Secretariat for Industry and the Ministry of Digital Governance.

Besides the aforementioned, in the latest months, two initiatives have been taken up by the Greek government in order to simplify and promote the regulatory environment of the country:

- Law 4622/2019, that seeks to re-organize the way the country's public administration is conducted, by simplifying the process of decision making (which from now on will be operated centrally from the Government).
- Law 4635/2019 (new multibill) that seeks to address the growth of the economy and the country at multiple levels. With respect to the Greek Industry, the multibill seeks to simplify the issuing of licenses for businesses in the Industry sector as well as offer financial incentives to businesses that seek to operate in the context of business clusters.

Furthermore, action has been taken towards the simplification of the regulatory framework for economic activities, the simplification of the standardisation, licensing and supervision process of enterprises as well as establishes a new framework for the supervision of economic activities and the product markets. On the same note, in an effort to reduce the administrative burdens of enterprises, the new law for electronic one-stop shops (e-OSS) was developed.

Besides political actions and initiatives, other non-public sector stakeholders promote and stress out the importance of a digital industry, state and economy in general. One of the main supporters of Industry 4.0 and its strategic importance for the competitiveness of the country and Greek enterprises in the future is the Federation of Enterprises (SEV) of Greece.

- SEV, since February 2019, established the Observatory of Digital Transformation for the country. In the lines of this venture, the Digital Manufacturing Index (DMI) has been developed in order to monitor the digital results of the country as a whole, compared to its EU counterparts within the EU-28.

Currently the Government's policies for the digitisation of the enterprises in the industrial sector are supported through two main funding streams, the Operational Program "Competitiveness, Entrepreneurship & Innovation" (EPAnEK) and the Hellenic Development Bank (former ETEAN).

The operational programme EPAnEK constitutes one of the seven sectoral Operational Programmes of the Partnership and Cooperation Agreement (former NSRF) for the period 2014-2020. The pivotal strategic objective of EPAnEK is to enhance the competitiveness and extroversion of enterprises, to facilitate transition to quality entrepreneurship with innovation and the growth of domestic added value as the cutting edge. The total public expenditure for EPAnEK is set at €4,66 billion.

EPAnEK funds the support measure " Research – Create – Innovate " (total of €542,5 million) and also provisions the use of financial instruments (loans, guarantees, microfinance and equity financing) that could support its purposes. The measure "Research – Create – Innovate"[446] is managed by the General Secretariat for Research and Technology and aims to support:

- research and innovation
- technological development and demonstration at operating enterprises for the development of new or improved products
- the development of synergies among enterprises
- research and development centres and higher education sector as well as to support
- the patentability of research results and industrial property.

EPAnEK has also published two actions that promote the digital transformation of enterprises and organisations., the "Digital Step" that aims at the digital upgrading of very small, small and medium sized enterprises with business plans from €5.000 to €50.000 and the "Digital Jump", that aims at the digital transformation of very small, small and medium sized enterprises with business plans from €55.000 to €400.000. The funding scheme was co-financed by Greece and the European Union – European Regional Development Fund with a budget of €51,6 million.

The Hellenic Development Bank (HDB) aims to support the design, implementation and management of specialized financial actions, delivered by financial institutions to small and medium sized enterprises. The Hellenic Development Bank created two funding schemes that aim to support digital development of enterprises, the programme "Business Innovation Greece" and the programme "4th Industrial Revolution".

- The programme "Business Innovation Greece", aims to support the general objectives of European Economic Area and Norway Grants 2014-2021. The programme targets to increase value creation and sustainable growth in the Greek business sector and to allocate 75% of the funding to SMEs. The total budget of the programme for the ICT sector is €3 million and it is divided in two grant schemes, the "Individual Project Scheme" concerning SMEs and large enterprises with no more than 25% public ownership, and the "Small Grants Scheme 1" concerning SMEs.

[446] Source : http://www.antagonistikotita.gr/epanek_en/news.asp?id=7

- The Investment Scheme "4th Industrial Revolution", aims to invest in new or existing SMEs that retain an establishment in the Greek territory at the time of the investment and are active in the field of the 4th Industrial Revolution. The budget of "4th Industrial Revolution" is set at €50 million from public funding and €15 million from private equity.

Besides the abovementioned funding sources and initiatives, there are additional funding sources that are used to support enterprises towards digital transformation:

- EquiFund[447]: An initiative created by the Hellenic Republic in cooperation with the European Investment Fund (EIF) that supports research projects of SMEs and start-ups.
- COSME[448]: The EU program for the Competitiveness of Enterprises and SMEs, running from 2014 to 2020, with a budget of €2.3 billion.
- InnovFin[449]: With InnovFin – EU Finance for Innovators, the EIB Group (the European Investment Bank and the European Investment Fund) can provide financing starting at €25.000 for investments in research and innovation to companies and other entities of all sizes and age. InnovFin supports start-ups, SMEs, mid-caps, larger private companies, research institutes/ organisations and universities or R&I-driven entities.
- EIB[450]: Offers loans, guarantees, equity investments and advisory services. The most suitable tool will depend on the objectives of the project and on various other factors.
- Tax incentives for investment[451]: General Secretariat of Research and Technology provides certifications of scientific and technological research expenditure and deduction of 30% surcharge.

[447] EquiFund Brochure (https://equifund.gr/wp-content/uploads/2018/02/EquiFund-Brochure.pdf)
[448] COSME – Leaflet (https://ec.europa.eu/docsroom/documents/9783)
[449] InnovFin (https://www.eib.org/en/products/blending/innovfin/products/index.htm)
[450] EIB (https://www.eib.org/en/products/index.htm)
[451] Source: General Secretariat for Research and Technology

7.8 Strategic Industry 4.0 policies and initiatives in Greece: The current situation

As we have analysed in previous chapters, Greece is only at the beginning of a long and demanding effort in order to achieve Digital Transformation in the Industry sector. Up until today, there has been no official policy or action in the form of a strategy/ initiative etc. from the side of the Greek state in order to support the transition of the Greek industry to the new digital era, i.e. towards Industry 4.0.

There has been however an ongoing effort since 2016, with the establishment of the Ministry of Digital Policy, Telecommunications and Media, whose major goal was to assist in the digitalisation of the country and the economy overall. The Ministry published in 2016 the National Digital Policy 2016-2021. This represented an effort to create a road map for Greece, acting in the lines of the aforementioned goal, addressing the burning need to embrace Industry 4.0 in order for the sector to become a driver for growth and competitiveness for Greece. For that reason, the following areas were prioritized with regards to the necessary actions that need to be taken:

1. Development of an Action plan for the introduction of the Greek Industry to the concept of Industry 4.0 (the responsible party being the General Secretariat for Industry and the Ministry of Development and Investments) in order to:
   - Design interventions for the introduction of Industry 4.0 in the core pillars of the Greek economy
   - Identify best practices
   - Organize supporting offices in local chambers
   - Support Greek companies to adopt and standardize i4.0 technologies
2. Actions related to the introduction and extension of sensor networks, smart grids and autonomous systems
3. Promoting the implementation of smart city solutions as critical factors for the introduction and development of relevant technologies by businesses to reinforce technological pillars such as microelectronics, sensors, “cloud computing” and “big data” technologies.

Towards that direction, on the 8th of July 2019, the Ministry of Digital Governance was established in the place of the former Ministry of Digital Policy, Telecommunications and Media, seeking to enhance the Ministry’s role and areas of action.

Based on our meeting with representatives from the Ministry of Digital Governance on the 13th of January 2020 in the lines of the current project, the Ministry is currently working on the update of the National Digital policy 2016-2021, in order to produce an enhanced and improved version that will be officially published within the first half of 2020. Moreover, it was determined by Law 4623/2019 that all co-financed ICT projects or actions should be approved by the General Secretariat of Digital Policy and Procedure simplification, in order to act as a central coordinator of digital policy in Greece. It remains to be seen to what extend and through what measures this policy will address Industry 4.0, highlighting the need for political action towards that direction. At the same time, an important first step has been taken by the signing of a memorandum of cooperation (in May 2019) regarding the setup of a digital Industry 4.0 platform, between the General Secretariat for Industry and the Ministry of Digital Governance. However, this effort has not yet materialized into actions towards that direction.

Besides the aforementioned, in the latest months of 2019, two initiatives have been taken up by the Greek government in order to simplify and promote the regulatory environment of the country:

- **Law 4622/2019:** This new law practically seeks to re-organize the way the country's public administration is conducted, by simplifying the process of decision making (which from now on will be operated centrally from the Government). This will allow for clarity and coordination of actions among all respective Ministries, resulting in turn in a more efficient and less time-consuming policy making procedure.
- **Law 4635/2019 (new multibill)** that seeks to address the growth of the economy and the country at multiple levels. With respect to the Greek Industry, the multibill seeks to simplify the issuing of licenses for businesses in the Industry sector as well as offer financial incentives to businesses that seek to operate in the context of business clusters. This latter provision can drastically create value chains among business, leading to greater synergies and better results.

Other than developing industry specific initiatives, there have been however during the recent years horizontal efforts to boost and assist the business environment of Greece in general. Since 2018 and more specifically laws L. 4442/2016 & 4512/2018 the simplification of the regulatory framework for economic activities has been pursued. Furthermore, in 2019, law L.4442/2016 was supplemented and extended by law 4635/2019, introducing simplification of the standardisation, licensing and supervision processes as well as by Law 4512/2018, which establishes a new framework for the supervision of economic activities and the product markets.

Also, since early 2018, the "Better Regulation Delivery Directorate" of the General Secretariat for Industry has been established in order to act towards the successful implementation of the aforementioned laws. As stated in the OECD Economic Survey of Greece 2018-2020, "the digitisation of licensing and inspection procedures through an Integrated Licensing Information Management System (ILIMS)" is pursued. "The development of the ILIMS has been approved for funding under the structural funds programme and will be key to the implementation of reforms through the digitisation of processes that enhance the transparency and efficiency of public administration". Further to that, since June 2017, the electronic licensing platform "Notify business – notifybusiness.gov.gr" was established. Lastly, in a significant effort to reduce the administrative burdens of enterprises, the new law for electronic one-stop shops (e-OSS) was developed (Law 4441/2016 and MD 63577/2018). As per OECD's report "E-OSS has been extremely successful and user-friendly, making the minimum time for creating a company just 6 minutes. Since July 2018, 8.838 companies have been created with e-OSS." The 2020 Doing Business Report ranked starting a business in Greece 1st in among EU countries and 11th worldwide.

The above initiatives will hopefully be of great value for the Greek Government to develop and set in motion regulations, initiatives and actions towards the digitalisation of the Greek industry.

In addition, as mentioned in paragraph 7.3.2, the country participates in several European digital initiatives. Namely:

- The European effort for building the next generation of computing and data infrastructures by signing the High-Performance Computing declaration (the EuroHPC declaration).[452]
- The Declaration for the European Blockchain Partnership (EBP)[453]
- The Declaration of cooperation on Artificial Intelligence[454]
- The 5G cross-border corridor initiative[455]

[452] https://ec.europa.eu/digital-single-market/en/news/greece-signs-european-declaration-high-performance-computing
[453] https://ec.europa.eu/digital-single-market/en/news/european-countries-join-blockchain-partnership
[454] https://ec.europa.eu/digital-single-market/en/news/eu-member-states-sign-cooperate-artificial-intelligence
[455] https://ec.europa.eu/digital-single-market/en/news/new-5g-cross-border-corridor-connected-and-automated-mobility-announced-digital-assembly-2018

- The Southern European Countries Ministerial Declaration on Distributed Ledger Technologies[456]
- The European Space Agency (ESA)[457]

Besides political actions and initiatives, other non-public sector stakeholders promote and stress out the importance of a digital industry, state and economy in general. One of the main supporters of Industry 4.0 and its strategic importance for the competitiveness of the country and Greek enterprises in the future is the Federation of Enterprises (SEV) of Greece.

SEV since February 2019 established the Observatory of Digital Transformation for the country[458]. It consists a mechanism aiming to monitor consistently, through the collection of data, the level of digital maturity of the Greek enterprises as well as the Greek economy in general. In the lines of this venture, the Digital Manufacturing Index (DMI) has been developed in order to monitor the digital results of the country as a whole, compared to its EU counterparts within the EU-28. Overall, according to the Special Report of the Observatory published by SEV on the 29th of October 2019, Greece ranks last (28th) among the EU-28, across the seven dimensions outlined in the table below. More specifically and as it can be seen, the scoring for each of the dimensions was the following:

DMI Dimension	Ranking 2017 (EU-28)	Ranking 2018 (EU-28)
1. Digital maturity of Greek enterprises	24th	26th
2. Digital maturity of Public administration	27th	27th
3. The Greek political & regulatory environment	28th	27th
4. Digital maturity of the Greek society	26th	26th
5. The ICT sector	28th	28th
6. Digital Infrastructure & Connectivity	28th	28th
7. Digital Skills	23rd	25th

As it can be inferred from above, and as indicated throughout the current Deliverable, Greece has a long way to go with regards to its digital transformation as a country. However, the survey pointed out some underlying strengths of the Greek economy, such as Research & Development in the ICT sector, Digital skills for the population of the country as a whole as well as the extensive use of online services by the Greek citizens.

Zooming into the Greek enterprises and in the lines of the 1st report of the Observatory, a survey ran with 278 higher level executives across the Greek economy, out of which, 34 were part of the Greek industry as a whole (not focusing on a selection of Industrial sectors, like our current Survey in the lines of this Deliverable has done, as analysed in Chapter 9). The findings showed that digital transformation is an important priority for Greek enterprises (90,8% of the sample), with more than 70% of them investing towards that direction, being willing to perform additional investments towards their digital transformation in the following years. However, based on the survey, enterprises have identified digital transformation as

[456] https://www.lexology.com/library/detail.aspx?g=3dc1e580-862c-4a4d-81ae-7f32bb24b5e5
[457] https://www.esa.int/Space_in_Member_States/Greece/Kalosorhisate
[458] 1st Annual Report of the Observatory of Digital Transformation (in Greek): https://www.sev.org.gr/vivliothiki-tekmiriosi/erevnes-meletes-2/psifiaki-kai-technologiki-orimotita-oikonomias-kai-epicheiriseon-1i-etisia-ekdosi/

a tool to cut costs and increase client satisfaction, not potentially realising the full spectrum of benefits that comes with digital transformation.

To sum up, no other actual initiatives or actions directly linked to Industry 4.0 have been pursued within the Greek environment so far. Such a major initiative should be a well-structured and carefully planned national strategy around Industry 4.0, which at this point and as recognized by all major stakeholders within the Greek environment is very much needed. This strategy should include specific tools and initiatives focused at Industry 4.0 and at the same time to pursue a synchronous motion of all stakeholders targeting at the optimal allocation of financial, human and other resources.

In the next chapter we will analyse the existing and potential funding schemes and sources which can be used for the digitisation of the industry.

7.9 A proposal for "National Strategy for Industry 4.0" by Hellenic Federation of Enterprises (HFE)[459]

During the SEV Industrial Conference "Industry 4.0: A growth opportunity Greece should not miss" in December 2019, the Hellenic Federation of Enterprises presented a proposition regarding the national strategy on Industry 4.0. The HFE formulated a national strategy regarding the digital transformation of the industry.

7.9.1 Program "Industry 4.0"

The program "Industry 4.0" constitutes the HFE's proposal for a national strategy and is elaborated on an action plan regarding the digital transformation of Greece.

The following table presents the proposed program's priorities.

2. Strengthen the innovative capability of enterprises	**5. Regulatory framework & cyber security**
3. Motivate partnerships to share new technologies	**6. National Platform for Collaborations**

Action Plan

The proposed program is consisting of 5 Pillars and 21 Actions. Each Pillar along with its Actions, are presented below.

Pillars	Actions
Accelerating Investments in Digital Technologies	Facilitate loan and investment process
	Investment incentives for advanced technological and digital equipment
	Tax adjustments as an investment tool
	Investment aid in Key Sectors
Strengthen the innovative capability of enterprises	Investment Aid via Innovation Vouchers
	Investment aid for research and innovation through tax reductions
	Strengthening commercialisation of intellectual property (Patent Box)
	Financing PhD theses related to I4.0

[459] Source: SEV Publication, Industrial Conference December 2019 (http://www.sev.org.gr/uploads/documents/SEB_ENTYPO_A4_FINAL_DIGITAL.pdf)

	Employment of researchers in the Industry
Motivate partnerships and Collaborations	Creation of the platform "Collaboration for Industry 4.0"
	Digital Innovation Hubs
	Competence Centres
	Innovation Districts
	National Patent Portal
Upgrade digital skills	Reorientation of higher education
	Learning programmes on digital technologies and skills
	Employment Policies
	Attracting and retaining talent
	Digital School
Improve Regulatory framework & cyber security	Securing intellectual property
	Cyber Security and cyber protection solutions

Beneficiaries

The beneficiaries are proposed to be SMEs and large enterprises, according to the categorisation defined by the European Commission under the following sectors (indicatively):

- **Industry:** NACE Rev. 2, Sectors B-E: Mines - Quarries, Processing, Energy - Water Supply - Sanitation - Waste Management.
- **Supply Chain:** NACE Rev. 2, Sector H: Transporting & Storage.
- **ICT:** NACE Rev. 2, Sector C26: Manufacture of computer, electronic and optical products, Sectors J62-J63: Computer programming, consultancy and related activities - Information service activities.

Budget

The proposed budget of public funds for the implementation of the proposed program is around €2 billion. The proposed program is suggested to be financed by utilizing mechanisms already in place (TEPIX II, NSRF, ETEp, Hellenic Development Bank, etc.), along with tools that will be developed for the period 2021-2027 (Digital Europe 2021-2027, NSRF 2021-2027). HFE estimated that the above funds will lead to approximately equal leverage of private capital. Therefore, the total amount is expected to reach approximately €4 billion.

7.10 Analysis of present and potential funding schemes/sources for the digitisation of the Industry

The following chapter presents the analysis concerning the mapping of the funding schemes/ sources for the digitisation of the Greek Industry. For its drafting, information was collected through desk research and technical meetings that took place in the context of the current project with the General Secretariat of Research and Technology and the General Secretariat for Public Investment.

The purpose of the chapter is to provide an overview of the funding mechanisms regarding the digitalisation of Greek enterprises and organisations. Regarding the future funding schemes for the digitisation of the industry we observe that there is an immediate need to connect businesses and organisations with funding schemes that support digital transformation under a holistic approach.

Currently the Government's policies for the digitisation of the enterprises in the industrial sector are supported through two main funding streams, the Operational Program "Competitiveness, Entrepreneurship & Innovation" (EPAnEK) and the Hellenic Development Bank (former ETEAN).

7.10.1 Operational Programme "Competitiveness, Entrepreneurship & Innovation" (EPAnEK) [460]

EPAnEK 2014-2020
OPERATIONAL PROGRAMME
COMPETITIVENESS
ENTREPRENEURSHIP
INNOVATION

The operational programme EPAnEK constitutes one of the seven sectoral Operational Programmes of the Partnership and Cooperation Agreement (former NSRF) for the period 2014-2020. The pivotal strategic objective of EPAnEK is to enhance the competitiveness and extroversion of enterprises, to facilitate transition to quality entrepreneurship with innovation and the growth of domestic added value as the cutting edge. The Operational Programme for Competitiveness, Entrepreneurship & Innovation plays a central role in the Country's efforts to create a new production model that will lead to development and will strengthen the competitiveness of the Greek economy by leveraging private financing.

The new model brings to the forefront productive, competitive and outward-looking sectors of the economy, such as tourism, energy, agri-food, the environment, the supply chain, information and communication technologies, health and the pharmaceutical industry, creative and cultural industries, materials – construction.

EPAnEK is financed by two specific budget lines, the European Regional Development Fund (ERDF) and the European Social Fund (ESF). The total public expenditure for EPAnEK is set at €4,66 billion.

EPAnEK funds five Strategic Pillars, nine Thematic Objectives (TO) and seventeen Investment Priorities. Digitalisation of Greek enterprises is promoted through Strategic Pillars 1 and 2 (SP1 and SP2), Thematic Objectives 1 and 2 (TO1 and TO2) and Investment Priorities 1b and 2b (IP1b and IP2b).[461]

[460] Source: NSRF, Calls - Digital Step, Digital Saltation, Collaborative Innovation Formations (http://www.antagonistikotita.gr/epanek_en/index.asp).
[461] Source: EPAnEK, Second Revision (http://195.167.92.28/epanek/wp-content/uploads/2019/01/EPANEK_2%CE%B7-%CE%91%CE%9D%CE%91%CE%98%CE%95%CE%A9%CE%A1%CE%97%CE%A3%CE%97_2018.pdf)

7.10.2 Thematic Objective 1 – Support of Research, Technological Development and Innovation

Thematic Objective 1 (TO1), supports research, technological development and innovation and includes Investment Priority 1b that promotes businesses' investment in research and innovation. For the TO1, the available public expenditure is set at €1,05 billion.

For the purposes of this TO1, EPAnEK funds the support measure " Research – Create – Innovate " and also provisions the use of financial instruments (loans, guarantees, microfinance and equity financing) that could support its purposes. More specifically EPAnEK provisions the support of enterprises.

Measure "Research – Create – Innovate"[462]

The measure is managed by the General Secretariat for Research and Technology and aims to support:

- research and innovation
- technological development and demonstration at operating enterprises for the development of new or improved products
- the development of synergies among enterprises
- research and development centres and higher education sector as well as to support
- the patentability of research results and industrial property.

In that context, the main objectives of the measure are:

- Economic development based on knowledge and sustainable specialisation;
- Integration of new knowledge and innovation to existing and new products, services, production systems and value chains;
- Connection of academic research with market needs and the economy.

The budget of the measure amounts to a total of €542,5 million (Public Expenditure) and until now two calls were announced:

- Cycle A with a total budget of €342,5 million and
- Cycle B with a total budget of €200 million.

Cycle A

The first call of the programme "Research – Create – Innovate" was published in March 2017 and it constitutes Cycle A of the program.

Financed businesses and organisations promote research, technological development and innovation and fall into one of the following three interventions: (a) Research and Development by SMEs, (b) Business Partnerships with Research Organisations and (c) Exploitation of Research Results.

The main objective of the "Research and Development by SMEs" intervention is to support research, promote innovation and strengthen networking in SMEs. The "Business Partnerships with Research Organisations" intervention aims to facilitate the co-operation between businesses and research organisations. Finally, the "Exploitation of Research Results" intervention aims to promote research on a higher level of technological readiness, based on results produced in previous research projects.

[462] Source : http://www.antagonistikotita.gr/epanek_en/news.asp?id=7

Cycle B

Cycle B of the program “Research – Create – Innovate” was initiated in March 2019.

Cycle B finances businesses and organisations which promote research, technological development and innovation and fall into one of the following four interventions: (a) Business Research and Development, (b) Business Partnerships with Research Organisations, (c) Exploitation of Research Results and (d) Seal of Excellence for Business. The intervention “Business Research and Development”, extends its reach to large enterprises and promotes the creation of new scientific staff jobs, more emphatically in Cycle B than in Cycle A. The interventions “Business Partnerships with Research Organisations” and “Exploitation of Research Results” remain the same, in terms of their aim, as in Cycle A. The intervention “Seal of Excellence for Business” deals with the financing of proposals that have received the Seal of Excellence (SME Instrument of Horizon 2020 of the European Union) as highly innovative proposals but were not funded due to the depletion of available funds.

At each sector, there are multiple areas of intervention and specific eligible interventions that are funded from the action, in order to aid research organisations and businesses in their digital transformation. More specifically, in the sectors that fall under the scope of our project we recorded indicatively the following interventions:

- The Materials and Construction sector includes 9 eligible interventions, related to digital transformation, i.e. the “Connect with Digital Production (Digital, Virtual and resource – efficient factories)”.
- The Tourism, Culture and Creative Industries sector includes 8 eligible interventions, i.e. the “Emerging Technologies for Creative Industries”.
- The Agri-food & Food Industry sector includes 5 eligible interventions, i.e. the “Application of new technologies in all agricultural and food production systems”.
- The Environment & Sustainable Development sector includes 2 eligible interventions, i.e. “Emerging Technologies for the Environment sector”.
- The Health & Medicine sector has 3 eligible interventions, i.e. the “Emerging Technologies for the Health and Medicine Sector”.
- The Energy sector includes 2 eligible interventions, i.e. the “Smart Network Technologies”.
- Finally, the ICT sector includes 41 eligible interventions related to digital transformation that constitute the total number of interventions for the ICT sector, i.e. the “Internet of Things”.

7.10.3 Thematic Objective 2 - Improve access, use and quality of ICT

The Thematic Objective 2 (TO2), aims to improve the access, use and quality of ICT and includes the Investment Priority 2b that promotes the development of ICT products and services, e-commerce and strengthens the demand for ICT products. For the TO2, the available public expenditure amounts to €665,5 million.

EPAnEK has published two actions that promote the digital transformation of enterprises and organisations.

Action "Digital Step"[463]

The first action "Digital Step" was published in June 2018 and aims at the digital upgrading of very small, small and medium sized enterprises with business plans from €5.000 to €50.000. The funding scheme was co-financed by Greece and the European Union – European Regional Development Fund with a budget of €84,4 million. The subsidized expenditures of the funding scheme are new ICT equipment, software, e-shop development, ordering and payment software, hosting, digital advertising (Google ads, Facebook ads), digital content creation, digital security, data transportation, wage cost, etc.

Action "Digital Jump"[464]

The second action "Digital Jump", was published in June 2018 and aims at the digital transformation of very small, small and medium sized enterprises with business plans from €55.000 to €400.000. The funding scheme was co-financed by Greece and the European Union – European Regional Development Fund with a budget of €51,6 million. The subsidized expenditures of the funding scheme are new ICT equipment, software, e-shop development, ordering and payment software, hosting, digital advertising (Google ads, Facebook ads), digital content creation, digital security, data transportation, wage cost, etc.

7.10.4 Hellenic Development Bank (former ETEAN) [465]

The Hellenic Development Bank (HDB) is an integral part of the wider Greek financial sector, aiming to support the design, implementation and management of specialized financial actions, through the application of innovative financial instruments, delivered by financial institutions to small and medium sized enterprises. In this context, the Bank pools from its own funds and the funds allocated for its purposes by the European Union's Structural Funds and/or Greek national resources.

The Hellenic Development Bank created two funding schemes that aim to support digital development of enterprises, the programme "Business Innovation Greece" and the programme "4th Industrial Revolution".

The programme "Business Innovation Greece" is a part of the EEA Financial Mechanism (EEA Grants) 2014-2021 and represents the contribution of Norway, Iceland and Liechtenstein to reducing economic and social disparities and strengthening bilateral relations with 15 EU countries in Central and Southern Europe. The programme aims to support the general objectives of European Economic Area and Norway Grants 2014-2021 and targets to increase value creation and sustainable growth in the Greek business sector and to allocate 75% of the funding to SMEs. The programme seeks to stimulate and develop long-term business cooperation between Iceland, Liechtenstein, Norway and Greece based on business development and innovation. The total budget of the programme for the ICT sector is €3 million and it is divided in two grant schemes, the "Individual Project Scheme" concerning SMEs and large enterprises with no more than 25% public ownership, and the "Small Grants Scheme 1" concerning SMEs. The scheme "Individual Project Scheme" has a budget of €2,4 million and the scheme "Small Grants Scheme 1" has a budget of €600.000, for the ICT sector. The call for proposals was open from April 2019 until October 2019. In total, this call for proposals resulted in 35 submitted applications, which account for a total volume of grants requested that reaches the amount of €25 mil. Keeping in mind that the overall budget competition has a cap of €19 mil, the projects submitted are currently under evaluation which, as estimated may take up to four to six months.

[463] Source: http://www.antagonistikotita.gr/epanek_en/prokirixeis.asp?id=25&cs=
[464] http://www.antagonistikotita.gr/epanek_en/prokirixeis.asp?id=26&cs=
[465] Source: Hellenic Development Bank – Programmes, Closed Tenders (http://www.etean.gr/PublicPages/HomePage.aspx)

The Investment Scheme "4th Industrial Revolution", that was only recently created in January 2019, aims to invest in new or existing SMEs that retain an establishment in the Greek territory at the time of the investment and are active in the field of the 4th Industrial Revolution. The field of the 4th Industrial Revolution involves products or services related to digital technology, Internet of Things (IoT), robotics, artificial intelligence (AI), genetics, biotechnology, molecular biology, 3D Printing, etc., providing motivation and capital adequacy to start-ups SMEs, but also contributing to the strengthening of existing businesses, creating the grounds for further development of work, mainly through research and development (R&D), synergies, partnerships, exchange of know-how with foreign companies, etc. In addition, the fund aims to help foster innovative eco-friendly and energy-efficient applications and services, with a significant environmental impact. The investment could be done at any business stage (launch, growth, shake-out, maturity) and the investment period is from 3 to 5 years. The funding is conducted through the acquisition of equity shares or convertible bonds. The budget of "4th Industrial Revolution" is set at €50 million from public funding and €15 million from private equity. As of February 2020, the Deputy Minister of Development and Investments "The Hellenic Development Bank will constitute the main tool for the growth strategy of the country as well as the central pillar for the change of its economic and production model." The investment scheme "4th Industrial Revolution" is "one of the financing tools that are currently being evaluated, along with other tools of the Hellenic Development Bank, so as to allocate them to the respective administrators and start announcing the first rounds of funds"[466].

7.11 Other funding mechanisms/ tools

Besides the abovementioned funding sources and initiatives, there are additional funding sources that are used to support enterprises towards digital transformation. These mechanisms are presented below.

7.11.1 European Investment Bank[467]

EIB offers loans, guarantees, equity investments and advisory services. The most suitable tool will depend on the objectives of the project and on various other factors. Some of the EIB's initiatives are presented below:

1. **EquiFund[468]**

EquiFund is an initiative created by the Hellenic Republic in cooperation with the European Investment Fund (EIF) that supports research projects of SMEs and start-ups. There are three growth stages that EquiFund supports: (a) start-ups that are at the idea and research stage, (b) start-ups that have launched their companies and whose ideas are achieving initial traction, (c) start-ups that have established businesses with strong sales. The budget of EquiFund is over €300 million.

More specifically, EquiFund offers three different types of equity financing to ensure that the ones interested can access the right financing, at the right stage for their business or idea. The "Innovation Window Funds" that are supporting the abovementioned growth stage (a); BigPi Ventures, Metavallon Fund, Uni.Fund and Velocity Partners. The "Early Stage Window Funds" that are supporting the growth stage are (b); Marathon VC and VentureFriends 400W. The "Growth Window Funds" that are supporting the growth stage are (c); Elikonos 2, EOS Capital Partners and Synergia Hellenic Fund IV.

[466] https://www.kathimerini.gr/1064714/article/oikonomia/ellhnikh-oikonomia/panw-apo-1-dis-eyrw-gia-prasines-ependyseis-apo-thn-ellhnikh-anapty3iakh-trapeza
[467] EIB (https://www.eib.org/en/products/index.htm)
[468] EquiFund Brochure (https://equifund.gr/wp-content/uploads/2018/02/EquiFund-Brochure.pdf)

The timeline of EquiFund's activity in Greece begins in 2016, and more specifically from August to December 2016 the funding agreement took place. From December 2016 to February 2017, a call for interest expression was announced, and from February to December 2017, the selection procedure took place. Eventually, in January 2018, the funds and venture capitals were selected, and the investments began. The evaluation of the investments is not available yet and is expected to be performed in the near future.

2. COSME[469][470][471]

COSME is the EU program for the Competitiveness of Enterprises and SMEs, running from 2014 to 2020, with a budget of €2.3 billion. One of COSME's main objectives is to provide enhanced access to finance for SMEs in different phases of their lifecycle: creation, expansion or business transfer, through the programs Loan Guarantee Facility (LGF) and Equity Facility for Growth (EFG). In order to achieve this objective, the EU will mobilize loans and equity investments for SMEs. COSME will support SMEs in the following areas:

- Facilitating access to finance,
- Supporting internationalisation and access to markets
- Creating an environment favourable to competitiveness and
- Encouraging an entrepreneurial culture.

In terms of relevance, COSME's greatest strength is its commitment to supporting any or all of Europe's SMEs in their pursuit of improved competitiveness and growth. Its widespread 'non-targeted' contribution supports the basic needs of enterprises, easing access to finance and providing access to guidance. COSME's main weakness is a result of this 'non-targeted' approach. Two of its major actions are accounting for about 80% of the total budget committed, target all SMEs without making distinctions to reflect the programme's 'inclusive and sustainable growth' and 'global competitiveness' policy objectives.

In terms of effectiveness, the strength of COSME is the use of intermediaries for the implementation of the programme. COSME exploits the proximity of these intermediaries to SMEs and enables the integration of services provided under the COSME framework with services provided by these intermediaries in their national and regional settings. A major weakness of the programme is the lack of capacity to respond effectively to EU policy objectives related to sectoral competitiveness and SME internationalisation (beyond the EU).

In terms of efficiency, the strongest limitations on COSME are the formation of its budget and the range of its scope as defined in the regulations. The main strength of COSME is the clarity of its work programme descriptions, leading to a relatively small share of ineligible proposals responding to the calls for grants. Two major weaknesses of the programme design are the unbalanced distribution and strong fragmentation of the accessible budget and the quality of data management.

In terms of internal coherence, the efforts are gradually being made to support the coherence and complementarities among the actions funded under COSME. For the external coherence, the interplay between the EU, national and regional levels of support for SMEs is not always synergistic and complementary, even though no substantial overlaps were found.

[469] COSME – Leaflet (https://ec.europa.eu/docsroom/documents/9783)
[470] Interim Evaluation of the COSME Programme
[471] https://www.nbg.gr/en/business/co-funded-loans/subsidized-loans/cosme

The value of the programme for the European Union, is on a good level. While many national and regional initiatives seek to strengthen the competitiveness of SMEs, the scale of support through COSME and its accessibility to financial and business support intermediaries in every EU Member State are relatively distinct and highly additional. In several cases, the EU level actions have not only been additional to, but have also helped in enhancing national, regional and local level measures.

Additionally, there still is a large variation among countries in terms of added value. There are difficulties to attain access to finance in Greece. The same holds for Ireland, Italy, Portugal and the Netherlands.

Nevertheless, under the Equity Facility for Growth (EFG), nine operations with financial intermediaries have been signed so far and four additional operations are in the making. These operations account for an overall investment of 64 ml € in eligible SMEs. The decline in the investment level under the EFG is at 13.4%, which amounts to 12.2 ml €. Twelve SMEs that are in development and growth stages have benefitted from these investments; they are based in France (4), Germany (2), Greece (2), Ireland, Italy, the Netherlands and the UK.

The National Bank of Greece, in order to provide direct and effective financial support to SMEs and boost investments that allow businesses to grow by securing competitive terms of financing, signed with the European Investment Fund (EIF) the first COSME agreement in Greece, with the amount of €800,000,000 for the implementation of the COSME Loan Guarantee Facility, with the support of the European Fund for Strategic Investments (EFSI), a key pillar of the Investment Plan for Europe.

3. InnovFin[472][473]

With InnovFin – EU Finance for Innovators, the EIB Group (the European Investment Bank and the European Investment Fund) can provide financing starting at € 25.000 for investments in research and innovation to companies and other entities of all sizes and age. InnovFin supports start-ups, SMEs, mid-caps, larger private companies, research institutes / organisations and universities or R&I-driven entities.

More specifically, InnovFin represents an important development in the provision of EU supported innovation financing that builds on the more modest and rather different schemes that previously existed. InnovFin has brought together different programmes previously run by the European Commission, EIB and the EIF under one umbrella. Some elements continue to work together, e.g. the Risk Sharing Instrument and the SMEG, and Large Projects and the Risk-Sharing Finance Facility (RSFF). Other aspects are new - the thematic products bring a new type of financial support.

So far, an estimated 7.42 bn € of InnovFin financial support has been committed to 5.780 enterprises (at 31 December 2016). This means that 32% of the SMEG budget and 8% of the InnovFin Equity funding that was reserved for InnovFin for the 2014 – 2020 period has now been committed.

In Greece, the proportion of total finance committed to the one and only beneficiary of the InnovFin financial instruments was 25 m €.

In terms of SMEs Guarantee, there has been a great take-up of the SM Guarantee with many contracts signed with financial intermediaries and several thousand loans made to final beneficiaries, covering almost all eligible countries. While the full delegation model adopted under the product is praised by financial intermediaries, there are some considerations about the pricing of guarantees which is seen as relatively high. Despite concerns among some banks, the fact that there has been such a big take-up of

[472] InnovFin (https://www.eib.org/en/products/blending/innovfin/products/index.htm)
[473] Interim Evaluation of Horizon 2020's Financial Instruments

the SMEG shows that InnovFin is proving a very effective intervention in terms of helping banks to provide finance to riskier businesses. Nevertheless, there seem to be some confusions regarding the correct application of the innovation eligibility criteria defined for the SMEGs. For example, in Greece, there is a lack of financial intermediaries with the know-how required to help implement the financial instruments. Experience in Greece suggests that there can be an accelerating effect – once the first agreement has been signed with a bank, its competitors are then keen to join in the SMEG, too.

In general, the research shows that the InnovFin scheme is performing well against its main objectives of improving access to finance for innovative companies and projects and helping to address related market failures.

All in all, the above mechanisms could be potentially utilised in the concept of innovative startups and SMEs of the Greek industry in order to help them utilise the much needed funding so as to grow and perform significantly better within their ecosystem.

7.11.2 Other funding mechanisms/ tools

Tax incentives for investment[474]

General Secretariat of Research and Technology provides certifications of scientific and technological research expenditure and deduction of 30% surcharge. As discussed in the 2nd Workshop of our project by the Secretary General of the General Secretariat of Research and Technology, they are currently under discussion to increase the aforementioned deduction from 30% to 100%, so as to encourage companies to invest in technological and research initiatives.

7.12 Critical public and private stakeholders for the transformation of the Greek Industry

The successful transformation of the Greek Industry shall be a national, holistic approach, in which all key stakeholders from the public and private sectors, as well as from the Greek academia shall have a pivotal role to play. Below we present the Industry 4.0 transformation Framework that identifies a high-level development value chain for Industry 4.0 technologies and applications, as well as the key enablers that will act as the accelerators for the Greek industry's digital transformation. All areas of activities have been analysed thus far throughout Deliverable 1.

[474] Source: General Secretariat for Research and Technology

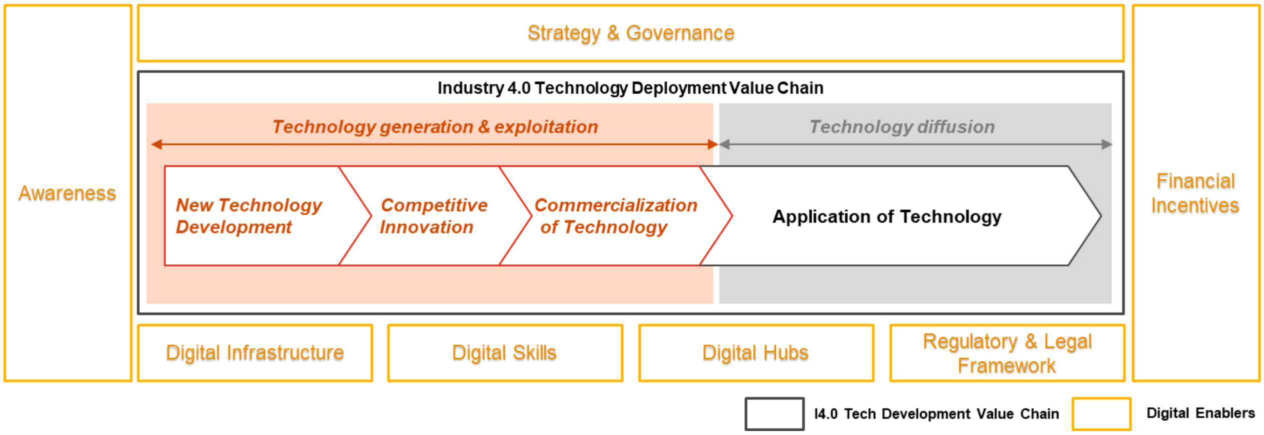

Figure 86: The Industry 4.0 transformation framework

This framework will also enable us to better demonstrate the different areas of intervention for each of the identified private and public stakeholders.

1) **Greek Industry & Manufacturing Companies:** These are the key private stakeholders, who are responsible directly for their organisations' digital transformation. The rotation of the Greek industry and manufacturing companies to digital will instigate the digital transformation of their respective economic sectors and therefore of the entire Greek industry. Greek industry & manufacturing companies are responsible for the active experimentation on new Industry 4.0 technologies, the commercialisation of Industry 4.0 applications and the implementation and application of Industry 4.0 capabilities for the mass-production of new, smart products as well as for the optimisation of their internal operations. Greek companies shall also be active on the digital up-skilling and reskilling of their human workforce, as this is one of the key enablers for their successful digital transformation.
2) **ICT Companies:** ICT companies (i.e. large telco providers, software providers, etc.) are usually called the national digital "multipliers", as they usually demonstrate the highest digital maturity within the economy and act as the national "multipliers", in order to accelerate "traditional" and "customer facing" industries' rotation to digital. Their role mainly focuses on the provision of the national digital infrastructure. Nevertheless, ICT companies can become valuable partners of the Greek industry & manufacturing companies in jointly exploiting and testing new Industry 4.0 technologies, co-design and co-develop new Industry 4.0 applications, and enable the "smartification" of traditional products, through the provision of technical expertise and capabilities. Finally, high-calibre ICT companies can act as the instigators of Hellenic digital hubs. However, they will also stand to benefit from the digital hubs, since the latter will increase the productivity and growth of the technology companies based within the digital hub through leveraging the network multiplier effect.
3) **Industry Federations:** Industry federations (i.e. the Federation of Enterprises, the Federation of Hellenic Information Technology & Communications Enterprises, Federation of Hellenic Food Industries, etc.) have an important role to play in the design and the operationalisation of Greece's national Industry 4.0 strategy, as they act as the interface between the Greek organisations and the Public Administration, and potentially to the academia and research institutes. Industry federations can bring significant expertise and know how on different elements of the

operationalisation of the national digital vision and can help set up operations. At the same time, they can provide expert advisory on specific digitalisation topics and cross-sectoral related tasks. In addition, industry federations can raise awareness through the organisation of relevant initiatives, can support the digital up-skilling and reskilling of their sectors' human capital and can conduct selected reviews on progress and outcomes of implemented digital initiatives by their members.

4) **Public Administration:** The Public Administration, that is the set of relevant ministries and respective General Secretariats (i.e. the Ministry of Development and Investments, the Ministry of Digital Governance, the Ministry of Education and Religion, the General Secretariat for Industry, the General Secretariat for Research and Technology, etc.), is the second most important player with regards to the digitisation of the Greek industry. Although it shall not directly intervene in industry's digitisation initiatives, the Public Administration shall provide indirect support through signalling, signposting and leading, co-ordinating and creating an environment in which enterprises working in the field can digitally transform and flourish. As a first priority, Public Administration shall provide the strategic guidelines for the industry's digital transformation (through active collaboration between the Ministry of Development and Investments and the Ministry of Digital Governance). At the same time, there are several areas where the public sector can also add value:
   - Where appropriate, the Public Administration shall put policies in place as regards, for example, education, migration, research in digital manufacturing, or institutions to support different ways of doing business. Indicative stakeholders for this could be (non-exhaustively) the Ministry of Digital Governance, the General Secretariat for Industry, General Secretariat for Research and Technology and the Ministry of Education and Religion.

   - The provision of financial incentives (i.e. funding, tax exemptions, vouchers of innovation, etc.) can also motivate the Greek industry in adopting Industry 4.0 capabilities. On this direction, Public Administration shall collaborate with European institutions such as ERDF and ESF to identify and develop appropriate support possibilities. Indicative stakeholders for this could be (non-exhaustively) the Ministry of Development and Investments, the Ministry of Economy and the Hellenic Development Bank (HDB).

   - The digitisation of the Greek industry shall also be transparent, simpler, faster and more user-centric digital services to increase citizens' and businesses' engagement, trust and motivation in the digital technologies. Indicative stakeholder for this could be (non-exhaustively) the Ministry of Digital Governance and its General Secretariat for the Simplification of Administrative Processes.

   - Public Administration shall collaborate with the Greek academia and the private sector to accelerate the reskilling of the Greek society and workforce. In more detail, the Public Administration shall equip all citizens with basic ICT skills and knowledge to improve their quality of life and increase awareness on the opportunities and threats of the information society. In addition, conjointly with the Greek academia, they shall influence the education curricula from the beginning to build digital skills and strengthen the talent pipeline from its source. Public Administration shall also actively participate in new skilling the workforce: Digitally upskill and reskill Public and Private Sector workforce to equip them with new digital skills required. Indicative stakeholders for this could be (non-exhaustively) the Ministry of Digital

Governance, the Ministry of Education and Religion, the General Secretariat for Industry and the General Secretariat for Research and Technology.

- In addition, the Public Administration shall design dedicated initiatives to raise awareness about the challenges and opportunities in the area of Industry 4.0 and the Industrial Internet and provide fora and platforms for stakeholders to become involved, including the national chambers of industry, research institutions, etc. Indicative stakeholders for this could be (non-exhaustively) the Ministry of Digital Governance and the General Secretariat for Industry.
- Finally, the Public Administration shall collaborate with other countries on the Greek industry's digitisation, e.g. share best practices, develop joint initiatives (e.g. for specific sectors). Indicative stakeholders for this could be (non-exhaustively) the Ministry of Digital Governance and the General Secretariat for Industry.

5) **The Greek Academia:** As mentioned earlier, the Greek Academia shall collaborate with the Public Administration in order to transform the learning of digital skills throughout all educational levels, develop ICT skills via higher education and stimulate STEM (science, technology, engineering, mathematics) education. In addition, the academia shall collaborate with the research institutions and the private sector to jointly perform research and exploit new Industry 4.0 technologies and their implementation in the Greek industry. Finally, the Greek academia shall infuse talent into the Digital Hubs and support the creation of digital ecosystems. In this context, Greek Universities shall support the design of a talent acquisition and development plan to attract local and international digital talent and accelerate talent repatriation. Primary stakeholders for this could be (non-exhaustively) the National Technical University of Athens, the Technical University of Crete, the University of Patras, as well as the technological educational institutes, etc.
6) **Research Institutes and organisations:** Greek research institutions and organisations (i.e. the National Center for Scientific Research "Demokritos" (NCSR "Demokritos"), Athena RC, the Foundation for Research and Technology- Hellas, etc.) shall also participate as key members in research activities and the commercialisation of Industry 4.0 technologies, together with the Greek academia and private sector. In addition, it can also be an important member of the Greek Digital Hubs and support them in leveraging emerging digital technologies to become world class IT and Communications hubs that will design and provide commercialized, industry agnostic, innovative, intelligent solutions at a global scale.
7) **European Commission Institutions:** European Commission Institutions can support the digitisation of the Greek industry through the provision of targeted financial incentives and structural funds, the establishment of a European flexible and digital-friendly regulatory and legal environment that will also force also the Greek regulatory environment to adapt accordingly, and the design of dedicated initiatives to raise awareness about the challenges and opportunities in the area of Industry 4.0 at a European level. In addition, they can accelerate the collaboration of their EU Member States through the introduction of inter-country digital platforms, the sharing of best practices and the development of joint initiatives across the EU members.
8) **Customer Associations:** Last but not least, customer associations appear to have an empowered role within the Industry 4.0 ecosystem. As products become personalized to satisfy specific customer needs, and value chains integrate, customer associations can actively participate in the

dynamic development of new products and services in the Greek industry and within the Digital Hubs. In addition, they can provide instant customer feedback to the provision of new, smart products and help towards their continuous improvement. Finally, they can participate in awareness-raising initiatives to inform their members on the benefits and advantages of the Industry 4.0 applications. Leading practice in this area is the British "Which?" Consumers' Association that that promotes informed consumer choice in the purchase of goods and services by testing products (including high-tech and Industry 4.0 related products), highlighting inferior products or services, raising awareness of consumer rights in the new digital era, and offering independent advice.[475]

The involvement of each of the stakeholder groups across the different areas of the Industry 4.0 framework is presented below.

[475] https://www.which.co.uk/

Stakeholders	Industry 4.0 Technology Deployment Value Chain				Key Enablers						
	New Technology Development	Competitive Innovation	Commercialisation of Technology	Application of Technology	Strategy & Governance	Digital Infrastructure	Digital Hubs	Digital Skills	Regulatory & Legal FW	Financial Incentives	Awareness
Industry & Manufacturing Companies		√	√	√			√				
ICT Companies		√	√			√	√				
Industry Federations					√			√			√
Public Administration					√		√	√	√	√	√
EC Institutions					√			√	√	√	√
Academia	√	√					√	√			
Research Institutions	√	√	√				√				
Customer Associations			√	√							√

8 Organisations' perception on their Industry 4.0 capabilities

8.1 Chapter's Summary

In order to capture the perception of the Greek Industry with regards to their Industry 4.0 capabilities, we performed the Industry 4.0 survey.[476] The outcomes of the survey enabled us to capture the pulse of the Greek industrial enterprises and to overlay the executives' opinions against "hard data", in order to extract an additional layer of insight.

A detailed analysis on the perception of different enterprise segments (according to number of employees, origin and years of operation) is presented in detail in paragraphs 11.3 – 11.5 of Appendix II.

The surveyed Greek executives recognize the significance of Industry 4.0 and the changing of the industrial paradigm – 1 out of 2 of the surveyed executives recognize that their respective organisations have understood the significance of Industry 4.0 and acknowledge the fact that this will disrupt their industries in the next years. Adding to the above, in terms of new opportunities that will arise from the introduction of Industry 4.0 technologies, most of the respondents expect Industry 4.0 to pave the way for "New Services", "New Business Models" and "New Markets".

Greek executives perceive their organisations' increased productivity as the most important direct benefit from implementing Industry 4.0 technologies: Business leaders currently direct their Industry 4.0 attention in areas where they expect to see wider benefits. 2 out of the 3 the respondents perceive that, primarily, Industry 4.0 will increase productivity, while 1 out of 2 believe that Industry 4.0 will improve decision making and decrease operational costs. This indicates that Greek executives appear to primarily use Industry 4.0 technologies within their organisations to "become digital", optimize their internal operations and reap direct benefits. The use of digital technologies to create new, smart, connected products currently comes as a second priority.

Greek organisations appear to have initiated their Industry 4.0 transformation, albeit at a variable degree: The majority of the surveyed organisations appear to have initiated their digital transformation across specific functions of their organisations. In fact, 7 out of 10 participants cited that their support functions demonstrate the highest level of digitisation, while Warehouse & Logistics and Marketing & Sales also demonstrate a relatively high degree of digital maturity. This verifies the abovementioned finding, that organisations primarily focus on internal efficiencies instead of aiming at the "smartification" of their products and services. In fact, according to the survey, the percentage of the surveyed organisations that produce "smart" products is still very low. Currently 1 out of 2 of them cite that their products have no interface or ability to communicate with any other machine, or that they can just send or receive only basic input/output signals (one-way communication).

Out of the total set of technologies that underpin the concept of Industry 4.0, Greek organisations appear to currently focus their attention to cloud, cybersecurity, big data analytics and

[476] The performed analysis and the respective conclusions were based on data recorded through the "Industry 4.0" survey ran by the Ministry of Development and Investments, PwC and Accenture, with 152 Greek executives across the following sectors: B. Mining & Quarring, C: Manufacturing, E: Water supply; sewage, waste management and remediation activities, F: Constuction, H: Transportation, J: Information & Communication, which was launched on November 2019 and closed in February 2020.

manufacturing-dedicated systems, i.e. SCADA and MES: In terms of the Industry 4.0 technologies that Greek organisations implement, our survey indicates that during the last years, our respondents have focused their attention on the cloud, cybersecurity, big data analytics and SCADA and MES systems.

Evidence also indicates that organisations intend to invest intensively in Industry 4.0 initiatives over the next 5 years. Respondents cited that in the near future they plan to continue their investments in Cloud, Cybersecurity and big data analytics, while they also aim at actively experimenting with IIoT, industrial robots and AI. These investments in the latter technologies are expected to further increase Greece's ranking across the respective indexes (i.e. % of Greek enterprises/ manufacturers implementing industrial robots).

At the same time, a quite alarming finding is surfaced. 20% of the respondents appear not to have implemented any Industry 4.0 technology in their organisations.

Participants' production lines demonstrate a variable degree of digitisation, although the majority of the respondents claim to have revamped their production equipment during the last two years: With regards to the digitisation of the surveyed organisations' production lines, an interesting finding emerges. Almost 4 out of 10 of the participants indicated that their organisations' production lines demonstrate a very low degree of digitisation. Nevertheless, at the same time 7 out 10 of the same sample claims that they have modernised their production lines within the last two years.

The Greek surveyed executives face multiple challenges during their rotation to Industry 4.0: Our survey results suggest that the lack of digital skills for implementing and using Industry 4.0, the limited time to experiment, test and implement new Industry 4.0 technologies, the low level of clients' readiness with regards to Industry 4.0 practices and the lack of technical knowhow in implementing and using Industry 4.0 capabilities are being identified as the four top-of-mind challenges. These challenges confirm Greece's low position, both across the integration of digital technologies (DESI Index's 4th pillar) and across the digital skills of the Greek Human Capital (DESI Index's 2nd pillar).

Greek surveyed executives verify the limited digital skills currently existing in the Greek market: Only 15% of the Greek executives believe that their workforce is currently digitally adept, with major upskilling required mainly on new technologies, complex problem-solving and soft skills. In addition, the majority of Greek executives perceive that "Expertise in new technologies" will be the most sought-after skill when hiring employees for Industry 4.0 activities over the next 5 years, while "Soft skills" and "Problem solving skills" appear to also be important for about half of them.

Greek executives welcome the support of the Greek Government to further enable their organisations' digitisation: Greek organisations also cited that the Greek Government has an important role to play in abolishing the abovementioned structural inhibitors and accelerate Industry 4.0 adoption within the Greek industry, through the provision of relevant financial and non-financial incentives. To start with, almost 9 out of 10 Greek executives believe that the provision of a modern technological infrastructure (e.g. 5G, integrated national fibre optic broadband and wireless networks) could catalyse the implementation of Industry 4.0 initiatives within Greek organisations. In addition, 8 out of 10 of the respondents perceive the provision of relevant tax incentives as an important motive for organisations' digital transformation. Next to tax incentives, the provision of technical expertise for the design and implementation of Industry 4.0 initiatives and for tackling cybersecurity issues feature high on the agenda of 8 out of 10 respondents. These results suggest that the breadth and depth of the digital interventions required to be implemented by the Greek Government shall be significantly deep and wide, to ensure the setup of a holistic support mechanism for the Industry's rotation to Industry 4.0.

8.2 Strategy & Organisation

According to the "Industry 4.0" survey[477], the surveyed Greek executives recognize the significance of Industry 4.0 and the changing of the industrial paradigm. In fact, over 50% of the surveyed executives recognize that their respective organisations have understood the significance of Industry 4.0 and acknowledge the fact that this will disrupt their industries in the next years (see Figure 87).

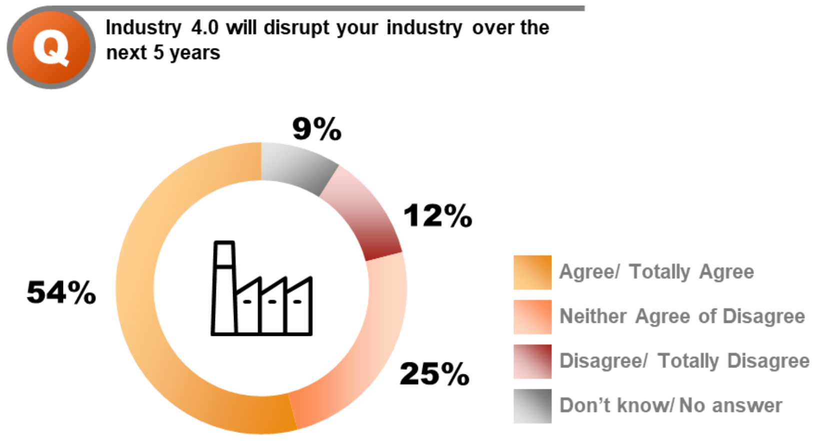

Figure 87: Greek executives' level of agreement regarding the disruption of their industry due to Industry 4.0, (%) – Source: Industry 4.0 survey

At the same time, in terms of new opportunities that are expected to arise from the introduction of Industry 4.0 technologies, most of the respondents expect Industry 4.0 to pave the way for the introduction of new services (72%), as well as new business models (72%) (see Figure 88). It appears therefore that the Greek executives understand the significant shift of the Industrial paradigm and confirm two major trends in this area, the smartification of products and the emergence of new business models (as also presented in chapter 5).

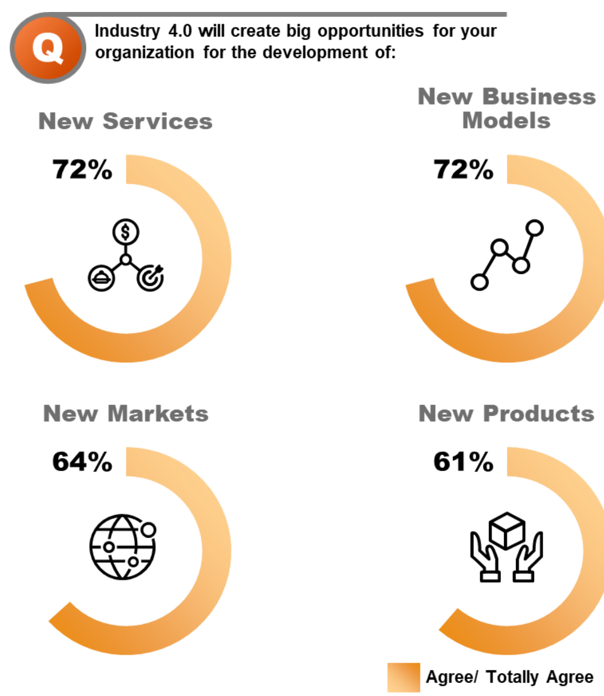

Figure 88: Greek executives' level of agreement regarding the opportunities that Industry 4.0 will open for their organisations, (%) – Source: Industry 4.0 survey

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477 The performed analysis and the respective conclusions were based on data recorded through the "Industry 4.0" survey ran by the Ministry of Development and Investments, PwC and Accenture, with more than 100 Greek executives across the following sectors: B. Mining & Quarring, C: Manufacturing, E: Water supply; sewage, waste management and remediation activities, F: Constuction, H: Transportation, J: Information & Communication, which was launched on November 2019 and remains open. In the pages below, we present a high-level view of select results of the Questionnaire on an aggregate level. As soon as the target sample is achieved (~200 Questionnaires), then a further deep-dive at a sectoral level shall be provided. Additional analysis on the Questionnaire structure and methodology, as well as the detailed list of results are presented in the Appendix.

Greek executives perceive their organisations' increased productivity as the most important direct benefit from implementing Industry 4.0 technologies. Indeed, business leaders currently direct their Industry 4.0 attention in areas where they expect to see wider benefits. 2 out of the 3 the respondents perceive that, primarily, Industry 4.0 will increase productivity, while 1 out of 2 believe that Industry 4.0 will improve decision making and decrease operational costs. This indicates that Greek executives appear to primarily use Industry 4.0 technologies within their organisations to "become digital", optimize their internal operations and reap direct benefits. The use of digital technologies to create new, smart, connected products currently comes as a second priority (see Figure 89).

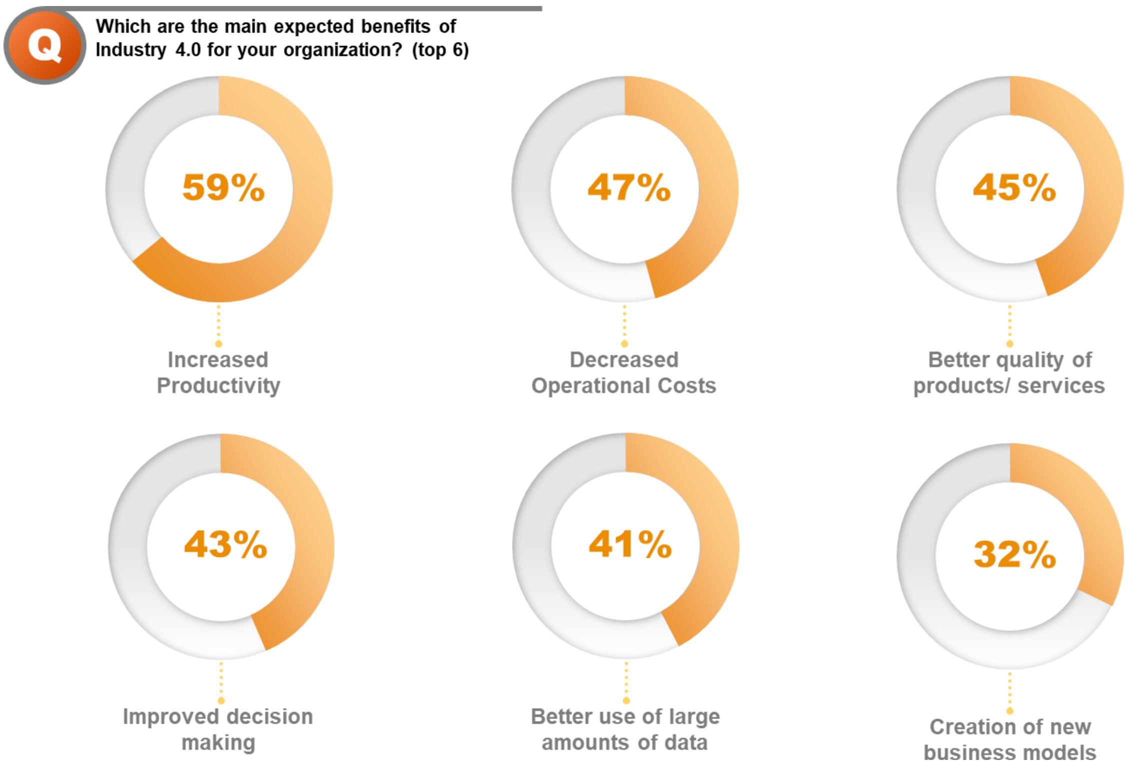

Figure 89: Greek executives' level of agreement regarding the benefits that Industry 4.0 will bring to their organisations, (%) – Source: Industry 4.0 survey

In terms of the Industry 4.0 technologies that Greek organisations implement, our survey indicates that during the last years, our respondents have focused their attention on the cloud (47% of the respondents), cybersecurity (44%), big data analytics (36%) and SCADA systems (24%). At the same time, a quite alarming finding is surfaced. 20% of the respondents appear not to have implemented any Industry 4.0 technology in their organisations (see Figure 90).

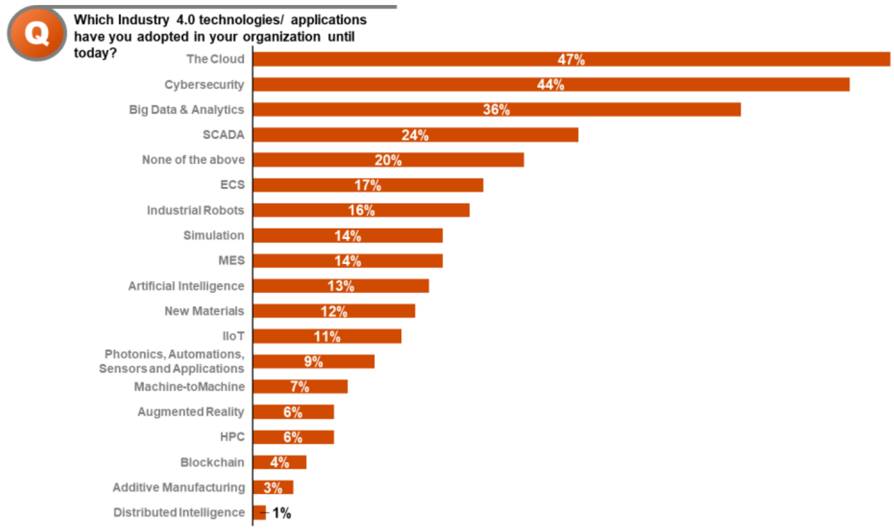

Figure 90: Key Industry 4.0 technologies/ applications that Greek executives have adopted in their organisations, (%)– Source: Industry 4.0 survey

Evidence indicates that organisations intend to invest intensively in Industry 4.0 initiatives over the next 5 years. Respondents cited that in the near future they plan to continue investing in Cloud (33%), Cybersecurity (32%) and big data analytics (29%), while they also plan to actively experiment with IIoT (26%), industrial robots and AI (24%),Simulation (22%) and SCADA (21%). The biggest increase in interest in denoted for IIoT (15%) (see Figure 91).

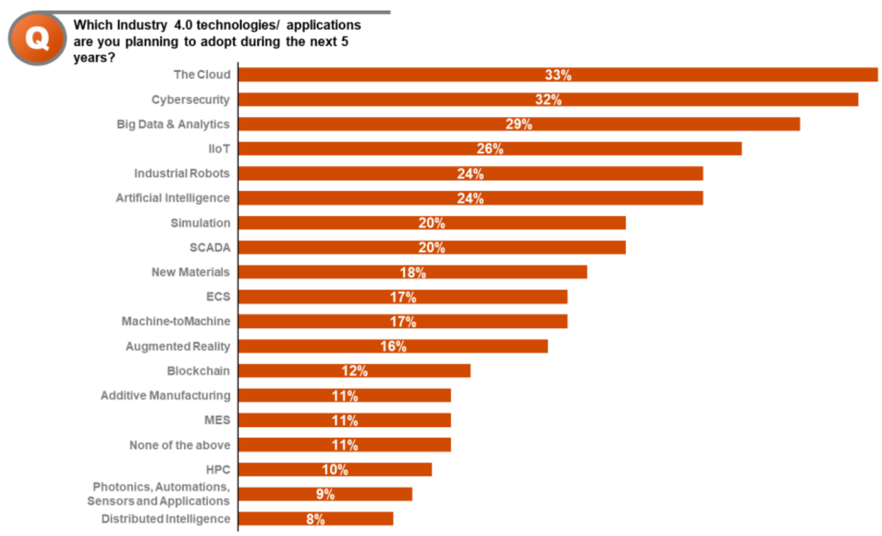

Figure 91: Key Industry 4.0 technologies/ applications that Greek executives plan to adopt in their organisations within the next 5 years, (%) — Source: Industry 4.0 survey

The outcomes of this survey question supplement with qualitative input to the hard-data analysis presented in chapter 6. Contrary to the high percentage of Greek executives (47%) that claim to currently invest in cloud and cybersecurity, hard-data evidence indicates that only 13 % of Greek enterprises used cloud computing in 2018.[478] This contradictory picture also emerges for cybersecurity, where according to the Global Cybersecurity Index (GCI), a trusted reference that measures the commitment of countries to cybersecurity at a global level, Greece scores on the 77th position against the overall, worldwide sample, that consisted of 193 countries.

Executives' perspective appears to be more aligned with regards to their investments in big data analytics and industrial robots. In fact, the fact that 36% of the surveyed executives stated that their organisations

[478] Eurostat https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicce_use&lang=en

invest in big data analytics is aligned with our data analysis, according to which 13 % of Greek enterprises reported using big data in 2018.[479] On the other hand, only a limited number of executives stated that they currently invest in industrial robots (16%). This is also confirmed by our data analysis, according to which only 2% of the Greek enterprises invested in industrial robots in 2018. [480]

Greek organisations have the ambition to make the most of Industry 4.0, but in practice extracting value remains a challenge for many. What is stopping them? Our survey results suggest that Greek executives confront several challenges for the deployment of Industry 4.0. The lack of digital skills for implementing and using Industry 4.0, the limited time to experiment, test and implement new Industry 4.0 technologies, the difficulties they face regarding securing the funds to further invest in Industry 4.0 initiatives and the lack of technical knowhow in implementing and using Industry 4.0 capabilities are being identified as the four top-of-mind challenges (see Figure 92). These challenges confirm Greece's low position, both across the integration of digital technologies (DESI Index's 4th pillar) and across the digital skills of the Greek Human Capital (DESI Index's 2nd pillar). In addition, the need for additional funding schemes is highlighted.

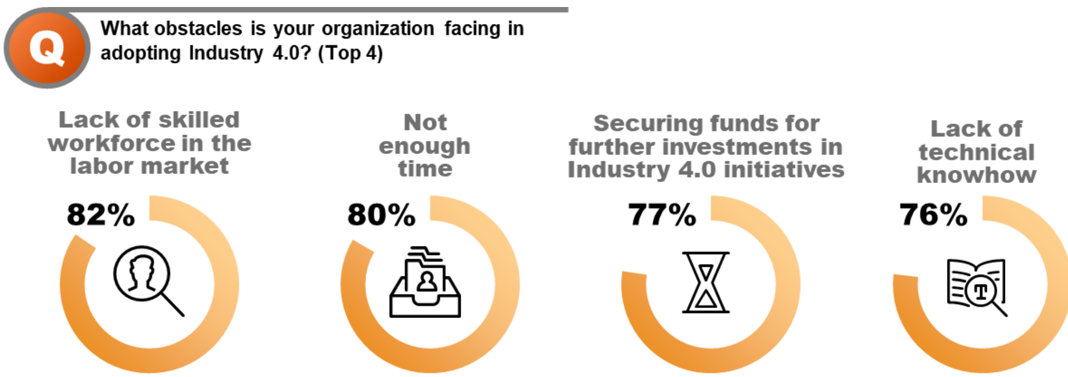

Figure 92: Key obstacles that Greek organisations face in adopting Industry 4.0, (%) – Source: Industry 4.0 survey

Greek organisations cited that the Greek Government has an important role to play in abolishing the abovementioned structural inhibitors and accelerate Industry 4.0 adoption within the Greek industry, through the provision of relevant financial and non-financial incentives. To start with, 9 out of 10 Greek executives believe that the provision of a modern technological infrastructure (e.g. 5G, integrated national fibre optic broadband and wireless networks) could catalyse the implementation of Industry 4.0 initiatives within Greek organisations. In addition, almost 9 out of 10 of the respondents perceive the provision of relevant tax incentives as an important motive for organisations' digital transformation. Next to tax incentives, the provision of technical expertise for the design and implementation of Industry 4.0 initiatives

[479] Eurostat, https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/comprehensive-database
[480] Eurostat, https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190121-1?inheritRedirect=true

and for tackling cybersecurity issues feature high on the agenda of more than 8 out of 10 respondents (see Figure 93).

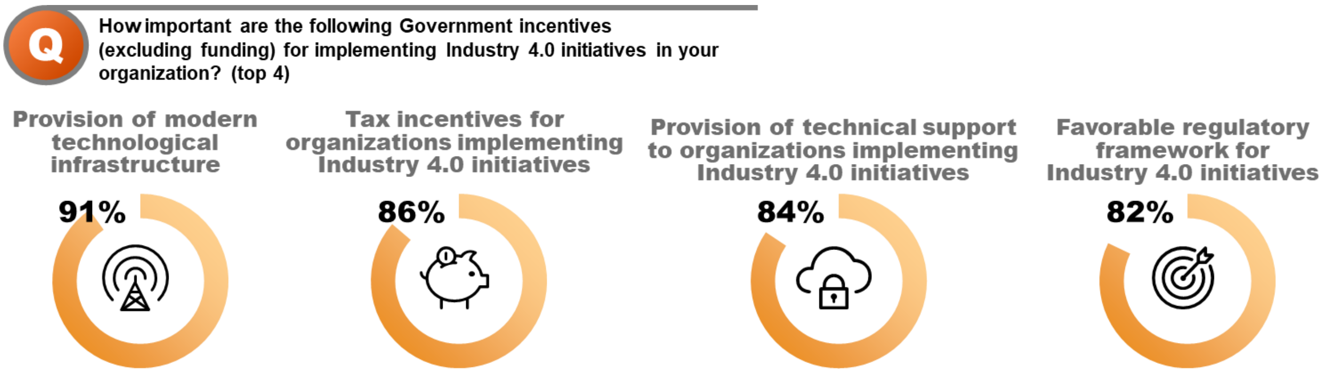

Figure 93: Important Government initiatives (excluding funding) that Greek executives wish to undertake in order to accelerate their organisations' digital transformation, (%) – Source: Industry 4.0 survey

The respondents provided additional useful insights with regards to the financing methods they used thus far for the implementation of Industry 4.0 initiatives, as well as for the methods they plan to use in the next 5 years.

In terms of short-term financing, during the last three years Greek organisations appear to have relied mainly on banking loans (42%), public funding (37%), and leasing (18%) to finance their Industry 4.0 projects. As Greece gets itself out of a decade-long economic crisis, Greek businesses expect to use additional public funds to accelerate their rotation to digital (55%) (see Figure 94).

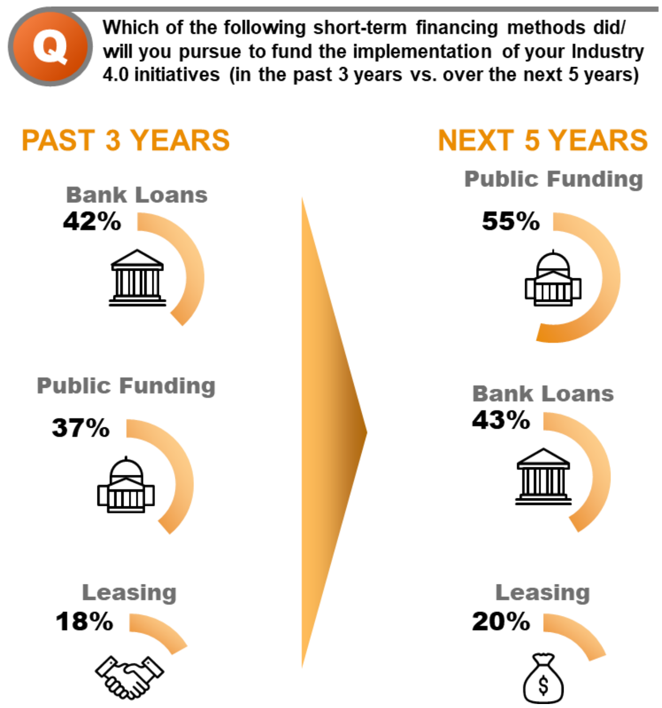

Figure 94: Short-term financing methods used/ to be used by Greek organisations during the last three years/ next five years, (%) – Source: Industry 4.0 survey

The respondents exhibit a slightly different approach when it comes to long term funding. Long-term financing methods in the past 3 years relied primarily on own capital (39%), bank loans (34%) and less on public funding (27%), indicating that such forms of funding were less attractive and/ or available (either too expensive or too scarce). In the next five years, more organisations plan to source long-term public funds (49%), indicating the belief that there will be an increased availability of public funds towards Industry 4.0 initiatives and/ or a better absorption rate of public funds. At the same time, more Greek organisations plan to continue relying on own capital (47%) and bank loans (40%) (see Figure 95).

According to our review of other EU countries' Industry 4.0 strategy, organisations across different EU member states also base their digitisation efforts significantly on public funding initiatives. In fact, SMEs across the different countries appear to leverage to a greater extent public funding mechanisms than their larger peers.

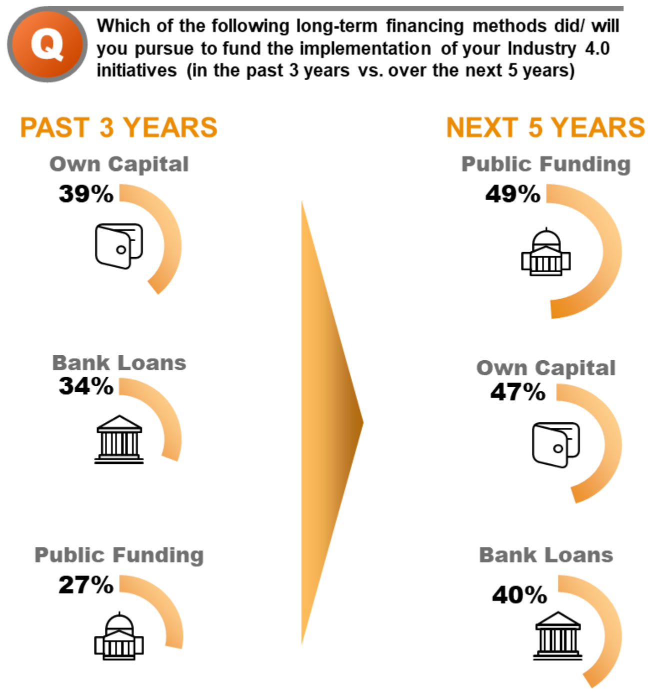

Figure 95: Long-term financing methods used/ to be used by Greek organisations during the last three years/ next five years, (%) – Source: Industry 4.0 survey

8.3 Value Chain & New Business Models

To achieve these expected Industry 4.0 benefits, the majority of respondents appear to have initiated their digital transformation across specific functions of their organisations. In fact, 7 out of 10 participants cited that their support functions demonstrate the highest level of digitisation, while Marketing & Sales also demonstrates a relatively high degree of digital maturity (see Figure 96). This once again indicates that organisations primarily focus on internal efficiencies of their operations and as a second priority to the “smartification” of their products and services.

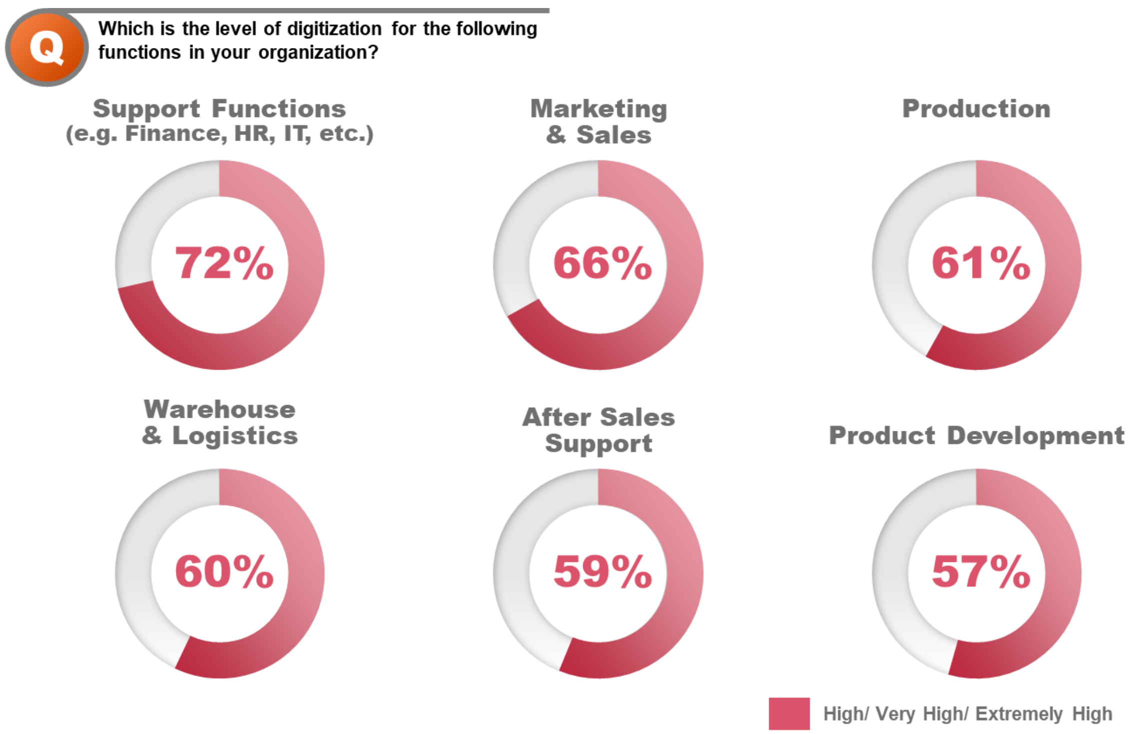

Figure 96: Greek executives’ perception with regards to the level of digitisation of their organisation’s functions, (%) – Source: Industry 4.0 survey

Moving forward, respondents aim to primarily funnel their funding for the digitisation of their Production and Product Development departments, in order to increase the organisation’s efficiency and speed to market. In addition, they also aim to further accelerate the digitisation of their already transformed functions. In fact, nearly 4 out of 10 of the respondents plan to continue investing in their Marketing & Sales, and Support Functions (see Figure 97).

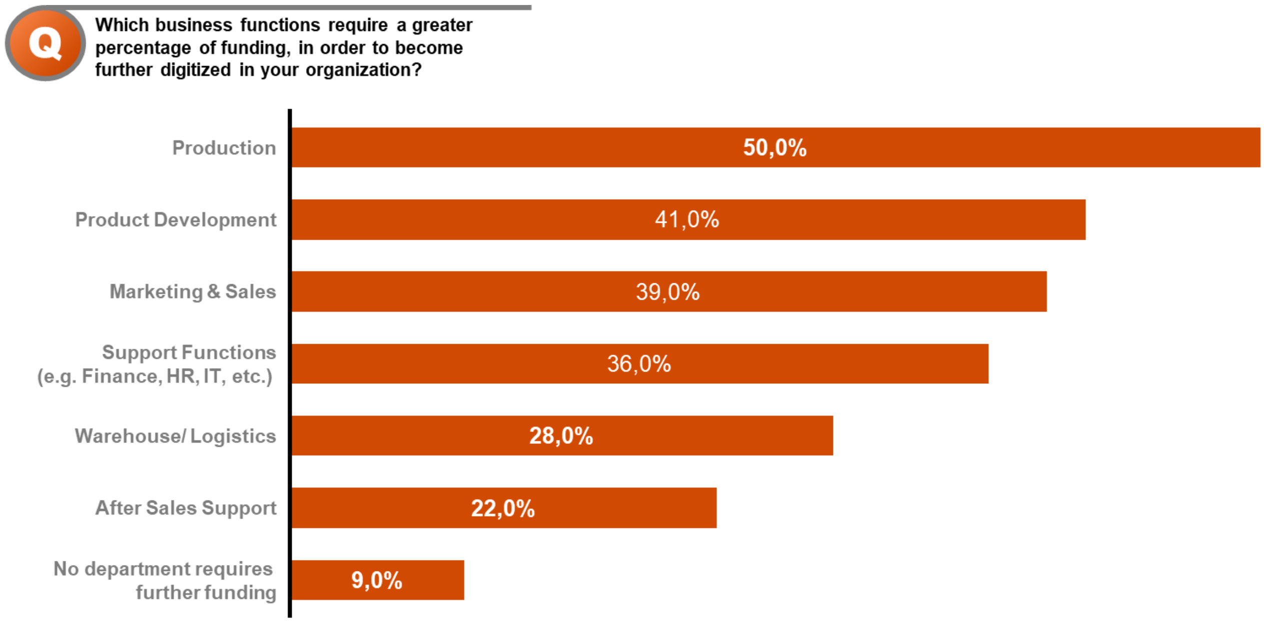

Figure 97: Funding required for further digitisation across different business functions of organisations, (%) – Source: Industry 4.0 survey

8.4 Interconnected products

Investments in the “smartification” and “personalisation” of the existing products appear to be indeed a high priority for the Greek respondents, as currently nearly 1 out of 2 of them cite that their products still have no interface or ability to communicate with any other machine, or they can just send or receive basic input/output signals (one-way communication) (see Figure 98).

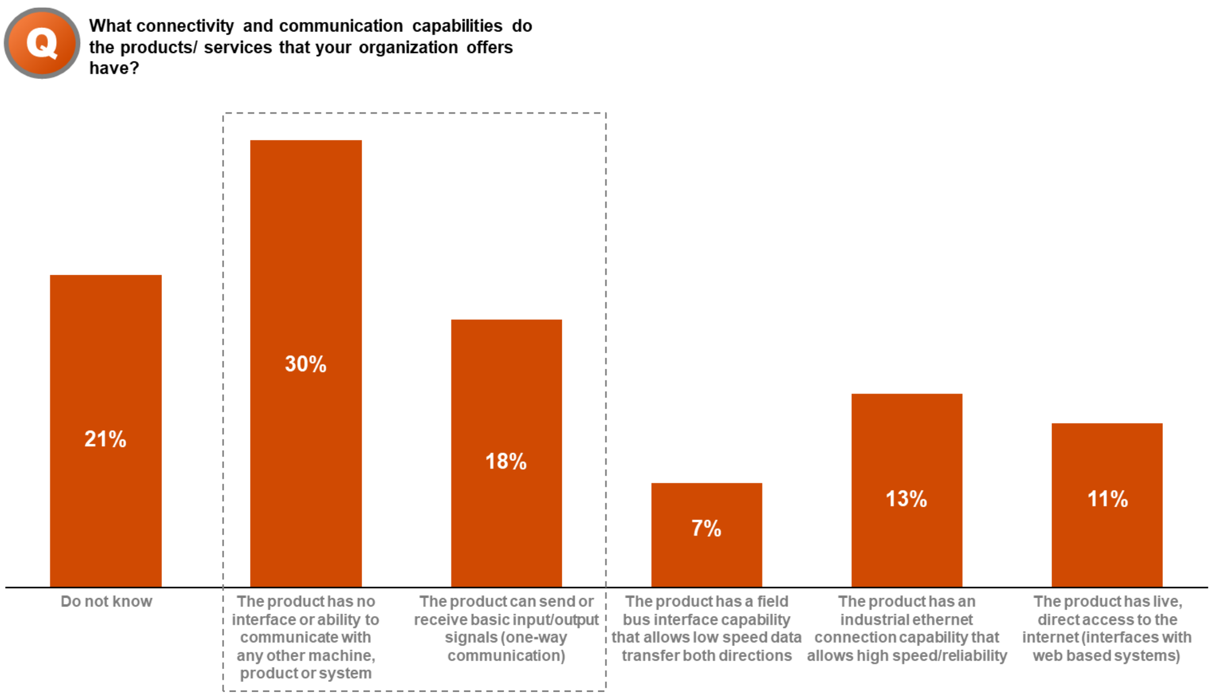

Figure 98: Degree of interconnectivity capabilities of products/ services that organisations offer, (%) – Source: Industry 4.0 survey

To achieve the “smartification” and “personalisation” of their products, the respondents appear to collaborate with their clients and suppliers, albeit to a different extent. Currently, 1 out of 2 and 1 out of 3 of the participants claim to closely collaborate with their clients and suppliers respectively for the development of customized products and services (see Figure 99).

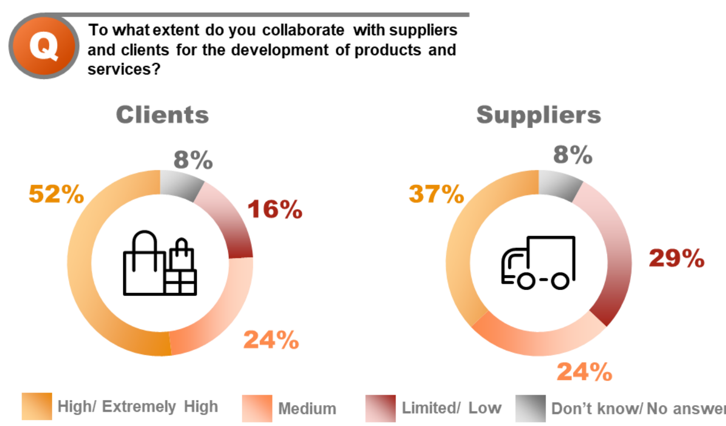

Figure 99: Degree of collaboration with partners/ suppliers for product/service development, (%) – Source: Industry 4.0 survey

8.5 Interconnected Production and Operations

Participants' production lines demonstrate a variable degree of digitisation. 3 out of 10 of the respondents cite that their production line demonstrates a high or significantly high level of digitisation. At the same time, nearly 1 out of 2 of the respondents are either unaware of the level of digitisation with regards to their organisation's production line, or they perceive this to be very limited (see Figure 100).

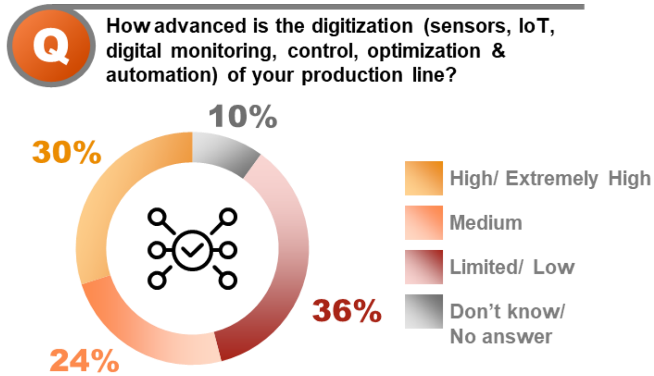

Figure 100: Degree of digitisation of the production line of organisations, (%) – Source: Industry 4.0 survey

This contradicts with the fact that many respondents (61%) claim to have revamped their production equipment during the last two years (see Figure 101) and that almost 1 out of 4 of them claim to possess a real-time view of their production (see Figure 102).

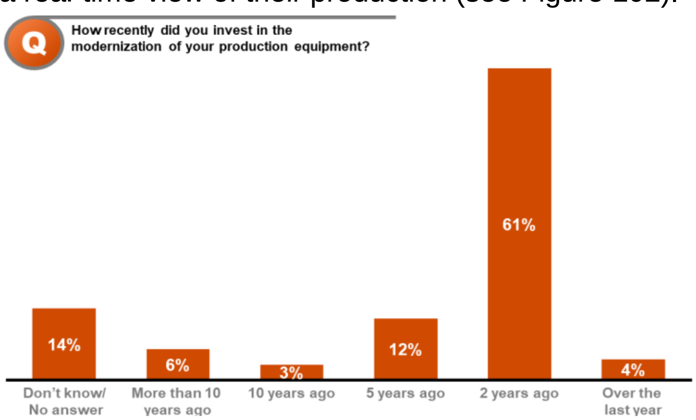

Figure 101: Last time organisations invested in the modernisation of their production equipment, (%)

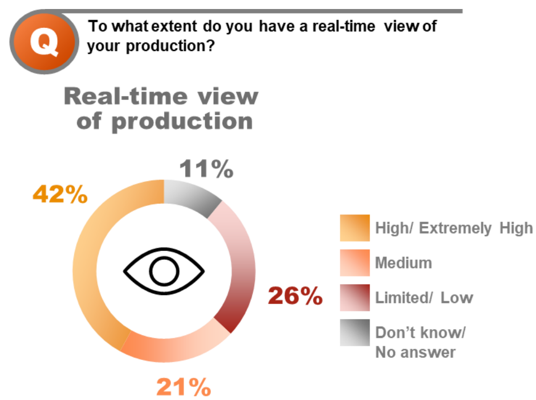

Figure 102: Degree of real-time view of production capacity, (%) – Source: Industry 4.0 survey

8.6 Digital Skills and Human Capital

Greek surveyed executives verify the limited digital skills currently existing in the Greek market. Only 17% of the Greek executives believe that their workforce is currently digitally adept, with major upskilling required mainly on new technologies, complex problem-solving and soft skills. In addition, the majority of Greek executives perceive that "Expertise in new technologies" will be the most sought-after skill when hiring employees for Industry 4.0 activities over the next 5 years, while "Soft skills" and "Problem solving skills" appear to also be important for about half of them (see Figure 103 & 104).

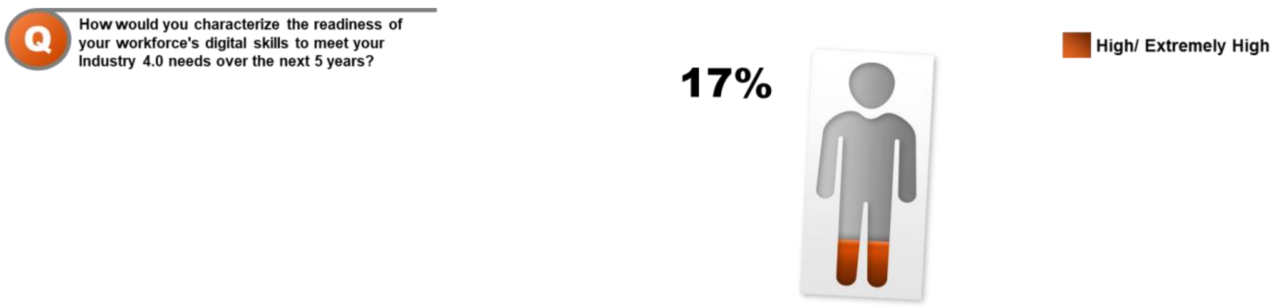

Figure 103: Degree of organisation's confidence in the current level of digital skills of their workforce, to meet Industry 4.0 challenges – Source: Industry 4.0 survey

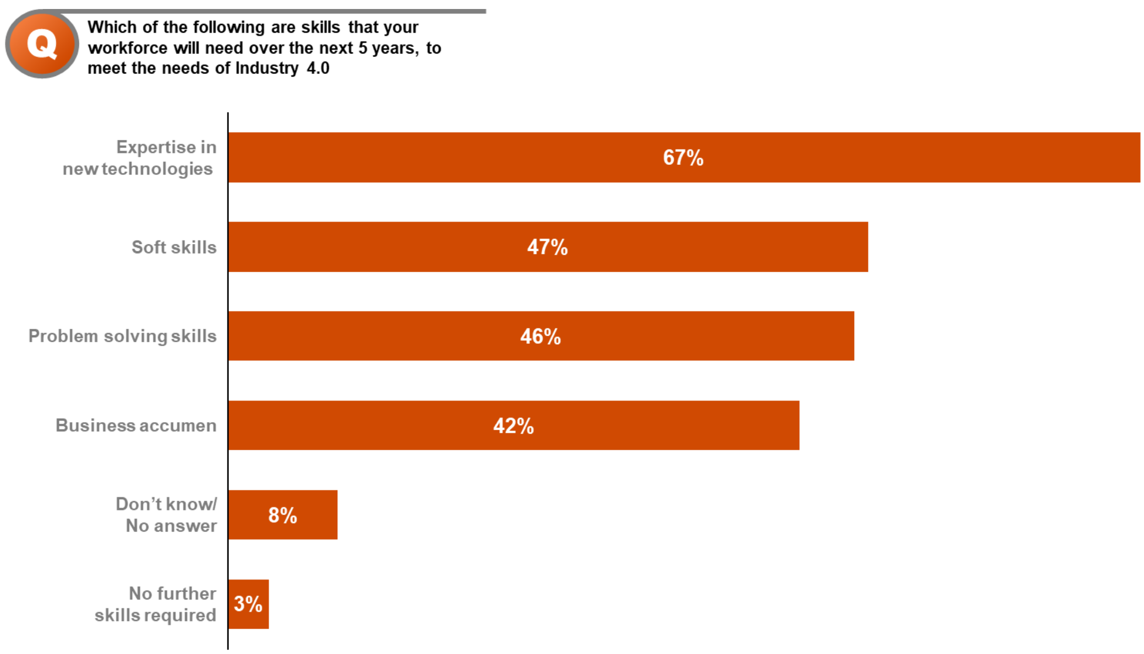

Figure 104: Level of importance that different types of skills will have with regards to Industry 4.0, in the next 5 years, (%) – Source: Industry 4.0 survey

Diving further into the expertise in new technologies, almost 20% of the Greek executives perceive that it will be more difficult in the future to source digital capabilities in the fields of Artificial Intelligence and The Cloud, while 18% of them expect to face difficulties in sourcing Big Data & Analytics, Cybersecurity and Industrial Robots (see Figure 105).

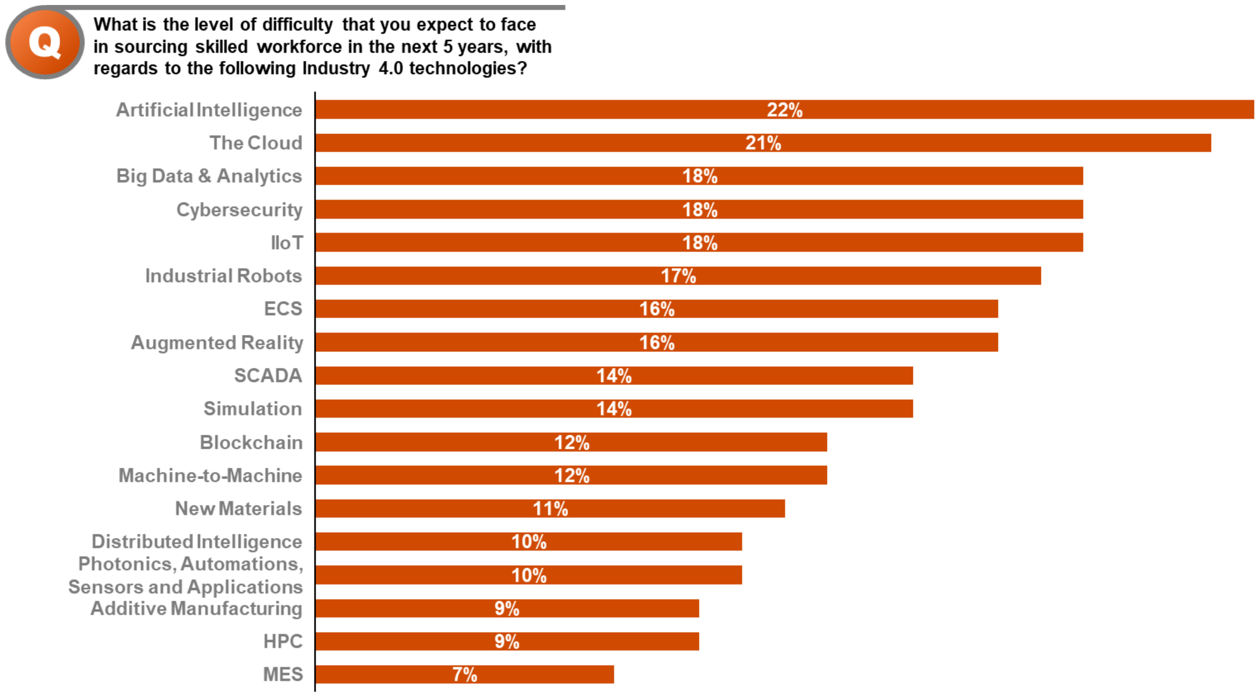

Figure 105: Level of difficulty that organisations expect to face in sourcing skilled workforce for adopting Industry 4.0 initiatives – Source: Industry 4.0 survey

8.7 IT Infrastructure and Technology

The IT infrastructure of half of the respondents appears advanced in terms of data collection and processing. In fact, more than 4 out 10 of the respondents claim that their organisations possess systems of high or very high maturity regarding collecting and analysing client, product and services production and operations data (see Figure 106). This comes as little surprise, if we consider the notable investment that Greek enterprises already perform in big data analytics. This investment highlights the fact that a high percentage of enterprises have in place the appropriate mechanisms and platforms to capture and consolidate data for its further analysis and generation of insights.

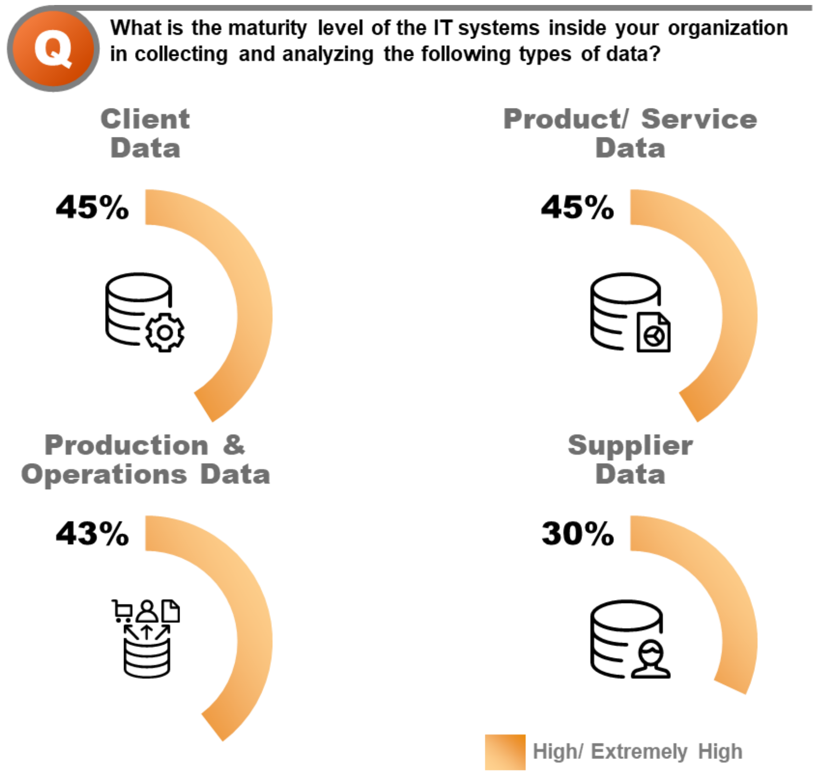

Figure 106: Level of IT systems maturity with regards to their capacity to collect and analyse data generated from different sources, (%) – Source: Industry 4.0 survey

Nevertheless, it appears that there is still room for improvement with regards to the integration of the respondents' IT infrastructure with clients' and suppliers' IT landscape. Currently, 4 out of 10 of the respondents cite that their IT systems are only connected to a limited or a very low extent, to their clients' and suppliers' infrastructure (see Figure 107).

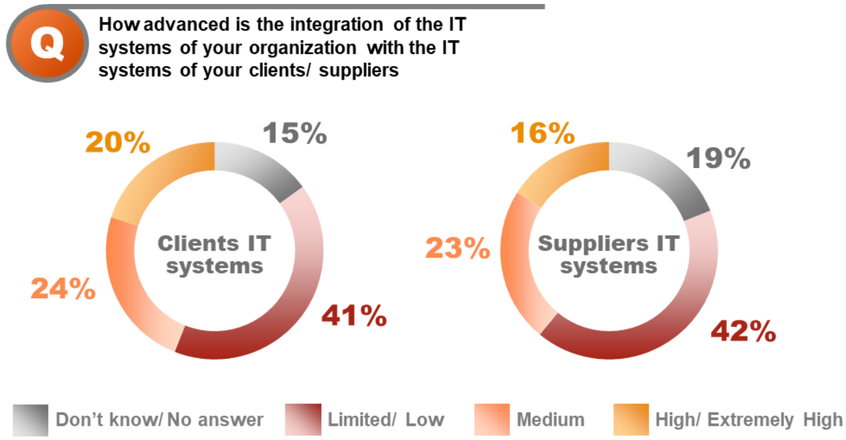

Figure 107: Degree of organisation's IT systems integration with IT systems of Clients/ Suppliers, (%) – Source: Industry 4.0 survey

Finally, 65% of the survey participants appear confident enough that their Production department is secure against cyberattacks while they also perceive their Support Functions (64%) and Product Development (64%) departments as secure (see Figure 108).

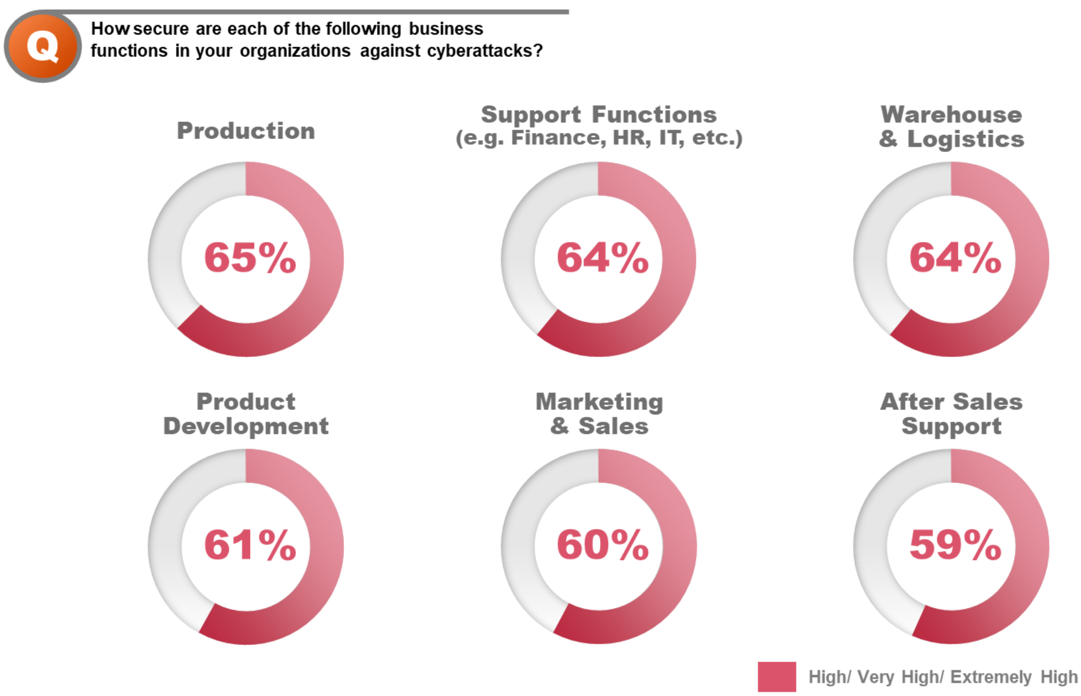

Figure 108: Degree of security against cyberattacks across different business functions, (%) – Source: Industry 4.0 survey

This can be translated in two ways. Either, respondents actually have in place advanced, cybersecure IT systems, or they have not realized to a full extent how Industry 4.0 can link to rising cyber vulnerability. Our data analysis in chapter 8 indicates that the latter is the most likely to happen, since according to the Global Cybersecurity Index 2018, Greece and its enterprises score significantly low with regards to their current level of cybersecurity.[481]

[481] https://www.itu.int/dms_pub/itu-d/opb/str/D-STR-GCI.01-2018-PDF-E.pdf

9 Appendix I

9.1 Key Industry 4.0 technology trends

9.1.1 Additive Manufacturing

Additive Manufacturing, also defined as 3D Printing, refers to the prototyping and production of customized, individual goods based on specific customer requirements. Within the Industry 4.0 context, additive manufacturing and 3D printing methods will be used to produce small batches of customized products that offer construction advantages, such as complex, lightweight designs and lead to less stock on hand and overproduction. In addition, Industry 4.0 is expected to bring customers and suppliers closer together, and customers will be able to directly send production orders to the production partner in real-time. In this case, additive manufacturing can significantly improve speed to production, manufacturing design freedom, supply chain reductions, rapid prototyping and small-scale production experiments.[482]

Recent advances in the speed, flexibility, and cost of additive manufacturing (AM) have made it accessible to industries previously concerned about the technology's scalability. One such industry is textile & apparel manufacturing, where firms are increasingly looking to 3D printing to quickly and affordably provide customers with customized products.

Adidas is leading the way for apparel manufacturers with the launch of its first commercially viable 3D-printed shoe in 2017 and goal to use 3D printing for mass production in the future. Driving the company's adoption of additive manufacturing is its "Creating the New" strategy, which includes goals to dramatically expand product customisation options while reducing production lead times. In fact, in April 2017, Adidas announced the launch of the Futurecraft 4D shoe, the world's first high-performance footwear with a sole crafted through the continuous liquid interface production process (CLIP). CLIP is a revolutionary 3D printing technique, through which designs are pulled out of a vat of polymer resin and fixed into the desire shape using UV light. The shoe was produced in partnership with Carbon, a Silicon Valley-based technology company that is leading the way in this technology.[483,484]

9.1.2 Artificial Intelligence

Artificial Intelligence (AI) consists of a combination of multiple scientific fields, that are supported by technologies that enable machines to sense, comprehend, act and learn. AI technologies such as Computer Vision, Natural Language Processing and Machine Learning, as well as their applications such as Virtual Agents, Recommendation Systems, and Cognitive Robotics, can optimize processes and operations, by interacting with humans and redirecting their time towards more productive labour.[485]

AI significantly impacts and transforms the Industry, as it can be implemented through different applications across all stages of its value chain. In BMW's automotive assembly plant in Dingolfing, Germany, workers and robots are collaborating to build a transmission[486], while Budapest-headquartered

[482] Lasi, H., Fettke, P., Kemper, H.-G., Feld, T. and Hoffmann, M. (2014), "Industry 4.0", Business & Information Systems Engineering, Vol. 6 No. 4, pp. 239-242.
[483] Adidas, 2017 Annual Report, p. 64-75,
[484] The perfect fit: Carbon + Adidas collaborate to upend athletic footwear, from Carbon website, https://www.carbon3d.com/stories/adidas/
[485] Accenture 2019, „With an AI to the Future", https://www.accenture.com/gr-en/insights/digital/greece-an-ai-future
[486] DPCCars, "BMW Factory Humans & Robots Work Together at Dingolfing Plant" YouTube Video 25:22 minutes, posted March 2, 2017,

Waberer's International Nyrt, a European transportation leader, deployed an AI solution to automate its truck scheduling function and seamlessly allocate driver team, load and journey schedules in the most efficient way.[487] At the same time, consumer brands, i.e. Coca Cola, become increasingly dependent on AI chatbots to represent them in the mass market.[488]

9.1.3 Augmented Reality

Augmented Reality is a technology that is quickly becoming a great tool for many types of sectors. From tourism to manufacturing and everything in between, Augmented reality is truly changing the way that things work. Augmented reality (AR) allows for visualisation of computer graphics placed in the real environment and supports a variety of services, such as the description, planning and real-time operation monitoring, fault diagnostic and recovery, and training related to industrial products and processes[489]. Augmented-reality-based systems can be used for selecting parts in a warehouse and sending repair instructions over mobile devices. Industry can use augmented reality to provide workers with real-time information to improve decision making and work procedures. Workers may receive repair instructions on how to replace a specific part as they are looking at the actual system that needs to be repaired.

One industry where AR is particularly relevant and is offering a significant change to the way things are done is the mining industry. More and more mining companies are turning to this technology as a way to improve safety, efficiency, and to drive innovation. For instance, AR can be used to assist with drilling practices, through visual guidance on the usage of the drilling equipment or machine, in order to enhance the accuracy and efficiency of drilling. This application can further be expanded to display the real-time location and orientation of the drill bit below surface or within the rock face, as measured through various tracking technologies. The visualisation of such positioning information of the drill bit and rod would then allow for faster reaction and adjustments by operators to improve drilling accuracy.[490]

The global AR market is set to grow exponentially. Currently at $19 billion[491], worldwide spending on AR is forecasted to expand at an average annual growth rate of 72% up until 2022. Europe makes up a fifth of the global market[492].

9.1.4 Big Data Analytics

Big Data Analytics is described as the collection and comprehensive evaluation of data from many different sources, from production equipment and systems to enterprise and customer-management systems to support real-time decision making and economically extract value through discovering, capturing and analysing very large volumes of a wide variety of data.

https://www.youtube.com/watch?v=Dm3Nyb2lCvs&t=152s
[487] Microsoft, Customer Stories, http://customers.microsoft.com/en-us/story/waberers-professional-service-azure-hungary
[488] Adweek, Coca-Cola Is Embracing AI and Chatbots in Preparation for a Digital-First Future, https://www.adweek.com/digital/coca-cola-is-embracing-ai-and-chatbots-in-preparation-for-a-digital-first-future/
[489] Doshi, A., Smith, R.T., Thomas, B.H. and Bouras, C. (2017), "Use of projector based augmented reality to improve manual spot-welding precision and accuracy for automotive manufacturing", The International Journal of Advanced Manufacturing Technology, Vol. 89 Nos 5-8, pp. 1279-1293.
[490] J. Jacobs, R.C.W. Webber-Youngman,E.A. van Wyk, University of Pretoria, Department of Mining Engineering & Tshwane University of Technology, Department of Computer Science,2016, „Potential Augmented Reality Applications in the Mining Industry"
[491] https://www.statista.com/statistics/591181/global-augmented-virtual-reality-market-size/
[492] https://techcrunch.com/2018/01/25/ubiquitous-ar-to-dominate-focused-vr-by-2022/?guccounter=1

In Industry 4.0, technological advances have made possible the collection, synthesis, and evaluation of data from every stage of the organisation's value chain. Data from the industrial production, sales and distribution process and product use can all be used in tandem to achieve more optimal and efficient operations. Data analytics have already led to significant efficiency gains for the manufacturing sector, enabling businesses to optimize their production quality, pre-empt system failures, streamline the maintenance process, save energy, and achieve sophisticated cross-enterprise inventory management.

For instance, Ducati Corse, part of world-leading sports motorcycle manufacturer Ducati Motor Holding, collaborated with Accenture to modernised motorbike testing, by combining two disruptive technologies – Data Analytics and Internet of Things (IoT) – to create a mobile application capable of simulating and monitoring a motorbike's performance under a vast array of track and weather conditions. Big data analytics was then applied to the racing performance KPIs and past test data to identify the optimal bike set-up configuration, using advanced algorithms working on the data patterns from the different sensors, machine learning and applying clustering and regression algorithms.[493]

9.1.5 Blockchain

Blockchain is an open distributed ledger of transactions, that securely transmits any type of information without the control of any central authority. Cryptography and digital signatures ensure authenticity, proof-of-identity and enforces read/write access rights while allowing contributors to be anonymous. Blocks are verified and added in near real-time eliminating arbitrage risks or data-sync problems. There is no single point of failure for a blockchain because the ledger is replicated across the globe.

Blockchain is the foundation of cryptocurrencies, like Bitcoin and Ethereum, however its capabilities extend far beyond this. Blockchain is immutable and redefines trust, as it enables transparent, secure, and trustworthy solutions.[494] According to recent studies, the blockchain technology can be a powerful tool for organisations' rotation to Industry 4.0. Blockchain can be used for any type of digitised transfer of information. Industry 4.0 develops on the foundation of automation, and blockchain can be used as the ledger to develop trusted and autonomous relationships among different components of smart factories, suppliers and even customers. For example, putting blockchain between interconnected equipment, cyber-physical production systems, and supply partners can enable machineries within the smart factory to securely and autonomously place an order for their replacement parts to further optimize the processes.

Blockchain gains significant momentum in the agri-food sector, as it can be applied for food traceability purposes and provides the ability to instantaneously trace the entire lifecycle of food products from origin through every point of contact on its journey to the consumer bolsters credibility, efficiency and safety. Nestlé and Carrefour, both members of the IBM Food Trust, are to offer food traceability for a famous French convenience food, Mousline instant mashed potato, one of Nestlé's brands. By using IBM's blockchain platform, consumers can access reliable and unfalsifiable information about the supply chain and production by scanning the QR code on the product using their smartphones.[495]

[493] Accenture, Client Case Study, https://www.accenture.com/us-en/success-traditional-motor-bikes-ducati-corse
[494] Underwood, S. (2016), "Blockchain beyond Bitcoin", Communications of the ACM, Vol. 59 No. 11, pp. 15-17.
[495] Ledger Insights, Food Traceability with Blockchain, https://www.ledgerinsights.com/blockchain-food-traceability-nestle-carrefour-ibm/

9.1.6 Cloud

Cloud computing is not a new concept. Nevertheless, it is expected to significantly enable organisations to transition to the Industry 4.0 era. Cloud computing evolved based on the recent advancements in hardware, virtualisation technology, distributed computing and service delivery over the internet. Within the Industry 4.0 context, production-related activities will require increased data sharing across sites and company boundaries. At the same time, the performance of cloud technologies will improve, achieving reaction times of just several milliseconds. As a result, machine data and functionality will increasingly be deployed to the cloud, enabling more data-driven services for production systems.

Cloud computing provides a number of benefits to organisations. Firstly, transitioning to cloud computing significantly reduces the cost of managing and maintaining IT systems. In addition, cloud enables the integration of distributed manufacturing resources and the establishment of a flexible infrastructure across geographically distributed manufacturing sites. By moving to the cloud organisations can avoid having to pay for costly system upgrades and employ experienced professionals to run their servers. Moreover, moving to the cloud significantly reduces energy consumption and leads to fewer time delays. Secondly, cloud computing allows organisations to seamlessly scale their operations and storage needs up or down according to their needs, minimizing the financial risk inherent in purchasing costly servers. Thirdly, storing data in the cloud ensures that it is backed up and protected in a safe and secure location. Finally, cloud computing allows employees, contractors and 3rd parties to collaborate more effectively and easily.

Enel, a large multinational utility company, started in 2015 to move all its IT services over onto the cloud. With the closure of the last data centre in April 2019 Enel became "full cloud", the world's first large utility company to achieve this.[496]

9.1.7 Cybersecurity

Through the increased connectivity and use of standard communication protocols that come with Industry 4.0, the need to protect critical industrial systems and manufacturing lines from cybersecurity threats increases dramatically. Within Industry 4.0, all equipment and products across the entire value chain become connected through the internet or amongst themselves and create a fully interconnected industrial networked environment. As a result, secure and reliable communications as well as sophisticated identity and access management of machines and users are essential. The Stuxnet, the notorious malware that infested control systems at the nuclear plants and manipulated the speed of centrifuges, causing them to spin out of control, is only one of the many cybersecurity threats appeared thus far.[497] A report from professional services firm EY has also shown that 55% of mining operators fell victim to a serious cybersecurity incident in 2017, with 48% admitting that it is unlikely that they would even be able to identify a sophisticated attack.[498]

Advanced persistent threat (APT) campaigns, which were initially used for industrial espionage, have been repurposed to impact businesses by attacking and damaging industrial assets. In December 2015, BlackEnergy (BE) and another APT campaign, Sandworm, were identified as the likely perpetrators behind service interruptions at two power generation facilities in Ukraine. In addition, BE and KillDisk were the

[496] Enel, Enel "full cloud": all the advantages of being the pioneers, https://www.enel.com/stories/a/2019/07/enel-moves-cloud-model-future
[497] Wired, Symantec Security Response, https://www.wired.com/images_blogs/threatlevel/2010/11/w32_stuxnet_dossier.pdf
[498] EY, Cybersecurity in Mining and metals, https://www.ey.com/en_gl/mining-metals/cybersecurity

suspected drivers behind similar cyberattacks against a mining company and a large railway operator that were also based in Ukraine.[499]

9.1.8 Distributed Intelligence

Centralized systems have disadvantages that make them unsuitable for large-scale integration, including reliance on centralized communication, high complexity, lack of scalability and robustness, and high cost of integration. The use of distributed intelligence system technologies avoids these weaknesses. Distributed intelligence systems are based on the use of cooperative agents, organized in hardware or software components, that independently handle specialized tasks and cooperate to achieve system-level goals and achieve a high degree of flexibility. By distributing the logistic and strategic requirements of a system, it is possible to achieve greatly improved robustness, reliability, scalability, and security. Key to achieving these benefits is the use of holonic system technologies that establish a peer-to-peer environment to enable coordination, collaboration, and cooperation within the network.

9.1.9 Electronic Components & Systems

Electronic Components and Systems (ECS), refer to components which are the hardware and software parts of the systems. The word "systems" is used in this context for the respective highest level of development targeted within the given part of the value chain. A "system" designed and implemented within a given development process may be integrated as a "component" into a higher level "system" within another development process. These systems typically include hardware and software parts. Electronic Components and Systems are core enablers and differentiators for the development of many innovative products and services in all sectors of the economy.[500]

Aemtec Gmbh (Germany), a company that provides technology solutions to customers in the equipment manufacturing, systems integration and applications sectors, leverages ECS in the development of innovative products and services. Some of the industries that use Aemtec's products are: a) Medicine, for the development of portable medical technology, wearables or point-of-care diagnostics b) ICT for the development of new, highly integrated solutions for chips, optics, packages and complete systems to support the ever increasing need for worldwide networking and increased bandwidth c) Industry and Automation, where they manufacture highly advanced sensors and actuators to support the development of reliable control systems.[501]

9.1.10 High Performance Computing

High-performance computing (HPC) is the use of parallel processing for running advanced application programs efficiently, reliably and quickly. The term applies especially to systems that function above a teraflop or 1012 floating-point operations per second. The most common users of HPC systems are scientific researchers, engineers and academic institutions. Some government agencies, particularly the military, also rely on HPC for complex applications.

Robert Bosch (Germany) has invested through their subsidiary Robert Bosch Venture Capital (RBVC) in HPC start-up IONQ which develops and commercializes Quantum Computers. According to RBVC

[499] MicroTrend, Cyber Threats to the Mining Industry, https://www.trendmicro.com/vinfo/ru/security/news/cyber-attacks/cyber-threats-to-the-mining-industry
[500] ECS-SRA, Strategic Research Agenda for Electronic Components and Systemshttps://www.smart-systems-integration.org/system/files/document/ECS-SRA-2019%20update-v5.3%20for%20web%20publishing%20-%20clean.pdf
[501] AEMTEK, https://www.aemtec.com/

Managing Director Dr. Ingo Ramesohl. "Commercially useable Quantum Computers could disrupt the way we develop products at Bosch." IONQ plans on making its computers commercially available via the cloud and developing next-generation systems for programming these machines.[502]

9.1.11 Industrial Robots

Automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications.

Current robots have higher flexibility, advanced functions and are easier to operate in multitudes of fields. In the near future, robots will interact with each other and collaborate actively with humans under the guidance of handlers. These robots will be cheaper and more sophisticated in order to achieve better abilities compared to those currently used in the manufacturing field.

BMW employs more than 380 robots at its factory in Spartanburg S.C. - there are nearly 1,000 of them plantwide manufacturing X5 vehicle bodies from 443 separate pieces of metal, performing 237 stud welds and more than 6,000 spot welds on each one, effectively doing nearly 100% of the work in the body shop. This way, BMW employees are better utilised in other areas such as the assembly line.[503]

9.1.12 Machine-to-Machine (M2M)

Machine-to-machine (M2M) refers to the direct communication between devices using any communications channel, including wired and wireless. Machine-to-machine communication can include industrial instrumentation, enabling a sensor or meter to communicate the information it records (such as temperature, inventory level, etc.) to application software that can use it (for example, adjusting an industrial process based on temperature or placing orders to replenish inventory).

Volvo (Sweden) has developed M2M communication capabilities for vehicles in construction sites (e.g. quarries, mines) that help reduce machine running costs, predict maintenance requirements and improve the overall efficiency.[504]

9.1.13 Manufacturing Execution System (MES)

Information systems used in manufacturing, to track and document the transformation of raw materials to finished goods. MES provides information that helps manufacturing decision makers understand how current conditions on the plant floor can be optimized to improve production output. MES works in real time to enable the control of multiple elements of the production process (e.g. inputs, personnel, machines and support services).

Carlsberg Group (Denmark), one of the largest breweries globally operating in over 50 countries, uses MES to trace and track production processes, resulting in reduced machine downtime, reduced energy costs, reduced overtime and labour costs, reduced manual data collection and report creation, reduced

[502] QuantaNeo, ROBERT BOSCH VENTURE CAPITAL INVESTS IN QUANTUM COMPUTING STARTUP IONQ, https://www.quantaneo.com/Robert-Bosch-Venture-Capital-invests-in-Quantum-Computing-Startup-IonQ_a320.html)
[503] Industryweek, The Future of Robotics in Manufacturing: Moving to the Other Side of the Factory, https://www.industryweek.com/technology-and-iiot/robotics/article/21957632/the-future-of-robotics-in-manufacturing-moving-to-the-other-side-of-the-factory)
[504] Volvo, The Future of Robotics in Manufacturing: Moving to the Other Side of the Factory, https://www.volvoce.com/global/en/news-and-events/news-and-stories/2018/construction-telematics-the-power-of-the-network/

inventory, elimination of duplicate processes, improved equipment utilisation, improved data accuracy for decision making, and in dynamic response capabilities to production or quality issues.[505]

9.1.14 New Materials

The development of new materials and nano-structures (e.g. graphene, composites, PVD, CVD), enable the creation of new components with useful traits such as, durability, shape retention, lightweight, thermo-electric efficiency and re-usability. Combined with additive manufacturing technologies, they will enable mass customisation of products, which wasn't possible up to now.

Composites are now cheaper to produce, and more companies make extended use of them. Flagship example of this use is BMW that uses composites to build its electric i3 car. BMW says the lighter weight helps the vehicle travel as much as 160 kilometres on a single charge. In addition, Lamborghini's fierce-looking Veneno Roadster is packed with weight-reducing composite parts that enable an acceleration of 0 to 100 km/hour in 2.9 seconds.[506]

9.1.15 Photonics, Automations, Sensors and Applications

New technologies such as Photonics, Automations, Sensors and Applications unlock advanced capabilities for seamless intercommunication throughout the production plant. In manufacturing, laser processing will be a basic prerequisite for high-volume, low-cost manufacturing. The Photonics technology will help overcome the limitations of electronics in computers through all-optical computing or even quantum computing. Photonics will move communications into the terabit era by dramatically increasing data capacity and data transmission speeds, while simultaneously reducing the networks' carbon footprint and the overall cost per bit. Photonics will play a key role in addressing the challenges of energy efficiency, gradually moving towards a low-carbon economy. In the future, solid-state light sources are expected to outperform almost all other sources in terms of efficiency, offering potential energy savings of 50% or even more, when used with intelligent light management systems. Sensor applications in smart power grids, smart buildings and smart industrial process control will contribute significantly to more efficient use of resources and meeting environmental challenges.[507]

Volkswagen has partnered with two university institutes at RWTH Aachen and FH Münster, the Fraunhofer Institute for Laser Technology (ILT) in Aachen and the Federal German Ministry of Research, to implement a laser system that will raise micro material processing to a new level of productivity. This system will alternate between hot nanosecond pulses for rapid material removal and cold picosecond pulses to introduce fine micrometre-scale structures. Despite its flexibility, it should be possible to operate this system "without any substantial knowledge of laser ablation procedures. [508]

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[505] Process worldwide, Carlsberg Chooses Siemens as its Global MES Supplier, https://www.process-worldwide.com/carlsberg-chooses-siemens-as-its-global-mes-supplier-a-297171/
[506] Advantage Environment, New materials reshape the manufacturing industry, http://advantage-environment.com/workplace/new-materials-reshape-the-manufacturing-industry/
[507] European Technology Platform Photonics21, Towards 2020– Photonics Economic Growth in Europe, https://www.photonics21.org/download/about-us/photonics-ppp/photonics-roadmap.pdf?m=1513605711&
[508] Laser Photonics, The faster way to microstructuring, https://world-of-photonics.com/en/newsroom/photonics-industry-portal/technologies/microstructuring/

9.1.16 Simulation

Simulation techniques focus on the simplification of the design, realisation, tests and running a live operation of manufacturing systems. Simulation will be used more extensively in plant operations to leverage real-time data to mirror the physical world in a virtual model, which can include machines, products, and humans, thereby driving down machine setup times and increasing quality.

Simulation is expected to enable manufacturers to prevent errors at an early stage that might otherwise result in substantial costs for plant operators. Simulation will also be used for preventive reasons, as it will enable organisations to optimize their manufacturing plants during ongoing daily operation.[509] For example, manufacturers are now able to simulate the machining of parts using data from the physical machine leading to the reduction of setup time for the actual machining process by as much as 80 percent.[510] Industrial reports reveal that manufacturing frontrunners see a much greater potential for simulation in the future through the virtual testing of complete production systems.

Simulation is widely used across all industrial sectors as well as in the transportation and storage sector. In this context, the port of Le Havre, the largest container port in France, implemented simulation techniques to construct a new multimodal terminal. In this terminal an area would be included where trains and river barges bring containers for further sea transportation and cranes load the containers from the carriers onto rail cars that carry them to sea transports. A simulation model was created that allowed the user to assign arrival times and required times for each container for the multimodal and sea terminal, assign train and river ship arrival & departure timetables, dynamically change the space availability for containers at the terminals, register the costs for different elements of the network, monitor the status of each entity.[511]

9.1.17 Supervisory control and data acquisition systems – SCADA

Supervisory control and data acquisition (SCADA) is a system of software and hardware elements that allows industrial organisations to control industrial processes locally or at remote locations, monitor, gather, and process real-time data, directly interact with devices such as sensors, valves, pumps, motors, and more through human-machine interface (HMI) software and record events into a log file. SCADA systems are crucial for industrial organisations since they help to maintain efficiency, process data for smarter decisions, and communicate system issues to help mitigate downtime.[512]

SCADA systems are widely used in the manufacturing, the electric power generation and the water and sewage sectors. In manufacturing, SCADA systems manage parts' inventories for Just-In-Time manufacturing. They also regulate industrial automation and robots. Also, to ensure good output, they monitor process and quality control. In the electric power generation, transmission and distribution sector, SCADA systems are used to detect two key things: current flow and line voltage. They monitor the operation of circuit breakers and also take sections of the power grid online or offline. Finally, state and municipal water utilities use these platforms to monitor and regulate water flow, as well as track reservoir levels and pipe pressure.

[509] Gilchrist, A. (2016), Industry 4.0: The Industrial Internet of Things, Springer, Heidelberg.
[510] Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P. and Harnisch, M. (2015), "Industry 4.0: the future of productivity and growth in manufacturing industries", Boston Consulting Group, available at: www.bcg.com/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries.aspx
[511] AnyLogic, Internal rail logistics simulation for the port of LeHavre, https://www.anylogic.com/internal-rail-logistics-simulation-for-the-port-of-le-havre/
[512] Inductive Automation, What is SCADA?, https://inductiveautomation.com/resources/article/what-is-scada

SCADA systems can also be used across other sectors for better facility management (i.e. SCADA to control devices, including heating, ventilation and air conditioning; refrigeration units; lighting; and entry systems) or for improved mass transit (i.e. SCADA to regulate electricity to subways, trams and trolley buses, automate traffic signals for rail systems, and track and locate trains and buses, etc.).

9.1.18 The Industrial Internet of Things (IIoT)

The Industrial Internet of Things refers to the network of interconnected and uniform addressed objects that communicate via standard protocols. Through the Industrial Internet of Things, more devices and final products will be enriched with embedded computing and will be connected using digital technologies. This will allow field devices to communicate and interact both with one another and with centralized controllers, as necessary. It will also decentralize analytics and decision making, enabling real-time responses.

In Europe, the 365FarmNet brings together equipment makers Claas, Rauch, Horsch and Amazonen-Werke, with Bayer, financial services giant, Allianz, the European Global Navigation Satellite Systems Agency and others to provide farmers, through the use of IIoT, with access to data and analysis on diagnostics, crops, fertilizers and other factors important to improving crop yield.[513]

The EU makes up approximately 40 percent of the global IoT market, at €366 billion in 2014. This figure is projected to increase to about €1,2 trillion in 2020. Six EU countries make up for more than 75% of the European IoT market. From largest to smallest in market value, these are the UK, Germany, France, Italy, Spain, and the Netherlands. With regards to growth rates, Sweden boasts the highest average annual growth rate (24%) and is projected to generate a market size of €50 billion in 2020. Furthermore, Germany, the Netherlands, Sweden and the United Kingdom are leading in capability and initiatives within Europe.[514]

[513] Big Data Comes to the Farm, Sowing Mistrust Seed Makers Barrel Into Technology Business, by Jacob Bunge, Wall Street Journal, February 25, 2014
[514] CBI, IoT Market Potential, https://www.cbi.eu/node/2668/pdf/

9.2 Advanced digital Technologies and Applications

9.2.1 Big Data

Big Data is one of the key topics discussed at an international level. Data is considered the driving force of the Industry 4.0 revolution and is called the "new oil". Despite data's significant importance, it appears that European enterprises have yet to adopt big data analysis as part of their business processes. On average, only 12% of EU enterprises were analysing big data from any source in 2018, while only 4% of European enterprises analyse data retrieved from sensors (see Figures 109 and 110).[515]

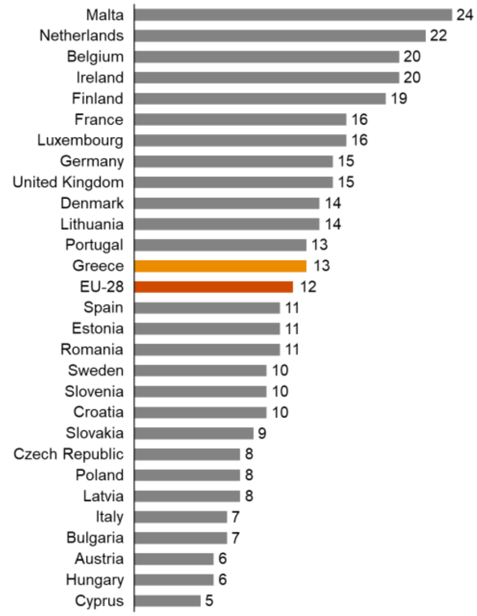


Figure 109: % of Enterprises analysing big data form any source EU, 2018 - Source: Eurostat, Big data analysis

Malta leads the European sample, with 24% of the country's enterprises analysing data. On second and third place, 22% and 20% of enterprises use big data analytics in the Netherlands and Belgium respectively. The lowest percentage of big data analysis in the EU were reported by Hungary and Cyprus with 6% and 5% of enterprises respectively (see Figure 109).[516]

Moving on to Greece, Greek companies seem to have understood that data is the new digital capital and increasingly exploit its potential. This is evinced by the fact that 13% of Greek enterprises (compared with 12% of the EU) invest in the collection and Big Data analytics. This is more than double the adoption rate of the lowest ranking country, Cyprus (5%). Nevertheless, with EU leaders reporting more than 20% big data adoption, it is clear that Greece still has space for significant improvements in order to perform on par with the continent's frontrunners (see Figure 109).[517]

[515] Eurostat, Big data analysis, https://ec.europa.eu/eurostat/web/products-datasets/product?code=isoc_eb_bd
[516] Eurostat, Big data analysis, https://ec.europa.eu/eurostat/web/products-datasets/product?code=isoc_eb_bd
[517] Eurostat, Big data analysis, https://ec.europa.eu/eurostat/web/products-datasets/product?code=isoc_eb_bd

Concurrently, the Netherlands report the highest percentage of enterprises analysing big data from sensors at 10%, followed by Malta, Finland, and Ireland at 8%.

Greece, tied with Bulgaria Poland and Latvia at 2%, demonstrates the lowest percentage of enterprises using data analysis from sensors in the EU (see Figure 110). The country's performance, nevertheless, only falls two percentage points below the EU average, which was 4% in 2018. Indeed, the number of enterprises that use sensor-generated data to perform big data analytics initiatives is low across Europe as a whole, with a relatively small level of variation between leaders and laggards. A testament to this is the fact that in the Netherlands, which was the EU leader in 2018, only 10% of enterprises reported having used big data analysis on data retrieved from sensors (See Figure 110).[518]

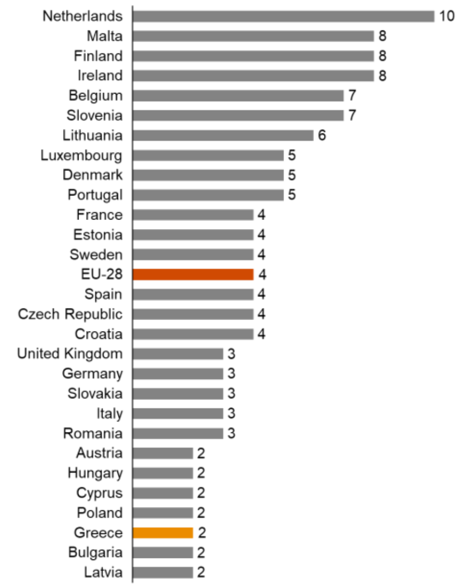


Figure 110: % of Enterprises analysing big data from sensors EU, 2018 - Source: Eurostat, Big data analysis

Focusing on manufacturing, organisations appear slower to adopt big data analytics than the overall economy, with 9% of all EU manufacturers using big data analysis, compared to 12% across the EU as a whole. Notably, there is less variation between adoption levels for manufacturers across Europe and enterprises as a whole. The leading EU manufacturers with respect to big data analysis adoption are Luxembourg for data regardless of source (see Figure 111) and Malta from data taken from sensors (see Figure 112). Respectively, Cyprus and Latvia score last among the EU. [519]

Zooming into Greece, 2% of Greek manufacturers in 2018 were using big data to analyse information from sensors, while the EU leader, Malta, reported that the practice was adopted by 12% of its manufacturers. The EU average is 4%, with two percent more manufacturers using big data analysis for data retrieved from sensors when compared to Greece. The only country ranking below Greece was Latvia, who reported just 1% adoption (see Figure 112). With regards to the use of big data analysis for data from any source, there is currently no reported data for Greek manufacturers (See Figure 111).[520]

[518] Eurostat, Big data analysis, https://ec.europa.eu/eurostat/web/products-datasets/product?code=isoc_eb_bd
[519] Eurostat, Big data analysis, https://ec.europa.eu/eurostat/web/products-datasets/product?code=isoc_eb_bd
[520] Eurostat, Big data analysis, https://ec.europa.eu/eurostat/web/products-datasets/product?code=isoc_eb_bd

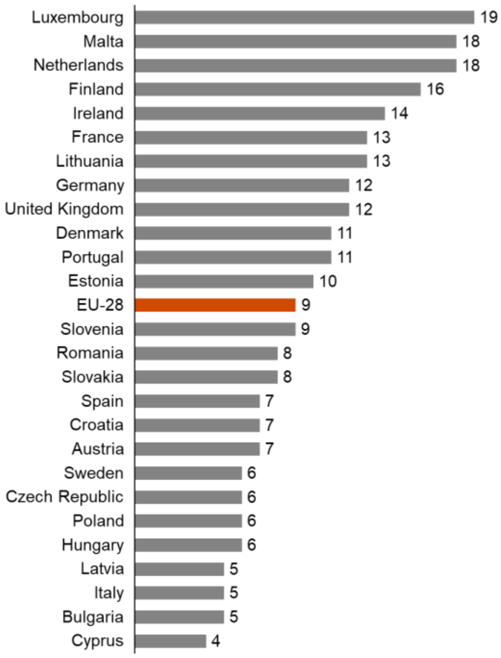


Figure 111: % of Manufacturers analysing big data from any source, EU, 2018 - Source: Eurostat, Big data analysis

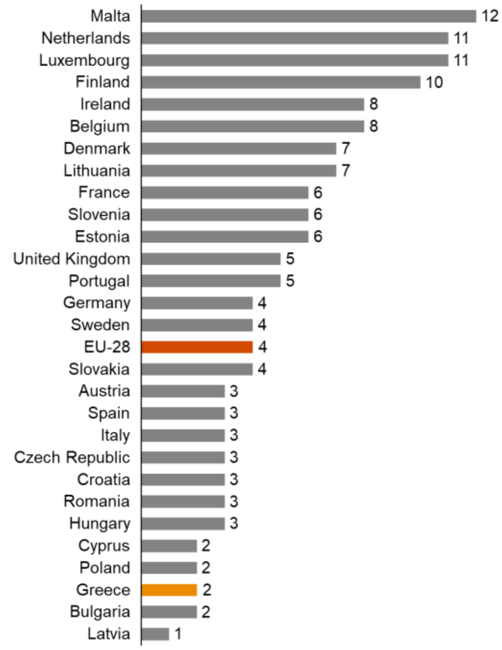


Figure 112: % of Manufacturers analysing big data from sensors, EU, 2018 - Source: Eurostat, Big data analysis

Case Study: France – Big Data Plan

In recent years, French government increased attention to the development of policy in the field of big data, through its strategic program "New Industrial France" adopted in 2013. This program includes Data as one of the main 34 largest interrelated projects of the reconstruction of French industry (medical biotechnology, digital hospital, cloud computing, online education, Nano-electronics, the Internet of Things, contactless services, supercomputers, robots, cyber security, the plants of the future and other areas). The goal of the plan is to make France a world leader in this field.

The initiative covers Big Data areas, such as building competence centres to develop trainings for data scientists and support big data related scientific research. The plan mainly covers three sets of activities: the development of a big data ecosystem in France; initiatives in the field of big data (which includes projects in the public and private sectors); evaluation and updating of big data related regulations.

Source: The new face of industry in France, http://www.entreprises.gouv.fr/**,** www.byte-project.eu

9.2.2 Cloud Computing

The adoption of cloud computing is a key enabler for the proliferation of other Industry 4.0 technologies. The Cloud's ability to free enterprises from the limitations of their own server capabilities makes it central to the scaling of data and computing capabilities required for the implementation of digital insights in manufacturing. On average, only 26% of EU enterprises purchased cloud computing services used over the internet in 2018.[521]

Finland leads the European sample, with 65% of the country's enterprises having purchased cloud services in 2018. On the second and third place, 57% and 56% of enterprises used cloud computing services in Sweden and Denmark respectively. The lowest percentage of cloud computing in the EU were reported by Romania and Bulgaria with 10% and 8% of enterprises respectively (see Figure 113).[522]

In Greece, enterprises show low rates of adoption, with only 13% of enterprises making use of the technology, half the EU average. Greece ranks 25th in Europe, with a mere five percentage points above the lowest ranked country. This demonstrates that Greek enterprises have been slow to adopt cloud technologies (see Figure 113).[523]

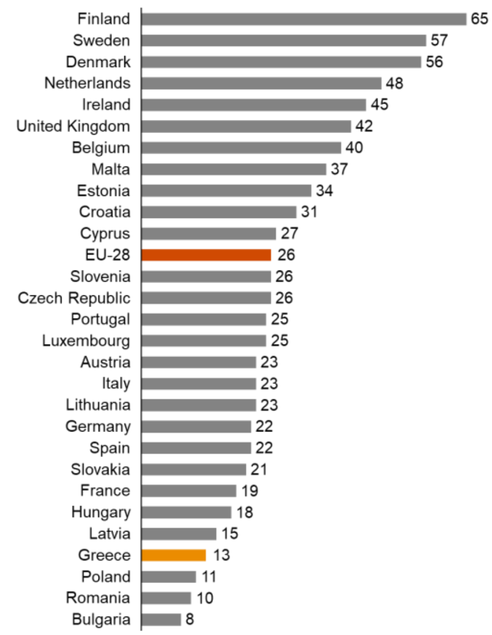


Figure 113: % of Enterprises buying cloud computing services used over the internet, EU 2018 - Source: Eurostat, Cloud computing services

[521] Eurostat, Cloud computing services, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicce_use&lang=en
[522] Eurostat, Cloud computing services, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicce_use&lang=en
[523] Eurostat, Cloud computing services, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicce_use&lang=en

In the manufacturing sector, organisations have been slower to adopt cloud computing than the overall economy, with 18% of all EU manufacturers having purchased cloud computing in 2018, compared to 26% across all EU enterprises. Notably, there is significantly more variation between cloud adoption for manufacturers across Europe than there is for cloud adoption among EU enterprises as a whole. The leading EU manufacturers with respect to cloud computing adoption are Finland with 72% adoption and Denmark at 56%. Ranking last among EU manufacturers, Romania and Bulgaria reported the lowest rates of cloud computing adoption at 6% and 4% respectively (see Figure 114).[524]

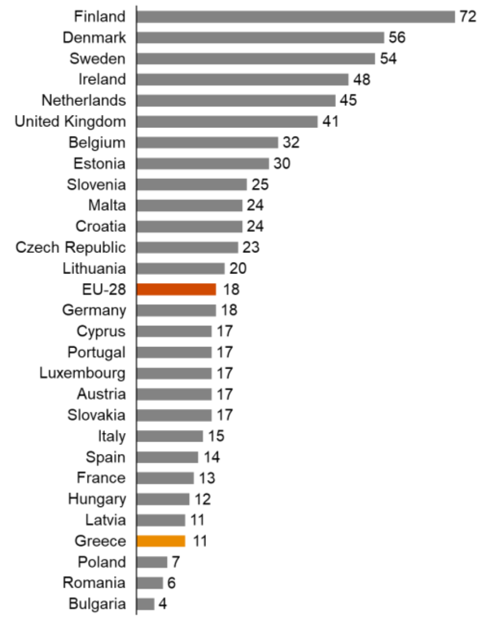


Figure 114: % of Manufacturers buying cloud services used over the internet, EU 2018 - Source: Eurostat, Cloud computing services

Greece's manufacturing sector has also been slow to leverage cloud computing, with just 11% of Greek manufacturers using the technology in 2018. While Greece's score is measurably higher than the level of adoption of recorded by lowest ranking countries like Romania and Bulgaria, the eighty-five percentage-point gap between Greece and Finland, the EU frontrunner, indicates that the former is in danger of falling significantly behind. However, it seems that this is the case for a number of EU manufacturers, as is demonstrated by fact that on average, only 18% of EU manufacturers make use of cloud computing (see Figure 114).[525]

[524] Eurostat, Cloud computing services, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicce_use&lang=en
[525] Eurostat, Cloud computing services, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_cicce_use&lang=en

9.2.3 RFID adoption

The use of Radio-frequency identification technologies (RFID) enables a wide range of manufacturing applications, from enabling machine-to-machine communication, to enhancing worker and customer experience by enabling a range of interactions between digital devices and the physical space, and vice versa. As RFID adoption becomes increasingly cost-efficient in the EU, the technology will play a significant role in the Industry 4.0 context. The EU has been relatively slow to adopt RFID technologies, with just 12% of EU enterprises using RFID on average in 2017.

Finland is the European leader in RFID adoption, with 23% of Finnish companies using the technology. The latter is closely followed by Belgium and Austria, where 21% and 19% of enterprises use RFID respectively.

Greece ranked last among all EU countries along with Hungary and Romania, where 7% of enterprises used RFID technologies in 2017 (see Figure 115).[526] Nevertheless, the EU average adoption rate of 12% demonstrates that enterprises across the continent have been slow to embrace the applications of RFID technologies into their operations. Finland reports the highest rate of RFID technology adoption among EU member states, with 23% of Finnish enterprises making use of the technology, corresponding to approximately three times the adoption rate of Greek enterprises (See Figure 115).[527]

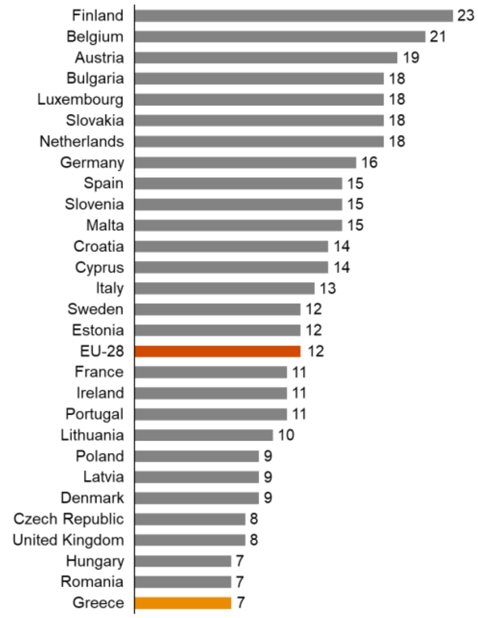


Figure 115: % of Enterprises using RFID, EU 2017 - Source: Eurostat, Enterprises using radio frequency identification (RFID) instrument

[526] Eurostat, Enterprises using radio frequency identification (RFID) instrument, https://ec.europa.eu/eurostat/web/products-datasets/-/tin00126
[527] Eurostat, Enterprises using radio frequency identification (RFID) instrument, https://ec.europa.eu/eurostat/web/products-datasets/-/tin00126

At the same time, the percentage of EU manufacturing companies using RFID is significantly higher, with 17% of EU manufacturers reporting the technology's use when compared to 12% in the EU economy at large. In 2017, 37% of Luxembourg's manufacturers used RFID technologies, making Luxembourg the EU leader by a significant margin. Coming in second and third, RFID was used by 29% and 28% of manufacturers in Finland and Austria respectively. Romanian manufacturers have the lowest percentage of RFID use, at 6%, (see Figure 116).[528] Notably, the adoption rate for RFID is higher for manufacturers, while manufacturing adoption rates are significantly higher for digitally advanced EU countries. Moreover, the variability of adoption among European countries is much higher among manufacturers than among EU economies as a whole.

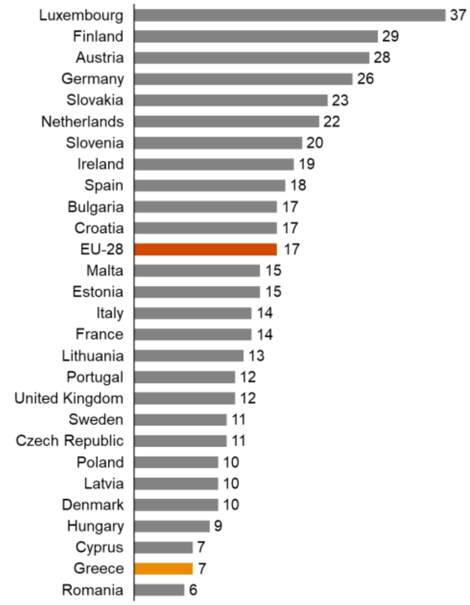


Figure 116: % of Manufacturers using RFID, EU 2017 - Source: Eurostat, Enterprises using radio frequency identification (RFID) instrument

In Greece, the adoption of RFID among domestic manufacturers is the second lowest in the EU, with just 7% of manufacturers making use of RFID technologies. When compared to the adoption figures for Luxembourg, the EU leader, where 37% of manufacturers where using RFID in 2018, the Greek manufacturing sector has significant progress to make in terms of RFID adoption (see Figure 116).[529]

[528] Eurostat, Enterprises using radio frequency identification (RFID) instrument, https://ec.europa.eu/eurostat/web/products-datasets/-/tin00126
[529] Eurostat, Enterprises using radio frequency identification (RFID) instrument, https://ec.europa.eu/eurostat/web/products-datasets/-/tin00126

9.2.4 ERP adoption

Enterprise Resource Planning (ERP) systems are used by companies to integrate digital information on their assets and resources in order to optimize a range of processes from planning, to purchasing inventory, sales, marketing, finance, human resources, and more. The adoption of ERP systems allows companies to optimize the way they operate across all enterprise functions by driving conclusions from the convergence of a diversity of performance indicators from their different departments. The integration of enterprise systems via ERP technologies is a significant step toward further digitalisation of a company's functions, and, concurrently, a country's ERP adoption levels provide a valuable indication of its Industry 4.0 readiness. The European Union demonstrates relatively high levels of ERP adoption, with 34% of EU enterprises using ERP software in 2017.

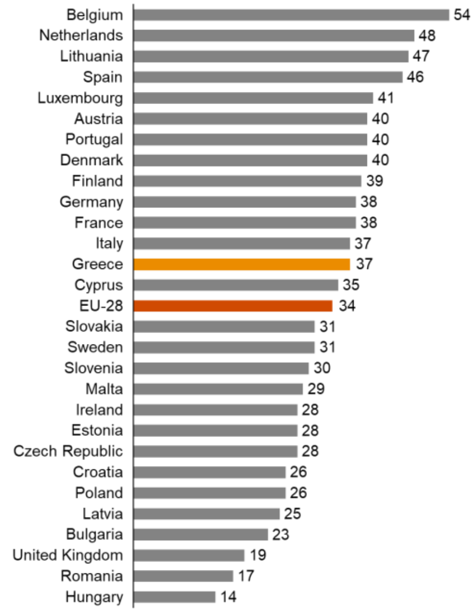


Figure 117: % of Enterprises using ERP, EU 2017 - Source: Eurostat, Integration of internal processes

Belgium leads the EU in ERP adoption, with 54% of its enterprises using ERP systems. The Netherlands and Lithuania come in second and third place, with 48% and 47% ERP adoption rates respectively. Last among EU countries are the United Kingdom, Romania, and Hungary, with 19%, 17%, and 14% of enterprises using ERP in 2017 (see Figure 117).[530]

Greece performs well with regards to ERP adoption, with 37% of Greek enterprises using ERP platforms. This level of adoption ranks Greece in the top half of European countries, three percentage points above the EU average for 2017. With a thirty-percentage point gap from the lowest ranking EU member state, Hungary (14%), Greece's enterprises show that they have been quick to adopt and implement ERP technologies. In fact, the levels of ERP adoption are higher in Greek enterprises when compared to the adoption of all other advanced digital technologies analysed in this segment. Nevertheless, with Belgium leading the way with a 54% adoption rate in 2017, Greece's enterprises still have a large gap to cover in order to reach the EU leaders (see Figure 117).[531]

[530] Eurostat, Integration of internal processes, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_bde15dip&lang=en
[531] Eurostat, Integration of internal processes, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_bde15dip&lang=en

EU manufacturers demonstrate higher adoption rates of ERP systems, while the variation from among different countries is higher. The average rate of ERP adoption among EU manufacturers is 45%, more than ten percentage points higher than the EU economy at large, which was 34% in 2017. The Netherlands has the most manufacturers using ERP in the EU, with 66%, followed closely by Finland, with 61%, and Germany, with 58%. Romanian manufacturers score last among the EU sample, with 17% ERP adoption, closely followed by Hungary and Bulgaria at 21% each (see Figure 118).[532]

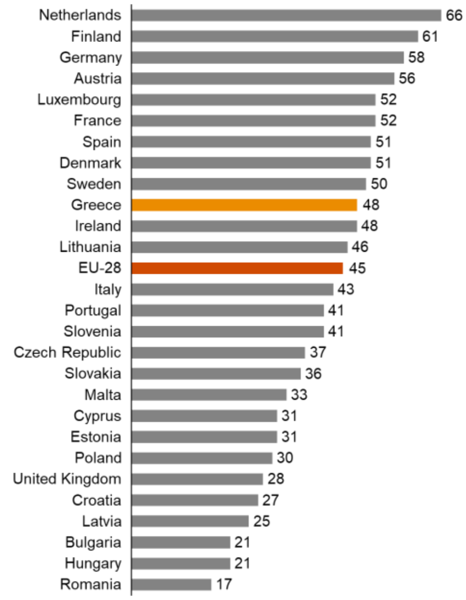


Figure 118: % of Manufacturers using ERP, EU 2017 - Source: Eurostat, Integration of internal processes

Manufacturers in Greece demonstrate strong performance in terms of ERP adoption, adopting ERP technologies at a rate of more than ten percentage points higher than the cross-sectoral average. In 2017, 48% of Greek manufacturers were using ERP's, ranking three positions above the EU average of 45%, and surpassing Ireland and the UK, among others. Greece's manufacturers use ERP at a rate of over thirty percentage points higher than the EU laggard, Romania, where just 17% of manufacturers use ERP (see Figure 118).[533]

[532] Eurostat, Integration of internal processes, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_bde15dip&lang=en
[533] Eurostat, Integration of internal processes, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_bde15dip&lang=en

9.2.5 CRM Adoption

Customer Relationship Management (CRM) systems allow enterprises to concentrate and analyse a range of data relating to customer demographics, customer behaviour, sales, marketing, and distribution channels. The adoption of CRM systems allows enterprises to enhance their decision-making using data analytics and innovate in the context of their customer experience offering. As is the case with ERP systems, high levels of CRM adoption should correlate with a higher level of readiness with regards to Industry 4.0 technologies. The EU demonstrates relatively high rates of CRM adoption, with 33% of EU enterprises using CRM in 2017.

The Netherlands and Germany rank first in the EU, with both with 47% of enterprises reporting CRM adoption in 2017. Belgium comes in third with 43% adoption. On the other side of the spectrum, Latvia, Romania, and Hungary have the lowest adoption rates in the EU with 17%, 14% and 14% respectively (See Figure 119).[534]

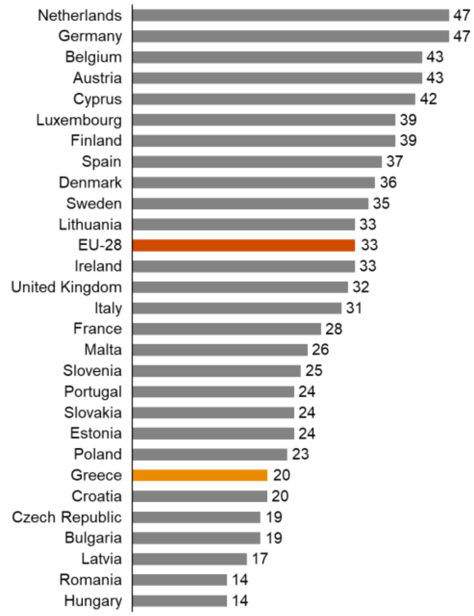


Figure 119: % of Enterprises using CRM, EU 2017 - Source: Eurostat, Integration of internal processes

In Greece, enterprises have been moderately slow in their adoption of Customer Relationship Management (CRM) systems, with just 20% of Greek enterprises using the technology, which represents less than two thirds of the EU average. Greece falls among the lower ranking EU member states in CRM adoption, just six percentage points above Hungary and Romania, where 14% of manufacturers reported use of CRM technologies in both cases for 2017. Greek enterprises have a long way to go in order to bridge the gap between themselves and the EU leaders (See Figure 119).[535]

[534] Eurostat, Integration of internal processes, https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
[535] Eurostat, Integration of internal processes, https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

Concurrently, the adoption rates of CRM among EU manufacturers are similar with those of the EU economy across sectors, with both samples averaging 33% CRM adoption rate. Germany is the EU leader, with 54% CRM adoption, followed by the Netherlands with 50% and Finland with 41% CRM adoption. Mirroring the finding for ERP, CRM adoption rates are significantly more variable among manufacturers than among enterprises across sectors. The lowest CRM adoption rate in 2017 among EU manufacturers was recorded by Hungary, with 12%, followed by Romania, with 13% adoption, and Bulgaria with 15% CRM adoption (See Figure 120).[536]

Greek manufacturers perform moderately in terms of CRM adoption, mirroring the cross-sectoral performance for the technology's adoption in Greece. In 2017, 22% of Greece's manufacturers were using CRM technologies, representing about two thirds of the average adoption rate reported for EU manufacturers, which was 33%. While the Greek manufacturing sector is significantly quicker to adopt Customer Relationship Management technologies when compared to the lowest ranking EU countries, it is lagging significantly behind from EU leaders (See Figure 120).[537]

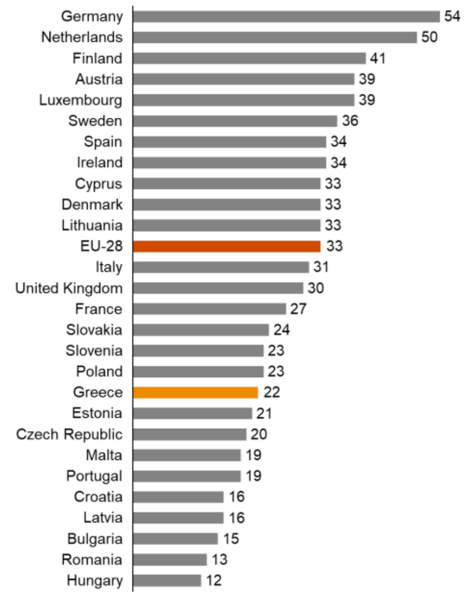


Figure 120: % of Manufacturers using CRM, EU 2017 - Source: Eurostat, Integration of internal processes

536 Eurostat, Integration of internal processes, https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
537 Eurostat, Integration of internal processes, https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

9.2.6 Industrial Robots

Industrial robots are indispensable parts of many production processes in the EU. While robots have been used extensively in industry over the past half century, the convergence of data-driven analytics, IoT, and other Industry 4.0 technologies paired with robotics will create a new horizon of cost efficiencies and operational effectiveness to be achieved in the space of industrial robotics. On average, EU enterprises demonstrate a low level of industrial robot adoption, with only 5% of enterprises making use of industrial robots in 2018.

Finland and Spain are the EU leaders in industrial robot adoption, with 8% of enterprises using industrial robots in 2018 in the two countries. Denmark and the Netherlands rank third and fourth in the EU sample, with 7% adoption. Cyprus has the lowest percentage rate of industrial robot adoption at 1%, scoring one point below by Greece, Lithuania and Romania, all of which reported 2% adoption in 2018 (See Figure 121).[538]

Just 2% of Greece's enterprises used industrial robot technology in 2018, demonstrating the country's slow rate of adoption in terms of industrial robotics. However, with just 5% of EU enterprises using industrial robots on average, the technology has yet to be adopted meaningfully by European countries at large, making (See Figure 121).[539]

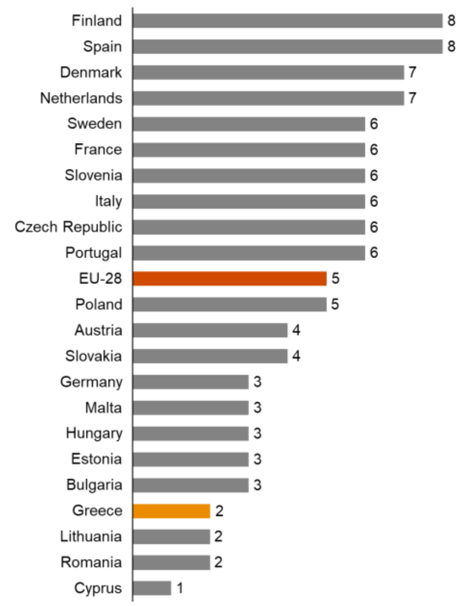


Figure 121: % of Enterprises using Industrial Robots, EU 2018 - Source: Eurostat, 3D printing and robotics

538 Eurostat, 3D printing and robotics, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_eb_p3d&lang=en
539 Eurostat, 3D printing and robotics, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_eb_p3d&lang=en

Enterprises in the manufacturing sector report significantly higher rates of industrial robot use, with 16% on average compared to just 5% for enterprises across all sectors. However, the variation in adoption rates is significantly higher between EU leaders and laggards among manufacturers. While Finland leads the way with 33% adoption, followed by Denmark and Sweden at 31% and 29% respectively, Cyprus and Romania rank last with just 6% of enterprises using industrial robots in 2018. (See Figure 122)[540]

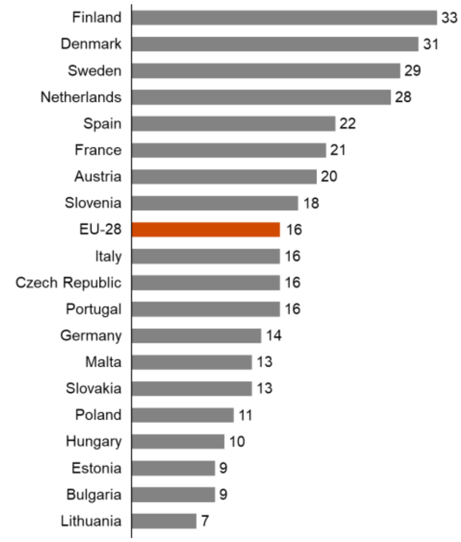


Figure 122: % of Manufacturers using Industrial Robots, EU 2017 - Source: Eurostat, 3D printing and robotics

[540] Eurostat, 3D printing and robotics, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_eb_p3d&lang=en

9.3 Digital Knowledge of total population and industrial workforce in the EU and Greece

9.3.1 Digital Skills in the overall EU population

Based on an EU wide analysis of skills relevant to digital technologies, the DESI report on Human Capital has measured the percentage of individuals with basic digital skills and above basic digital skills in each EU member country. These two classifications depend on the sophistication of information skills, communication skills, problem solving skills and software skills of the population.

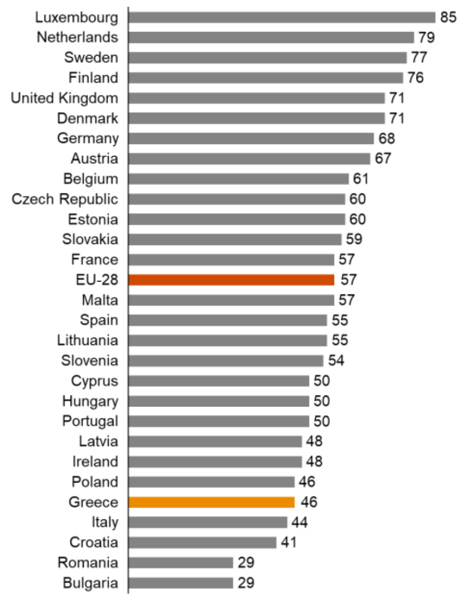


Figure 123: Individuals with basic or above basic Digital Skills as a percentage of total population, 2017 - Source: Eurostat, Individuals' level of digital skills

Across Europe, in 2018, the level of digital skills varies significantly. On average, over half (57%) of Europeans have basic or above basic digital skills. However, the gap between Luxembourg (85%), the EU leader in digital skills, and Bulgaria (29%), the lowest ranking country, amounts to a skill gap representing more than 50% of the national population. Luxembourg is closely followed by the Netherlands and Sweden at 79% and 77% of their population respectively. At the lower end of the spectrum, Croatia (41%) and Romania (29%) and Bulgaria (29%) rank lowest among EU countries with regards to basic digital skills adoption (see Figure 123).[541]

Zooming in to Greece, 46% of Greeks were reported to have basic or above basic digital skills. In other words, 46% of the population are capable of accessing information, communicating, problem solving, and creating content at a basic level using digital technologies. When compared to other EU countries, Greece scores almost twenty percentage points below the EU average. This indicates that, even in the case of basic digital skills, the Greek population has significant ground to cover in order to reach the levels of EUs frontrunners (See Figure 123).[542]

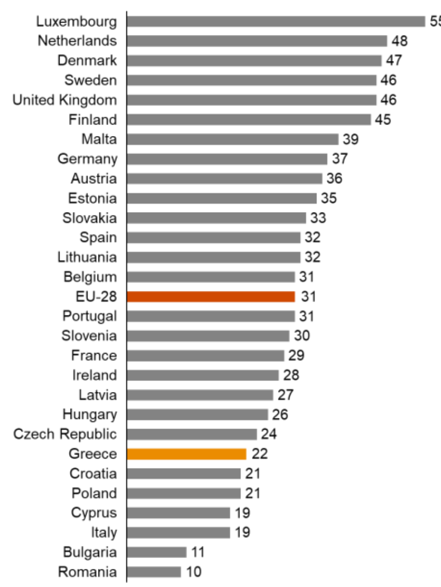


Figure 124: Individuals with above basic Digital Skills as a percentage of total population, 2017 - Source: Eurostat, Individuals' level of digital skills

Looking at the level of 'above basic' digital skills for 2018, the EU-28 average is significantly lower, at half the levels reported for basic digital skills or above (31%). Moreover, the variation among EU countries seems to be lower and the overall range between the leader Luxembourg (55%) and the lowest scoring country Romania (10%) is lower than that for overall digital skills at 45 percentage points. The Luxembourg (55%), Netherlands (48%) and Denmark (47%) have the largest population percentages with advanced

[541] Eurostat, Individuals' level of digital skills, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_sk_dskl_i&lang=en
[542] Eurostat, Individuals' level of digital skills, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_sk_dskl_i&lang=en

digital skills, while Italy (19%) Bulgaria (11%) and Romania (10%) have the least citizens with advanced digital skills (see Figure 124).[543]

In Greece, only 22% of the population has above basic digital skills. Greece performs relatively better on this indicator when compared to the basic digital skills dimension, despite being placed ten percentage points below the EU average.

On average, the percentage of EU citizens with above basic software skills is higher than the abovementioned digital skills categories. On average, 41% of the European population has basic software skills. Luxembourg (67%), Denmark (55%) and the Netherlands (55%) are leaders in Europe with respect to software skills adoption, while Cyprus (24%), Bulgaria (17%,) Romania (16%) have the lowest percentage of basic software skills in their citizenry (see Figure 125).[544]

In 2017, only 32% of Greeks were characterized as having above basic software skills. Greece performs moderately low when compared to the rest of the European Union. The country's subdued performance along this dimension calls for further reinforcement of the educational initiatives in place for the promotion of software skills (see Figure 125).[545]

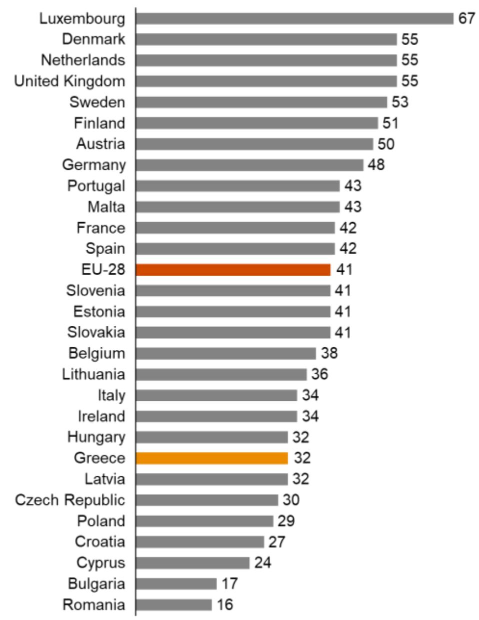


Figure 125: Individuals with above basic Software Skills as a percentage of total population, 2017 - Source: Eurostat

[543] Eurostat, Individuals' level of digital skills, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_sk_dskl_i&lang=en
[544] Eurostat, Individuals who have basic or above basic overall digital skills by sex, https://ec.europa.eu/eurostat/web/products-datasets/product?code=tepsr_sp410
[545] Eurostat, Individuals who have basic or above basic overall digital skills by sex, https://ec.europa.eu/eurostat/web/products-datasets/product?code=tepsr_sp410

9.3.2 Digital Skills in the EU Education

On average, ICT graduates in Europe represent a small percentage of the total number of EU graduates, with only 4% of EU graduates holding ICT-related degrees. Nevertheless, the share of ICT graduates varies significantly among EU member states. Finland, Ireland and Malta lead the EU, with 7% of their graduates having received ICT degrees in 2018. This number contrasts starkly with the European laggards, Portugal and Italy, where only 1% of graduates completed degrees in ICT-related fields (see Figure 126).[546]

In Greece, the share of ICT graduates was on par with the EU average in 2018, with 3% ICT graduates, just one percentage point below the average.

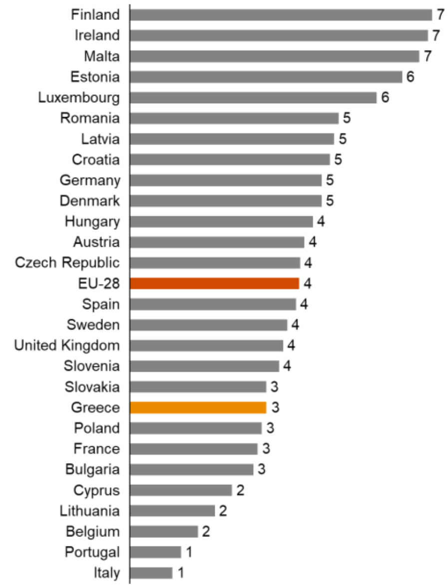


Figure 126: % of ICT graduates out of total graduates, EU, 2018 - Source: DESI 2019, Employed persons with ICT education by educational attainment level

In terms of the number of graduates in science, math, computing, engineering, manufacturing, and construction, EU countries average 18 graduates for every 1000 citizens aged 20-29. In similarity to the percentage of ICT graduates, EU countries demonstrate significant variations along this metric. Ireland leads the European sample with 33 graduates per 1000 citizens in science and engineering-related fields, followed by France at 26 and Poland at 24. On the other side of the spectrum, Luxembourg displayed the weakest performance among EU countries with 4 graduates per 1000 citizens in science and engineering-related fields scoring measurably below Cyprus, which reported 10 science and engineering-related graduates for every 1000 citizens in 2017 (see Figure 127).[547]

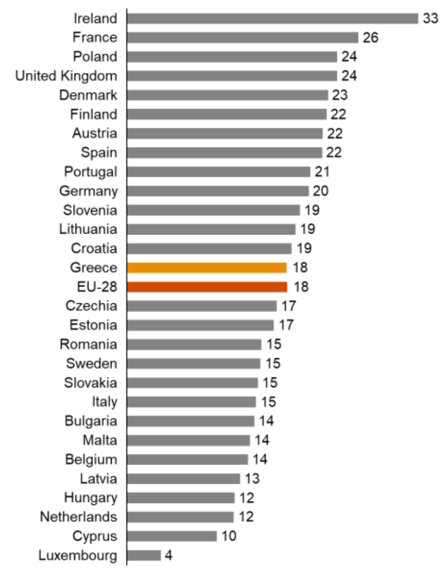


Figure 127: Graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction, - per 1000 of population aged 20-29, EU 2017 - Source: Eurostat, Graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction, by sex - per 1000 of population aged 20-29

Greece is in sync with the EU average along this dimension, with 18% of Greek graduates pursuing tertiary education in the abovementioned fields. Greece's moderate performance along the indicator demonstrates that the country has the potential of accommodating the human capital requirements of Industry 4.0, which is expected to rely on increasing levels of scientific literacy. That being said, there still is room for improvement, as

[546] Eurostat, Employed persons with ICT education by educational attainment level, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ski_itedu&lang=en
[547] Eurostat, Graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction, by sex - per 1000 of population aged 20-29, https://ec.europa.eu/eurostat/web/products-datasets/product?code=educ_uoe_grad04

demonstrated by the 15-percentage point gap between Greece and Ireland (33%), the EU frontrunner (see Figure 127).[548]

9.3.3 Digital Skills in the Workforce

A valuable proxy used for quantifying digital skills in European businesses is the percentage of enterprises employing ICT specialists. On average, EU countries report that 20% of their enterprises are currently employing ICT specialists. Ireland is the EU leader at 32%. Followed by Denmark 28% and Belgium 28%. Estonia (13%), Poland (13%), and Romania 11% rank last among EU countries (see Figure 128).[549]

Zooming into Greece, in 2018, 22% of Greek enterprises had ICT specialists on their payroll, ranking the country above the EU average. Greece demonstrates a clear competitive advantage with respect to this indicator (see Figure 128).[550]

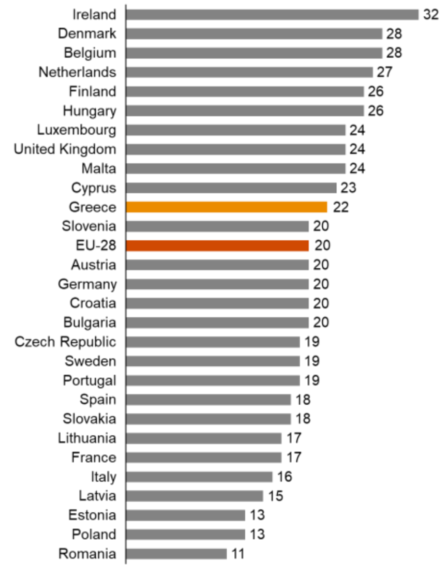


Figure 128: % of Enterprises that employ ICT specialists, 2018 - Source: Eurostat, Enterprises that employ ICT specialists

[548] Eurostat, Graduates in tertiary education, in science, math., computing, engineering, manufacturing, construction, by sex - per 1000 of population aged 20-29, https://ec.europa.eu/eurostat/web/products-datasets/product?code=educ_uoe_grad04
[549] Eurostat, Enterprises that employ ICT specialists, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ske_itspen2&lang=en
[550] Eurostat, Enterprises that employ ICT specialists, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ske_itspen2&lang=en

Another significant metric with regards to the level of digital skills adoption and promotion within businesses Is the percentage of enterprises providing ICT skills training. In 2018, 23% Of European enterprises reported providing some form of ICT skills training. While the front runners report that more than one third of their enterprises provide ICT skills, the first 3 being Belgium (36%), Finland (36%), and Germany (30%), the weakest performers in Europe report significantly lower percentages, with Romania coming last at 5% preceded by Lithuania (9%) and Bulgaria (9%) (see Figure 129).[551]

Greece scores poorly on this indicator, as only 14% of Greek enterprises offer ICT skills training their employees in 2018, eleven percentage points from the EU average. This places Greece among the European laggards in enterprise ICT skills training (see Figure 129).[552]

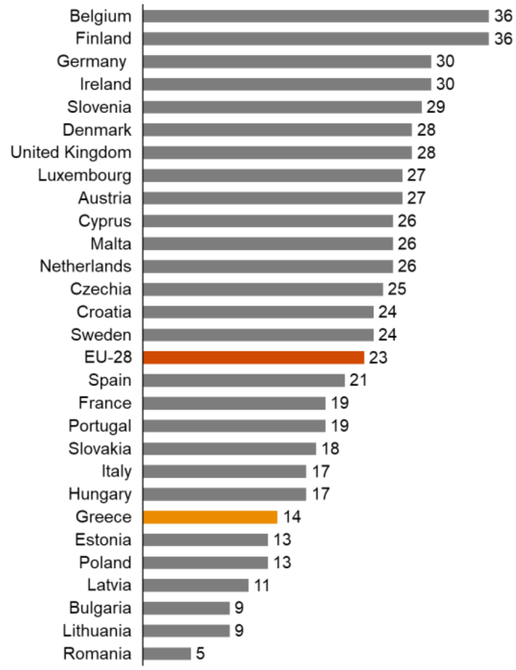


Figure 129: % of Enterprises that provide ICT skills training, 2018 - Source: Eurostat, Enterprises that provided training to develop/upgrade ICT skills of their personnel

[551] Eurostat, Enterprises that provided training to develop/upgrade ICT skills of their personnel, https://ec.europa.eu/eurostat/en/web/products-datasets/-/ISOC_SKE_ITTN2
[552] Eurostat, Enterprises that provided training to develop/upgrade ICT skills of their personnel, https://ec.europa.eu/eurostat/en/web/products-datasets/-/ISOC_SKE_ITTN2

9.3.4 Digital Skills in the Industrial Workforce

When compared with the prevalence of digital skills in the EU workforce across all sectors, the variance of the digital skills' adoption in manufacturing is greater among EU member states. This is demonstrated in the higher levels of disparity among frontrunners and laggards. While less than 10% of Romanian (4%), Bulgarian (5%), Latvian (8%) and Lithuanian (9%) manufacturers offer ICT training to their personnel, the EU leader, Finland, reports that 42% of Finnish manufacturers offer ICT training, followed by Belgium, Ireland and Austria at 33%. The EU average was 22% 2018 (see Figure 130).[553]

With only 13% of manufacturers providing ICT training to their personnel, Greece's industry ranks low among EU industries, nine points below the EU average (see Figure 130).[554]

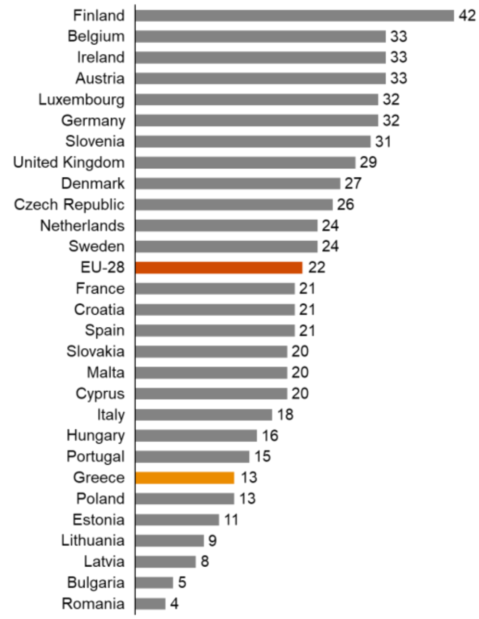


Figure 130: % of Manufacturers providing ICT training to their personnel, 2018 - Source: Eurostat, Enterprises that provided training to develop/upgrade ICT skills of their personnel

[553] Eurostat, Enterprises that provided training to develop/upgrade ICT skills of their personnel, https://ec.europa.eu/eurostat/en/web/products-datasets/-/ISOC_SKE_ITTN2
[554] Eurostat, Enterprises that provided training to develop/upgrade ICT skills of their personnel, https://ec.europa.eu/eurostat/en/web/products-datasets/-/ISOC_SKE_ITTN2

The limited ICT training provided by the Greek manufacturing enterprises is further accentuated by the fact according to EU research, employment within the manufacturing sector is expected to significantly increase in Greece during the next decade. Greek employment appears to recover from the declining trend observed in employment over the period 2011-16 and is expected to experience its biggest increase in distribution & transport sector (over the period 2016-21) and in manufacturing sector (over the period 2021-30). In terms of sub-sectors, hotels and catering, and the rest of manufacturing (i.e. pharmaceuticals, metal products, motor vehicles, sewerage and waste) are those where the greatest increase is expected (see Figure 131).[555]

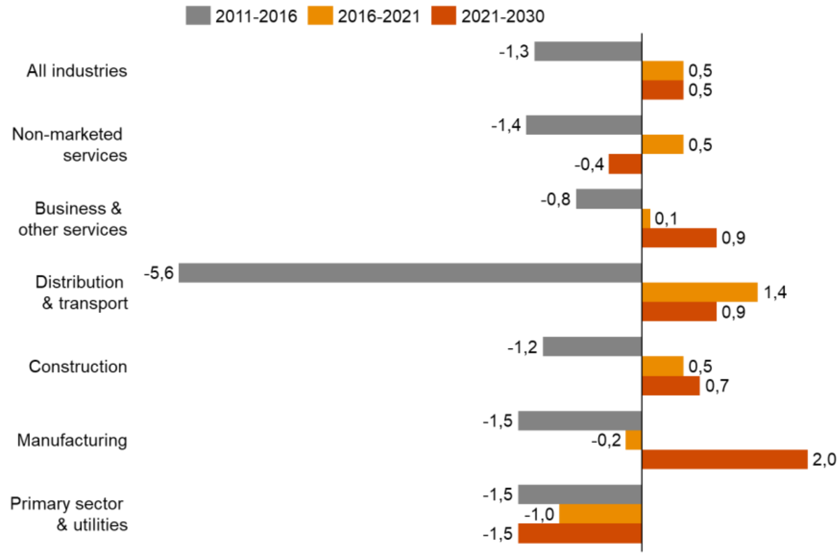


Figure 131: Employment growth by broad sector of economic activity (% growth per annum), 2016-2030 - Source: Cedefop (2018 Skills Forecast)

This being said, it is of paramount importance for the Greek Industry, supported by the Greek Public Administration and academia, to intensify their efforts in digitally upskilling and reskilling of their workforce, if not for the digital skills gap between the country and the EU to further widen.

555 Cedefop, 2018 Skills Forecast, https://www.cedefop.europa.eu/en/publications-and-resources/data-visualisations/skills-forecast

Case Study: The United Kingdom – Industrial Strategy

Britain's Industrial Strategy will invest 406 million GBP in maths, digital and technical skills in England. The amount includes £84m over the course of five years aiming at the delivery of a comprehensive programme to improve the teaching of computing and drive up participation in computer science. Moreover, the strategy aims at up-skilling 8,000 computer science teachers and work with industry to set up a new National Centre for Computing Education. Additionally, the strategy aims at creating a new engineering university, the New Model in Technology & Engineering, which will offer co-created courses with employers, mandatory work placements of 6-12 months before graduation, and accelerated degrees that allow students to graduate in 2 years. In the field of reskilling, the UK has created a National Retraining Scheme, aiming to help people up-skill and re-skill, with a £64m investment for digital and construction training. The scheme is informed closely by the career learning pilots, whose role it is to test the barriers to adults engaging in learning.

Furthermore, the strategy aims to leverage digital technologies to achieve better results in digital skills training. Firstly, investment of £30m will be made to test the use of AI and innovative education (edtech) in online digital skills courses. Secondly, the British government will utilize new technologies to achieve a better understanding of digital skills gaps in the workforce. Building on the work of Skills Advisory Panels and local Digital Skills Partnerships in England, the government and industry will explore how data analytics can be used to build an evidence base about the skills required by industry, thereby improving the understanding of employer demand for skills.

Source: https://www.gov.uk/government/topical-events/the-uks-industrial-strategy

9.4 State of digital infrastructure

9.4.1 The DESI Index – Pillar 1: Connectivity

The deployment of next generation connectivity and coverage of smart sensor frequencies is critical to the successful implementation of Industry 4.0 technologies and should be a critical component of any Industry 4.0 transitional strategy.

The DESI Connectivity dimension accesses the demand and supply side of fixed and mobile broadband. In the case of fixed mobile broadband, the availability as well as the take-up of basic, fast (at least 30MBps), and ultrafast (at least 100MBps) broadband and domestic broadband retail prices. The dimension also calculates the availability of mobile broadband with one indicator for 4G and one measuring 5G readiness. Denmark, Luxembourg, and the Netherlands rank are European leaders in terms of connectivity, while Lithuania, Hungary and Greece rank last among their European peers (see Figure 132).

In 2019, Greece had an overall Connectivity score of 0,41 (out of 1), ranking last among all EU countries. Specifically, Greece's Connectivity score was 31% lower than the European average and 44% lower than Denmark, the EU leader, which recorded a score of 0,74 in 2019 (see Figure 132).

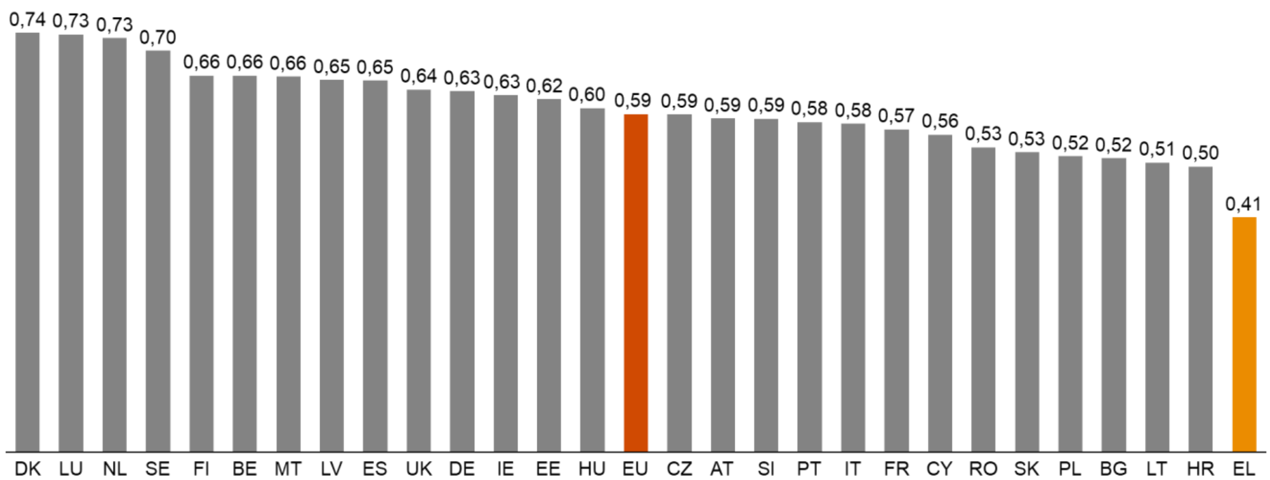


Figure 132: DESI Index 2019 - Pillar 1: Connectivity, EU ranking – Source: DESI 2019

9.4.2 Broadband coverage for European Member States

With regards to fixed broadband (basic, fast, ultrafast), the Netherlands and Luxembourg rank on top of the EU, while Greece, Poland and Croatia are the worst performers (see Figure 133).[556] With the EU at a level of 97%, more than 10 Member States have above 99% fixed broadband coverage. Nevertheless, the uptake of Next Generation Access broadband is significantly more varied, 90% or more coverage among EU leaders (Malta, Netherlands, Belgium) and low-ranking countries like France, Lithuania, Greece and Poland with less than 67% of homes using NGA. These divergences become increasingly more pronounced when comparing access to Ultrafast fixed broadband, where Malta, the Netherlands, and Belgium have more than 90% access, while Greece, at the tail end of the European sample, has 1% Ultrafast fixed broadband access. EU states display similar disparities in the adoption of Fibre to the Premises (FTTP) connections.

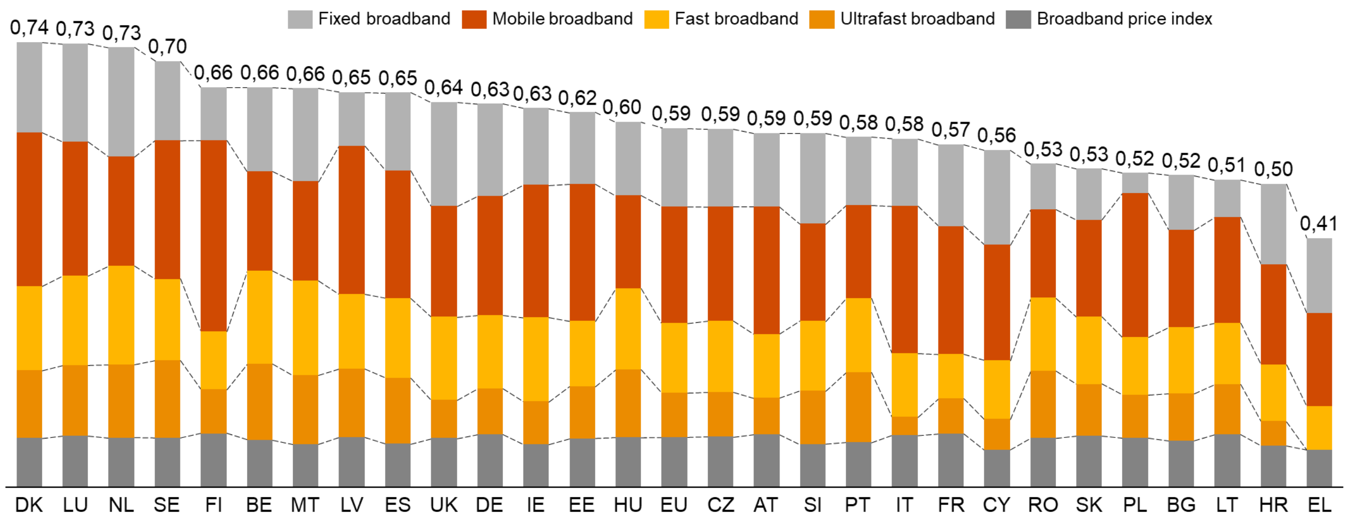


Figure 133: DESI Index 2019 - Pillar 1: Connectivity and its sub-dimensions: Fixed & Mobile Broadband, Fast & Ultrafast Broadband, Broadband price index - EU ranking – Source: DESI 2019, Connectivity

Mobile Broadband coverage is highest in Finland, Latvia, and Italy, with Romania and Hungary scoring the lowest. While more than 70% of all active mobile SIM cards in the EU using mobile broadband, the prices and availability of mobile broadband vary significantly between EU member states.

Across the board, countries demonstrating low overall DESI connectivity scores also have some of the highest internet broadband prices. As such, the prices for the basket of 300 voice calls and 1GB data are cheapest in Italy and Luxembourg (below €10) and highest in Bulgaria (€59) and Greece (€56). Finally, Finland ranked first in terms of 5G readiness, with the EU average still with less than 20% of assigned spectrum as a percentage of total harmonized 5G spectrum.[557]

9.4.3 Broadband take-up for EU households

Although fixed broadband coverage is provided to 97% of the European households, only 77% of them had a fixed broadband subscription in 2018. The Netherlands, the UK, Luxembourg and Germany appear

[556] Digital Economy and Society Index Indicators 2019, Connectivity, https://digital-agenda-data.eu/datasets/desi/indicators
[557] EU DESI Scores – 'Connectivity: Broadband market developments in the EU'

to lead the pack in terms of fixed broadband subscriptions, while Bulgaria, Finland, Poland and Latvia demonstrate the lowest take-up rates (see Figure 134).[558]

In 2018, 74% of Greek households reported using fixed broadband, placing Greece close to the EU average

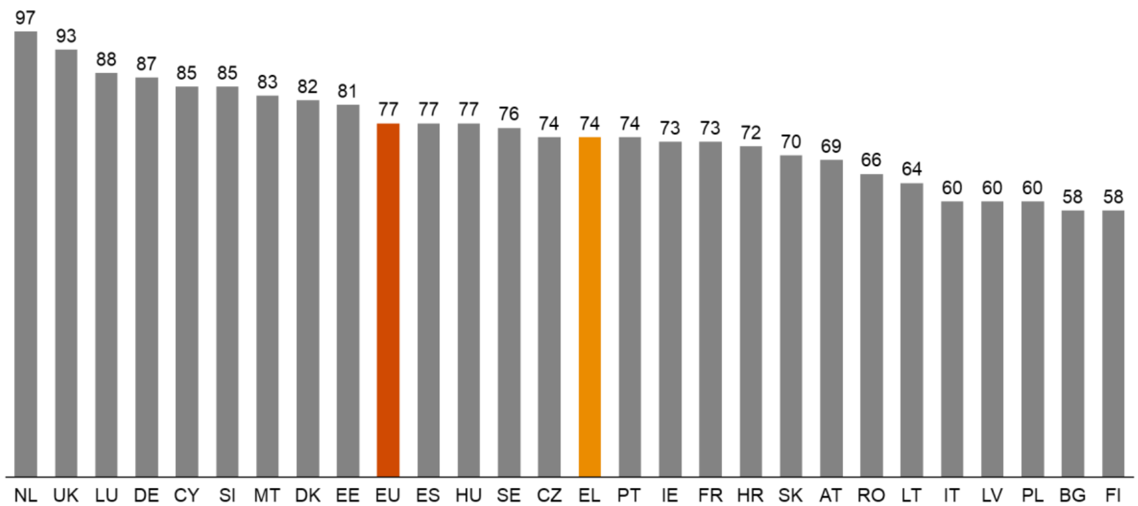


Figure 134: Households with a fixed broadband subscription (% of households), 2018 – Source: DESI 2019, Connectivity

With regards to the fast-broadband access, there has been an exponential increase in its take-up since 2010. This can be mainly attributed to the deployment and upgrade of the respective digital infrastructure. The Netherlands, Malta and Luxembourg are the frontrunners across this index, while in Greece, Cyprus and Croatia take-up remains below 20 % of their households (see Figure 135).[559]

The performance recorded by Greece in 2018 is significantly lower for fast broadband than it is for fixed broadband subscriptions. Only 11% of Greek households have a fast-broadband subscription, approximately a fourth of the average reported for European households. This indicates that European

[558] Digital Economy and Society Index Indicators 2019, Connectivity, https://digital-agenda-data.eu/datasets/desi/indicators
[559] Digital Economy and Society Index Indicators 2019, Connectivity, https://digital-agenda-data.eu/datasets/desi/indicators

households have already transitioned towards fast broadband, while Greece is still at the nascent stages of adoption (see Figure 135).[560]

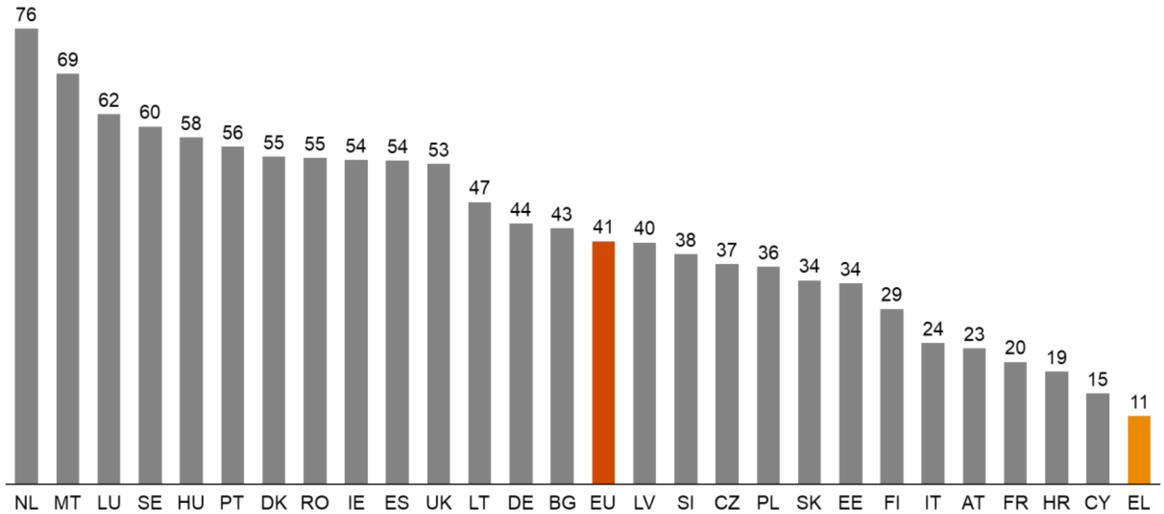


Figure 135: Households with a fast broadband (at least 30 MBps) subscription (% of households), 2018 – Source: DESI 2019, Connectivity

9.4.4 Broadband take-up for EU Businesses

The availability of digital infrastructures for doing business has shown significant progress over the past decade in the EU. Indicatively, the percentage of enterprises with a broadband connection has increased by 10%, from 85% in 2010 to 96% in 2017 (see Figure 136).[561]

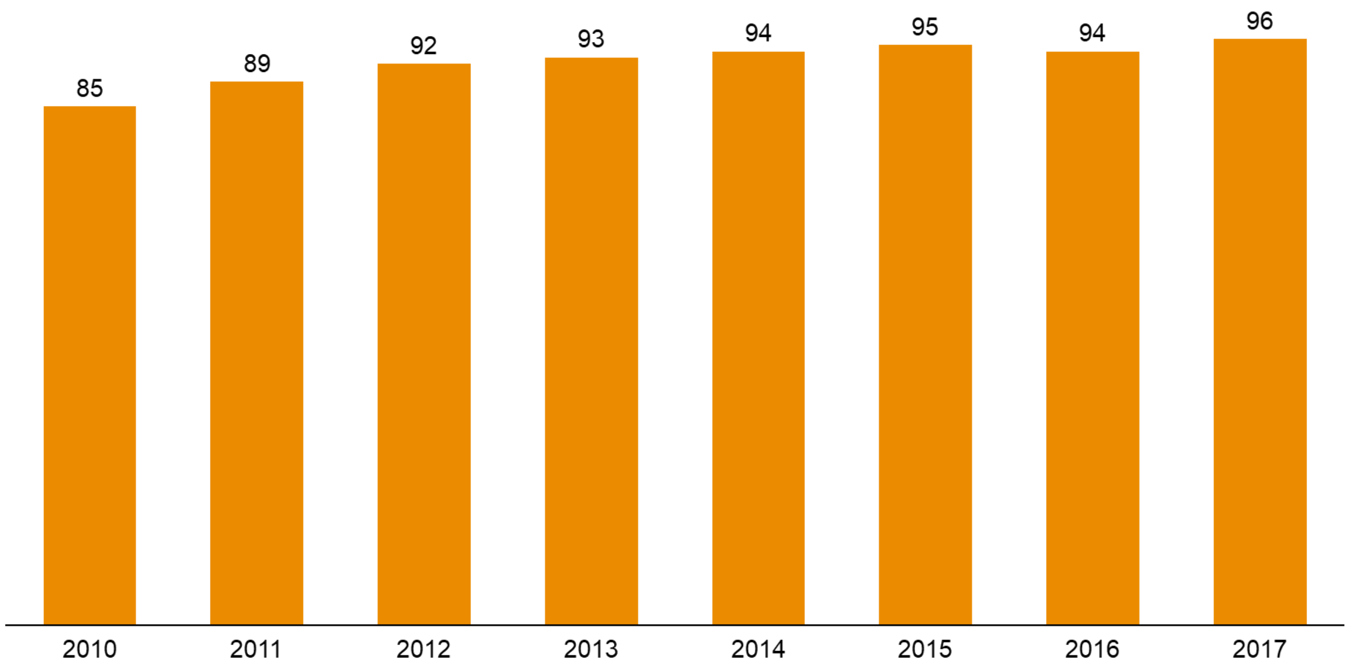


Figure 136: % of Enterprises with Broadband Connection, EU 28, 2010-2017 – Source: Eurostat, Type of connections to the internet

[560] Digital Economy and Society Index Indicators, Connectivity, https://digital-agenda-data.eu/datasets/desi/indicators
[561] Eurostat, Type of connections to the internet, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_it_en2&lang=en

In Greece, the share of enterprises with a broadband connection has remained relatively static over the past decade, growing by just four percent, from 81% in 2010, to 85% in 2017. Compared to the EU average, Greece has only grown its share of enterprises with broadband connectivity at half the European rate, while the share of Greek enterprises with broadband remained at 85% from 2015 to 2017 (see Figure 137).[562] The slow increase of broadband connections in Greek enterprises is troubling and could be due to several reasons. Decreasing the cost of broadband tariffs and increasing fast and ultrafast broadband coverage in Greece are key actions for promoting broadband adoption.

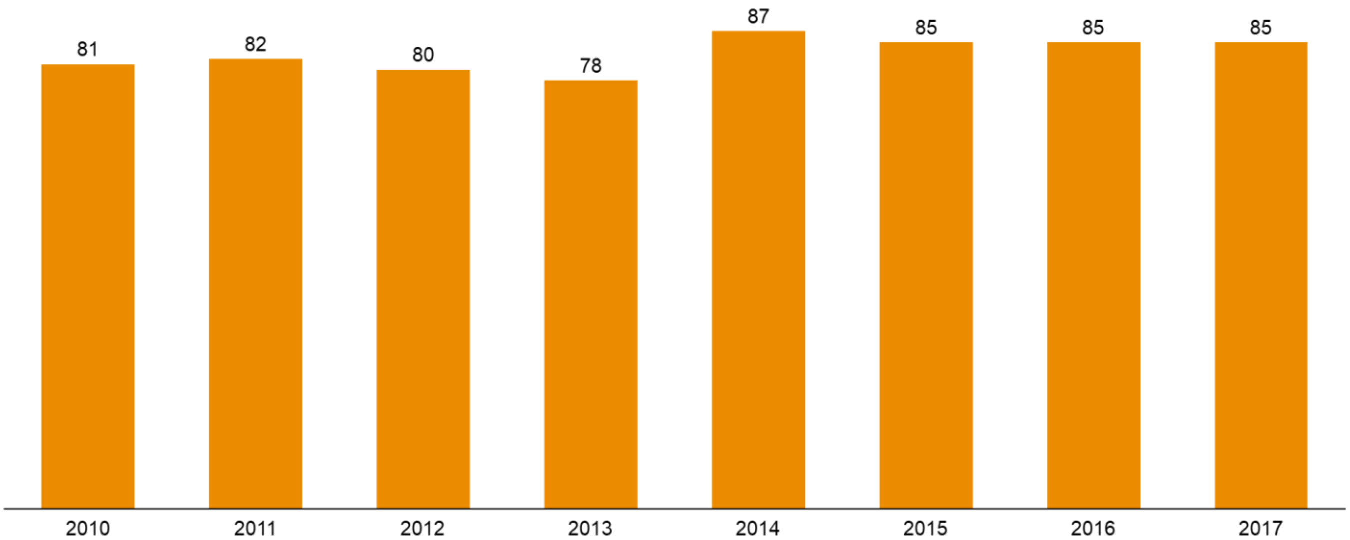


Figure 137: % of Enterprises with Broadband Connection, Greece, 2010-2017 – Source: Eurostat, Type of connections to the internet

562 Eurostat, Type of connections to the internet, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_it_en2&lang=en

However, there are still variations in the quality of digital connectivity among EU member states. While enterprises in the Netherlands, Lithuania, Finland and Denmark report 100% access to broadband, the lowest rates of connectivity in countries like Bulgaria (89%), Greece (85%) and Romania (82%) are significantly below the EU average (97%), on par with 2010 connectivity levels (see Figure 138).[563]

When compared to the rest of Europe, Greece ranks 27th out of the 28 EU member states, on the share of broadband connections by enterprises, outperforming only Romania. With the average broadband coverage per EU enterprise at 97% in 2018, Greek enterprises are significantly behind when it comes to access to internet connectivity (see Figure 138).[564]

Not enough enterprises are connected to fast and reliable internet and as a result, innovation, collaboration and industry disruption is stifled. As Greece is looking to revive its economy and the competitiveness of its manufacturing sector, actions should be taken to drive broadband adoption on a mass scale.

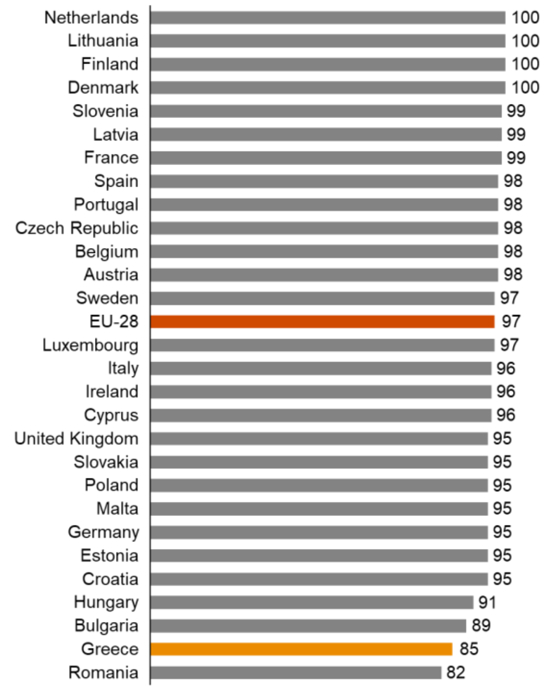


Figure 138: % of Enterprises with Broadband Connection, 2017 – Source: Eurostat, Type of connections to the internet

[563] Eurostat, Type of connections to the internet, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_it_en2&lang=en
[564] Eurostat, Type of connections to the internet, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_it_en2&lang=en

A similar trend is observed for EU manufacturers, who nonetheless exhibit higher rates of broadband adoption with only 1 country with less than 90% coverage (see Figure 139), when compared to three in the case of all EU enterprises.[565]

Zooming in on the Greek manufacturing landscape, broadband connectivity among enterprises is significantly higher than the economy at large, with 93% of manufacturing businesses reporting a broadband subscription in 2017. The Greek industry is on par with other European industrial sectors in terms of connectivity (See Figure 139).[566]

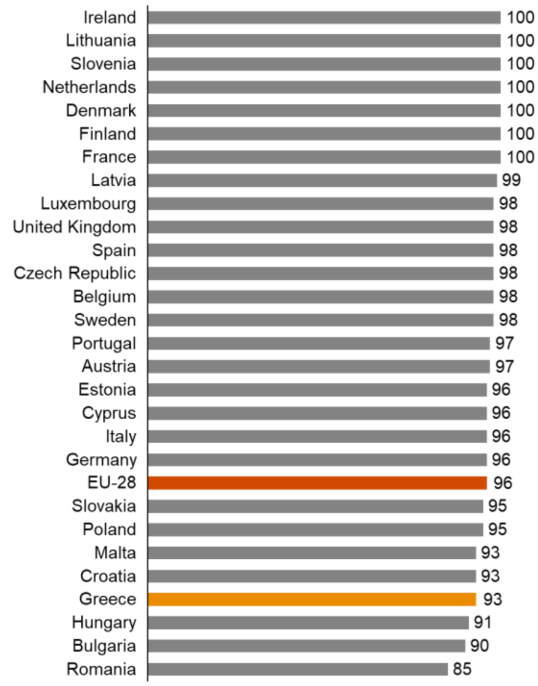


Figure 139: % of Manufacturers with Broadband Connection, 2017 – Source: Eurostat, Type of connections to the internet

Nevertheless, the performance of EU member states is mixed with regards to fast (30-100MBps) and Ultra-fast (>=100MBps) broadband connectivity among enterprises. Denmark ranked first among all other EU countries in 2013 with 23% and 21% enterprise adoption of 30-100MBps and >=Mbps respectively, while Croatia comes in last with just 1% of enterprises using fast and ultra-fast broadband (see Figure 140).[567]

Greece also performs poorly, ranking 26th out of the 28 countries in the EU sample. Only 5% of Greek enterprises use fast broadband, compared to 12% of enterprises across the continent. In terms of ultra-fast broadband, with speeds of above 100 Mbps, only 2% of Greece's business reported coverage when compared to the EU average of 7% (see Figures 140).[568]

[565] Eurostat, Type of connections to the internet, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_it_en2&lang=en
[566] Eurostat, Type of connections to the internet, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_it_en2&lang=en
[567] Eurostat, Type of connections to the internet, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_it_en2&lang=en
[568] Eurostat, Type of connections to the internet, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ci_it_en2&lang=en

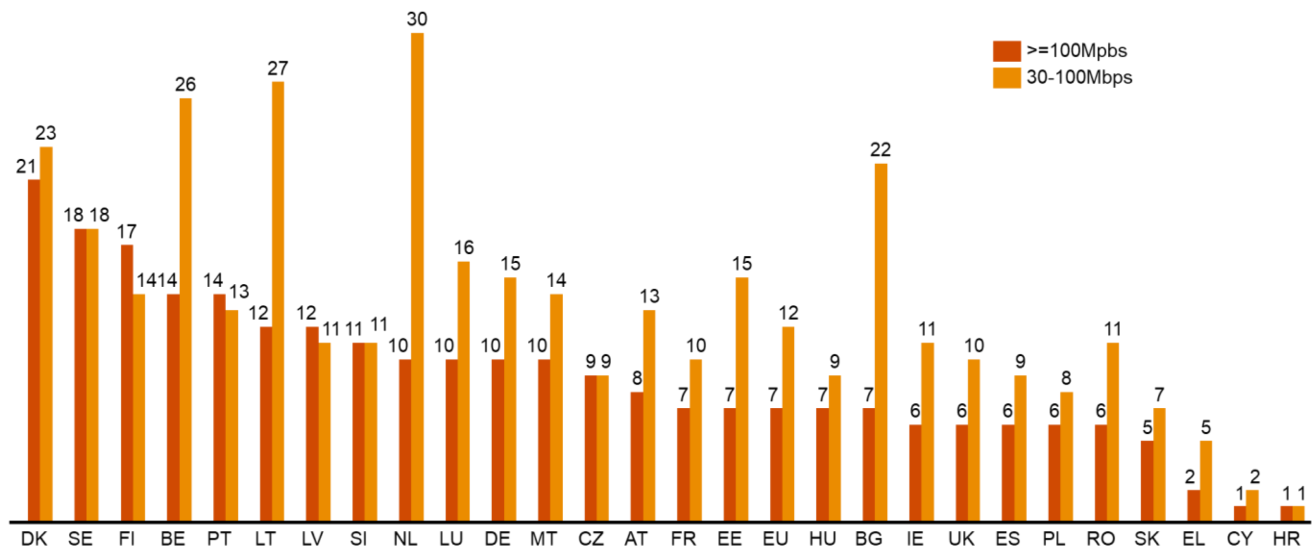


Figure 140: % of Enterprises with over 30Mbps and over 100MBps on Their Fastest Contracted Download Speed, 2013 – Source: Eurostat, Type of connections to the internet

To address the country's unfavourable position, in 2018 Greece updated its National Broadband Plan to meet EU's Gigabit Society targets and launched a set of relevant initiatives. Indicative initiatives are:

- The superfast broadband initiative (SFBB), which provides vouchers to increase Greece's take-up of broadband services with download speeds of at least 100 MBps. The project's maximum overall budget is EUR 50 million per year, and is funded from national resources, under the general state budget.[569]
- The Ultrafast Broadband (UFBB) initiative, that aims at covering most areas of the country that will remain NGA-white and about 2.5 million people (about 18 % of the active lines) at national level. The project's total budget is EUR 700 million.[570]
- The WiFI4EU initiative that promotes free access to Wi-Fi connectivity for citizens in public spaces including parks, squares, public buildings, libraries, health centers and museums in municipalities. Greece is one of the successful Member States in the WiFi4EU first call as it won 117 vouchers (about 40 % of those applied, 268 in total).[571]

[569] Ministry of Digital Governance, SFBB Initiative, https://www.sfbb.gr/
[570] Ministry of Digital Governance, UFBB Initiative,https://mindigital.gr/old/index.php/26-g-g-t-t/%CE%B1%CE%BD%CE%B1%CE%BA%CE%BF%CE%B9%CE%BD%CF%89%CF%83%CE%B5%CE%B9%CF%83/2247-nga-o-ultra-fast-broadband-ufb
[571] European Commission, WiFi4EU Initiative, https://ec.europa.eu/digital-single-market/en/policies/wifi4eu-free-wi-fi-europeans

9.5 State of integrated eGovernment applications

Digital adoption doesn't come in a vacuum. On the contrary, it also sets as a prerequisite that the Public Administrations of EU countries undertake targeted efforts towards providing transparent, simpler, faster and more user-centric digital services to increase citizens' and businesses' engagement, trust and motivation in the Industry 4.0 technologies.

To assess the Europe's current state with regards to their integrated eGovernment applications, we will use both the 5th pillar of the DESI index, dedicated to the digital public services[572], EU's eGovernment Benchmark 2019 report[573] and a set of additional indexes that demonstrate EU countries' maturity with regards to their provision of eGovernment services and applications.

9.5.1 The DESI Index – Pillar 5: Digital Public Services

The 5th dimension of the EU's DESI Index – Digital Public Services, assesses the quality level of online public administration services for EU member states. The dimension consists of the following sub-dimensions:

- The "eGovernment" sub-dimension that includes: the eGovernment users measured as a percentage of those internet users who need to submit forms to the public administration (the eGovernment users indicator), the extent to which data that is already known to the public administration is pre-filled in forms presented to the user (the pre-filled forms indicator), the extent to which the various steps in dealing with the public administration can be carried out completely online (the online service completion indicator), the degree to which public services for businesses are interoperable and cross-border (the digital public services for businesses indicator) and the government's commitment to open data (the open data indicator).
- The "eHealth" sub-dimension that includes: the percentage of people who used online health and care services without having to go to a hospital or doctors surgery (the e-health services indicator); the extent to which general practitioners are using electronic networks to exchange medical data with other healthcare providers and professionals (the medical data exchange indicator); and the extent to which general practitioners are using electronic networks to transfer prescriptions to pharmacists (the e-prescription indicator).

[572] The Digital Economy and Society Index 2019, Digital Public Services, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=59975
[573] European Commission, eGovernment Benchmark 2019, https://ec.europa.eu/digital-single-market/en/news/egovernment-benchmark-2019-trust-government-increasingly-important-people

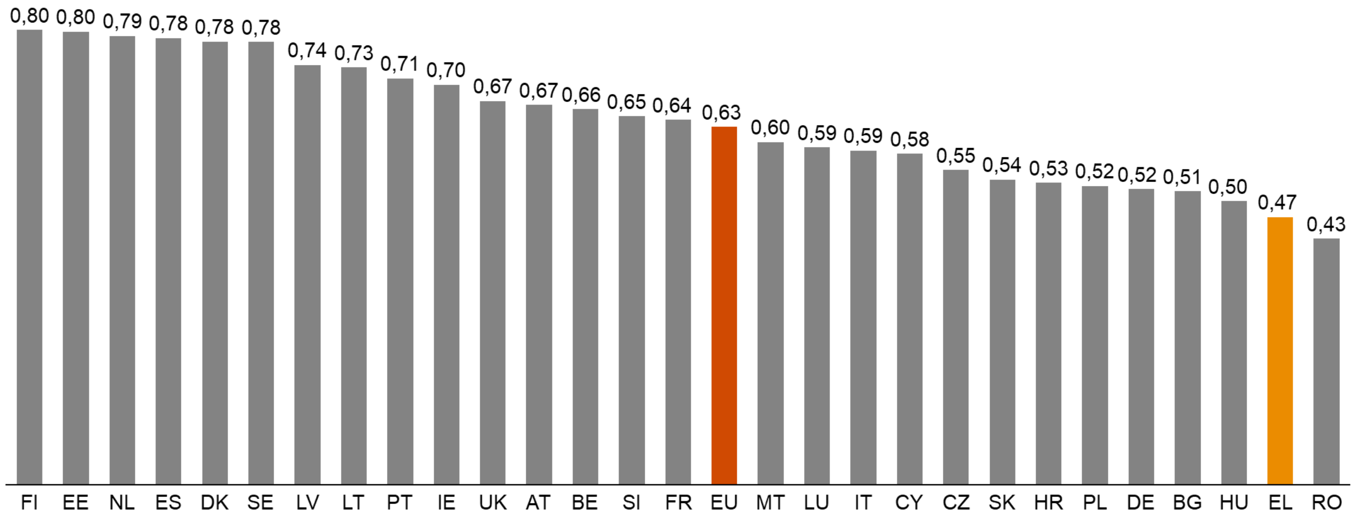


Figure 141: DESI Index 2019 - Pillar 5: Digital Public Services, EU ranking – Source: DESI 2019, Digital Public Services

In 2019, Finland, Estonia, and the Netherlands scored the highest among the EU while Hungary, Greece, and Romania held the last positions in the ranking (see Figure 141).[574]

Zooming into Greece, the country is among the lowest ranking EU countries, positioned at the 27th place among the EU 28. Specifically, Greece's Digital Public Services score is 26% lower than the EU average (see Figure 141).[575]

With regards to the demand of eGovernment applications, it appears that a higher number of EU citizens has used eGovernment services in 2018 (64% in 2018 against 57% in 2017). Sweden, Estonia, Finland and Denmark performed best, with more than 90% of internet users who need to submit filled forms to the public administration via governmental portals (see Figure 142).[576]

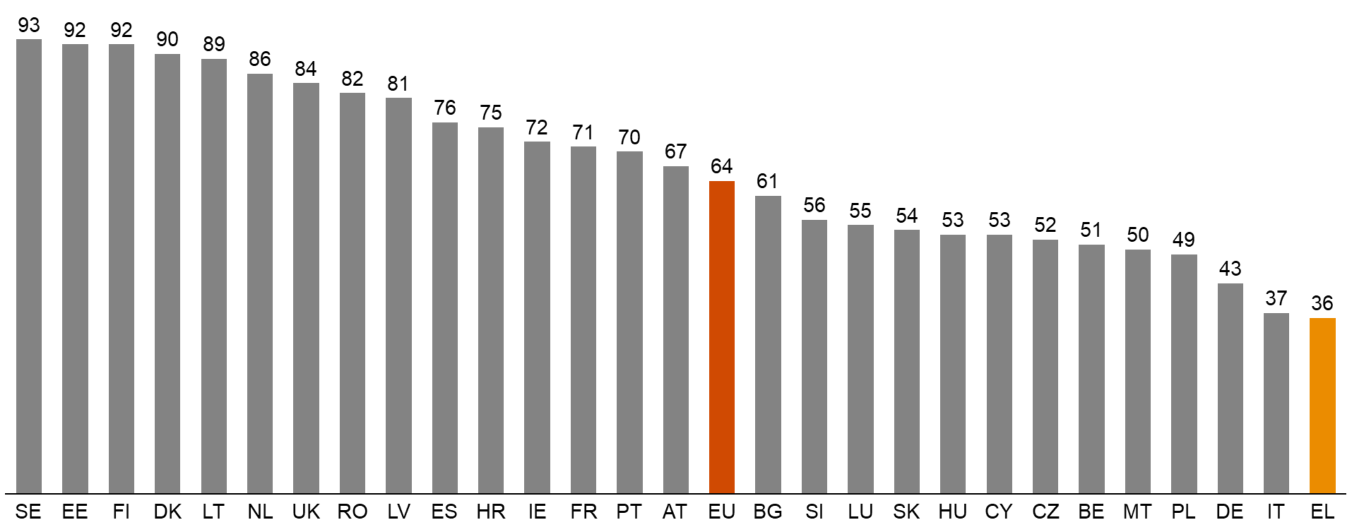


Figure 142: EGovernment users, 2018 (% of internet users needed to submit filled forms to public authorities over the internet in the last 12 months) – Source: DESI 2019, Digital Public Services

[574] Digital Economy and Society Index Indicators 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators
[575] Digital Economy and Society Index Indicators 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators
[576] Digital Economy and Society Index Indicators 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators

Furthermore, Greece also performs poorly with regards to the country's share of eGovernment users, scoring last among all 28 EU countries with just 36% of Greek citizens submitting forms to public authorities over the internet during 2018. This corresponds to approximately half the average share reported by the EU (see Figure 143).[577]

With regards to the provision of eGovernment applications and the extent to which the steps required in order to deal with the government can be done completely online, Malta, Portugal and Estonia are leading the way, while Bulgaria, Romania and Hungary score last (see Figure 143).[578]

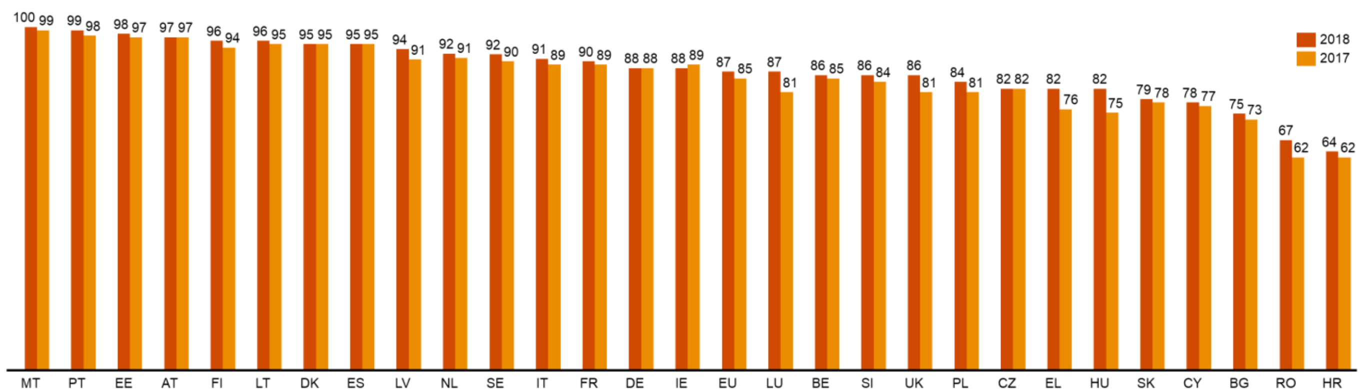


Figure 143: Online service completion, 2017-2018 (score 0 to 100) – Source: DESI 2019, Digital Public Services

Moreover, in terms of online service completion via eGovernment websites, Greece performed well in 2018, scoring 82 points, just slightly below the EU average of 87 points. Furthermore, Greece's recent performance significantly outpaced the EU average in terms of annual growth. The country grew by 8%, about four times the growth rate of the EU average (2%) along the Online Service Completion dimension (see Figure 143).[579]

In 2018, Denmark and Ireland appear the frontrunners in the provision of eGovernment services to their businesses, while Greece, Croatia and Romania rank last among their EU counterparts (See Figure 144)[580].

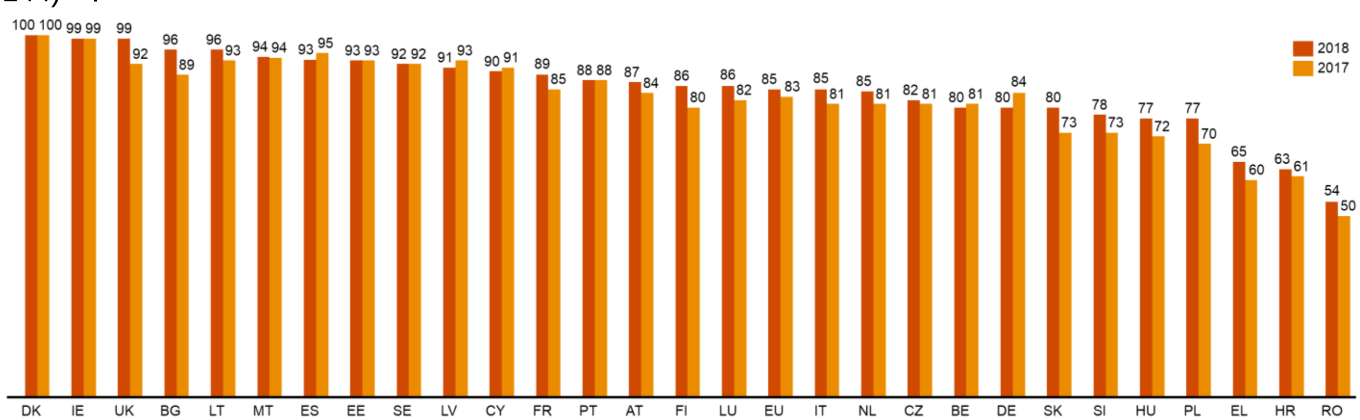


Figure 144: EGovernment services for businesses, 2017-2018 (score 0 to 100) – Source: DESI 2019, Digital Public Services

[577] Digital Economy and Society Index Indicators 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators
[578] Digital Economy and Society Index Indicators 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators
[579] Digital Economy and Society Index Indicators 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators
[580] Digital Economy and Society Index Indicators 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators

Greece scores poorly in terms of the eGovernment services for businesses, indicating that the country must significantly upgrade its current framework for accommodating the eGovernment needs. Greece's score was 65 points in 2018, 20 points below the EU average. Nevertheless, the country seems to be evolving its eGovernment services at a fast pace along this dimension as well, growing 8% rate YoY compared to 2017, which is four times greater than the EU's growth rate over the same period (see Figure 144).[581]

Finally, with regards to open data use, Ireland, Spain and France are leaders among EU countries, while Estonia, Denmark and Malta underperform, scoring last (see Figure 145).[582]

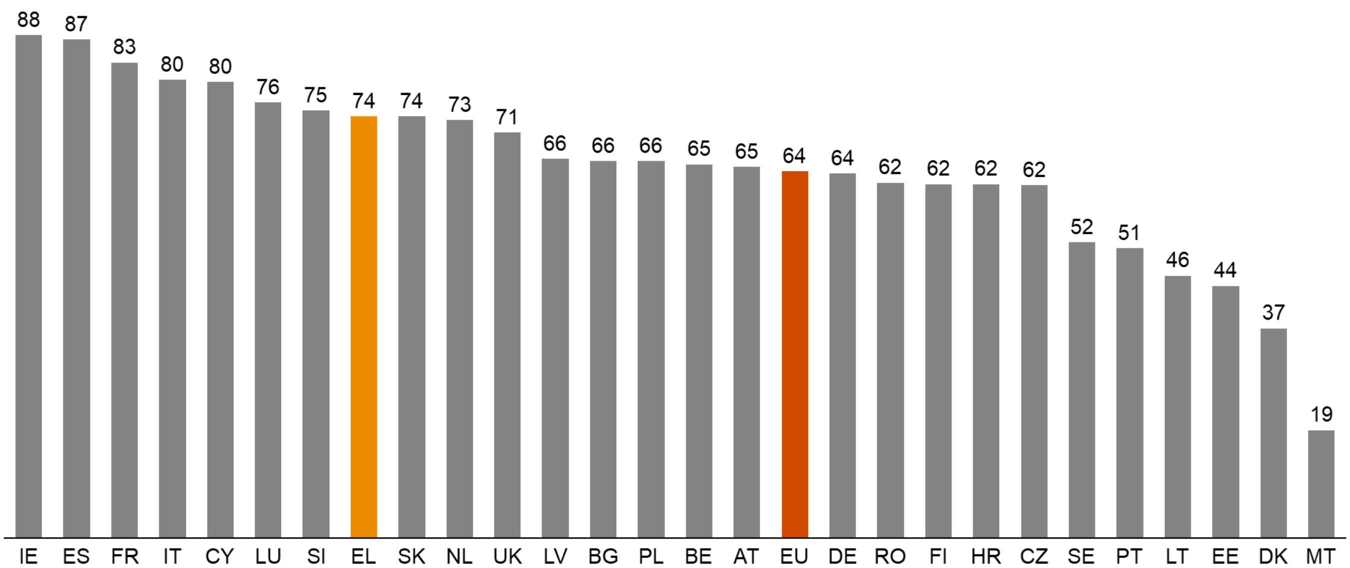


Figure 145: Open Data, 2018 (% of the maximum open data score) – Source: DESI 2019, Digital Public Services

Greece scores at well along the Open Data dimension, demonstrating that the government's data is accessible to its citizens to a significant degree. However, there is still ample room for improvement, as evidenced by the 14% gap between Greece's (74%) score and that of the Ireland' (88%) (see Figure 145).[583]

In order to derive the open data maturity of the EU countries, four indicators have been evaluated:

- The presence of an Open data policy and the extent of coordination at national level to provide guidelines to national, local and regional administrations, and set up coordinated approaches towards data publication.
- The development and upgrade of Open data portals
- The political, social, environmental and economic impact of open data at country level
- The quality of Open data. That is the extent to which national portals have a systematic and automated approach for collecting data and the compliance level of open data to the metadata standard DCAT-AP (specification for metadata records).

[581] Digital Economy and Society Index Indicators 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators
[582] Digital Economy and Society Index Indicators 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators
[583] Digital Economy and Society Index Indicators 2019, Digital Public Services, https://digital-agenda-data.eu/datasets/desi/indicators

It is important to highlight that countries with lower open data maturity appear to solely focus on modernising their national portals. On the contrary, "mature" open data countries have already established fully functional national portals and now focus on boosting the quality of their open data.

Although Greece still ranks among the bottom of EU countries in terms of digital public services, recent performance shows that measures taken to improve those scores, have been effective and towards the right direction. While there is still a long way to go, a set of targeted and realistic actions can further improve Greek scores and become a bright example of digital transformation that the rest of Greece can benefit from and look up to.

9.5.2 The eGovernment Benchmark Report

In addition to the DESI Index, the European Commission has introduced the eGovernment Benchmark report, which is tailored to the measurement of the quality of eGovernment services based on four dimensions: **User-centricity, Transparency, Cross-border mobility, and Key enablers.**

User Centricity	**User-centricity** is defined as the provision of public services and information online, in a mobile friendly manner and with sufficient support channels in place.
Transparency	**Transparency** is a crucial building block for the formation of strong relationships between citizens and governments, crucial for the development of accountable, trustworthy and efficient public organizations. Transparent public administrations are expected to explain how budgets are spent, how long it takes for the delivery of services, and the way in which citizens' personal data is processed
Cross Border Mobility	To ensure cross-border mobility for EU businesses and citizens, online public services need to be made accessible to citizens residing in all EU member states. The **Cross-border mobility** dimension measures the extent to which a country's public services are internationally oriented. This includes lifting language and other related barriers, availability of electronic identification and electronic documents for non-nationals and businesses, and the capability of transacting with public sector authorities in a seamless and secure manner abroad.
Key Enablers	In addition to the abovementioned dimensions, the safe and efficient provision of eGovernment services relies on the availability of a number of digital key enablers. **Key enablers** for eGovernment services include eID capabilities and availability, eDocuments such as parking permits, authentic source availability such as the use of eForms for the submission of corporate taxes and digital-only communication between the government and nationals or EU non-nationals.

Figure 146: Four dimensions of the eGovernment Benchmark Report 2019

Greece's low performance in the field of eGovernment is echoed in the country's low ranking across a variety of international indices focusing on eGovernment. Based on the EU's eGovernment Benchmark Report, Greece belongs to the group of countries whose public administration lags considerably behind in terms of its digitalisation and digital service offerings. Specifically, Greece reports a 27% penetration of digital and electronic services, compared to the EU average of 57%. In the area of digitisation of public services, Greece reports 51% digitalisation, with the EU average being 68%.

User Centricity

On average, eGovernment services in the EU score relatively well on the user-centricity benchmark, with the EU average scoring at 85 points, higher than the continent's average score across all the remaining dimensions.

Malta is the EU leader with respect to eGovernment user-centricity, with 98 points, followed by Austria, Finland, Portugal and Denmark, all of which scored 95 points on the user-centricity on the 2019 eGovernment benchmark. Romania and Croatia have the least user-centric eGovernment services, scoring 67 points each (see Figure 147).[584]

Greece's eGovernment services are on par with the European average in terms of user-centricity. Greece scored 83 points on the 2019 eGovernment Benchmark on User centricity, only two points below the EU average, demonstrating that Greek eGovernment services are to a large extent placing their citizen at the centre of their offerings (see Figure 147).[585]

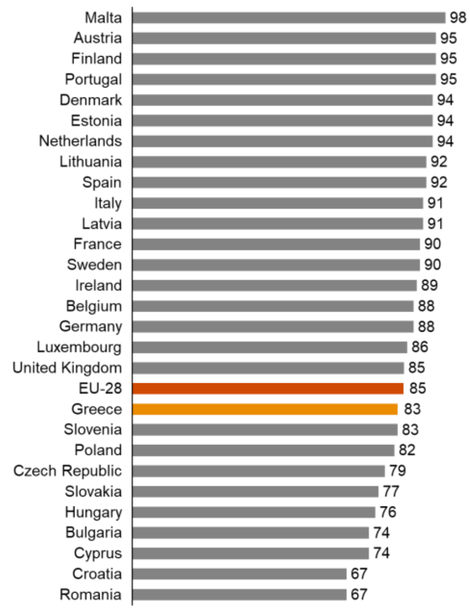


Figure 147: User-Centricity eGovernment Benchmark Scores, EU, 2019 - Source: European Commission, eGovernment Benchmark Report 2019

Transparency

EU eGovernment services score lower with regards to transparency, with a 62-point score on average, almost twenty points below the corresponding score for user-centricity.

Malta is reported to have the most transparent eGovernment services, with a score of 96. Lithuania and Estonia closely follow, with 90 and 88 eGovernment benchmark scores on transparency respectively. Slovakia, at 42 points, and Cyprus, at 45, had the least transparent eGovernment services in the EU according to the 2019 eGovernment Benchmark (see Figure 148). [586]

Zooming into Greece, the country's eGovernment services are significantly lower with respect to the European average in terms of their transparency. Greece is behind the EU average, with a score of 47. This indicates that eGovernment services in the country need to become more transparent, either in terms of revealing more about eGovernment processes, such as their state of completion, or in terms of

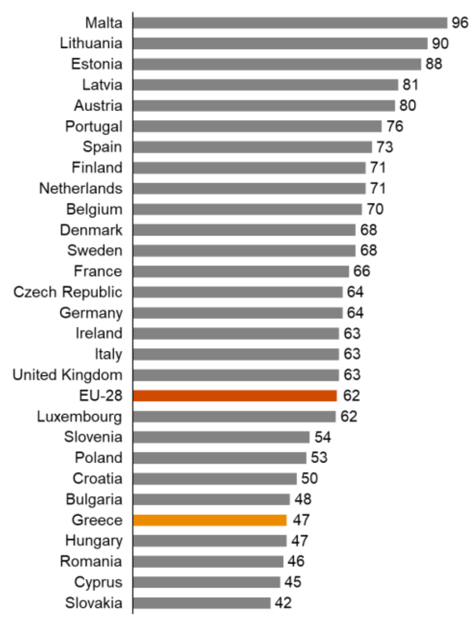


Figure 148: Transparency eGovernment Benchmark Scores, EU, 2019 - Source: European Commission, eGovernment Benchmark Report 2019

[584] EGovernment Benchmark 2019, Country Fact Sheets, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=62368
[585] EGovernment Benchmark 2019, Country Fact Sheets, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=62368
[586] EGovernment Benchmark 2019, Country Fact Sheets, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=62368

making more government data open to the citizenry (see Figure 148).[587]

Cross-Border Mobility

Overall, the European Union performs poorly in terms of the cross-border mobility dimension of its eGovernment, with 2019 eGovernment benchmark scores implying that there is significant space for improvement in this dimension. Notably, EU countries perform significantly poorer with respect to citizen cross-border mobility, averaging 48 points, when compared to business cross-border mobility, which averaged 63 points in the 2019 eGovernment benchmark report. (see Figures 149 and 150).[588]

In terms of citizen cross-border mobility, the leading countries in the EU are Malta with 87 points, Finland with 75 points, and Sweden with 74 points. The countries with the weakest performance in terms of the cross-border mobility of their eGovernment services for citizens are Romania with 29 points, Slovakia with 26 points and Hungary with 15 points. (see Figure 149) [589]

Greece scores 36 points in terms of Citizen Cross-Border Mobility of eGovernment Services, positioning itself measurably below the EU average. Nevertheless, Greece requires a significantly higher level of cross-border eGovernment services, to address the tourist and refugee movements both in and out of the country (see Figure 149).[590]

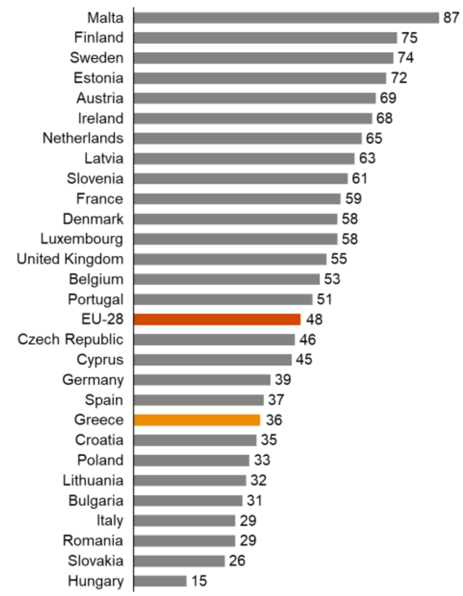


Figure 149: Citizen Cross-Border Mobility eGovernment Benchmark Scores, EU, 2019 - Source: European Commission, eGovernment Benchmark Report 2019

[587] EGovernment Benchmark 2019, Country Fact Sheets, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=62368
[588] EGovernment Benchmark 2019, Country Fact Sheets, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=62368
[589] EGovernment Benchmark 2019, Country Fact Sheets, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=62368
[590] EGovernment Benchmark 2019, Country Fact Sheets, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=62368

The UK leads the European sample in terms of the cross-border mobility of eGovernment services for business, with a 92-point score. The latter is closely followed by Malta and Denmark, which come second and third with 89 and 84 points respectively. Romania, with a 20-point score, has the least favourable eGovernment services regarding business cross border mobility, following Greece at 45 points. (see Figure 150). [591]

Greece's performance is significantly worse with respect to eGovernment Cross-Border Mobility for Businesses. With a 45-point benchmark score, the Greek eGovernment services are positioned 18 points below the EU average and just one rank above the worst performer in the EU, Romania. Greece's poor score along this dimension indicates that international organisations and professionals who do business in Greece experience low-quality eGovernment services when dealing with public services. As businesses increasingly rely on the internet to perform their legal and administrative duties toward the domestic authorities, it is crucial for Greece to grow its score along this dimension in order to attract more businesses and investments in the country in the future (see Figure 150).

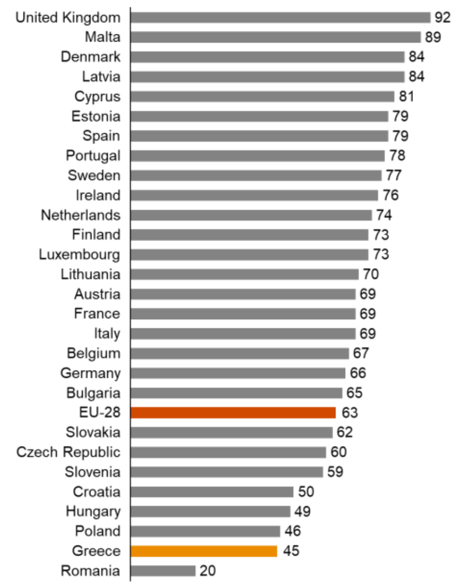


Figure 150: Business Cross-Border Mobility eGovernment Benchmark Scores, EU, 2019 - Source: European Commission, eGovernment Benchmark Report 2019

Key Enablers

The Key Enablers eGovernment dimension tracks the extent to which eID, eDocuments, Authentic sources, and Digital Post are available online. On average, EU countries score fairly along the Key Enablers dimensions, averaging 58 points on the 2019 eGovernment Benchmark.

Malta is the EU leader along this dimension, reaching a perfect score of 100 points. Estonia, with 92 points, and Austria, with 89, come second and third. The worst performing countries in the EU on the eGovernment Key enablers dimension are Romania, with 18 points, closely following Croatia and Bulgaria, with 26 points each (see Figure 151).[592]

Gathering just 30 points in 2019, Greece performs poorly along the Key Enablers metric. The country's score corresponds approximately half the EU average, pointing to the lack of adequate files, IDs, and forms available through the Greek eGovernment service. The Greek Government is in need of a radical digital upgrade in order to bring the country up to par with the EU standards (see Figure 151).[593]

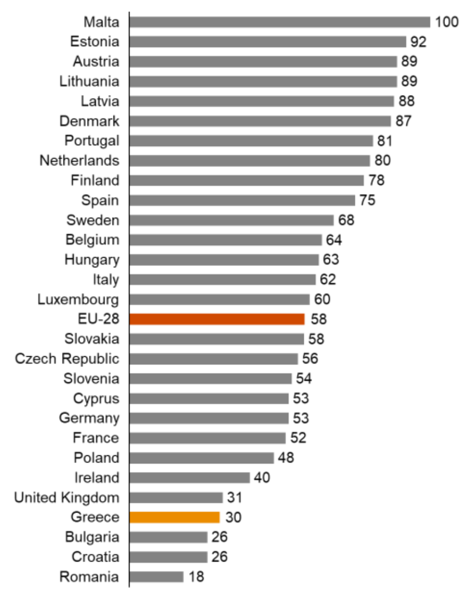


Figure 151: Key Enablers eGovernment Benchmark Scores, EU, 2019 - Source: European Commission, eGovernment Benchmark Report 2019

[591] EGovernment Benchmark 2019, Country Fact Sheets, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=62368
[592] EGovernment Benchmark 2019, Country Fact Sheets, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=62368
[593] EGovernment Benchmark 2019, Country Fact Sheets, https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=62368

10 Appendix II

10.1 Industry 4.0 Survey - Methodology

The analysis was based on the Industry 4.0 Survey open from November 20, 2019 to February 29, 2020.

The Industry 4.0 survey was completed by Board members, Top and Middle management level personnel of Greek organisations.

The Survey was structured around 6 dimensions and considered 18 technologies that characterize Industry 4.0, with 26 questions that covered key aspects of the fourth industrial revolution with regards to organisation's adoption levels and outlook.

1. Strategy & Organisation
2. Value Chain & New Business Models
3. Interconnected Products
4. Interconnected Production & Operations
5. Digital Skills & Human Capital
6. IT Infrastructure &Technology

The questionnaire was sent to 40 different associations who in turn, sent it to organisations they overlook. The associations correspond to 40 sub-sectors included in NACE sectors

B. Mining and quarrying
C. Manufacturing
E. Water supply; sewerage, waste management and remediation activities
F. Construction
H. Transportation and storage
J. Information and communication

The participative sample consists of 152 organisations, with the following distribution across Greece's industries.

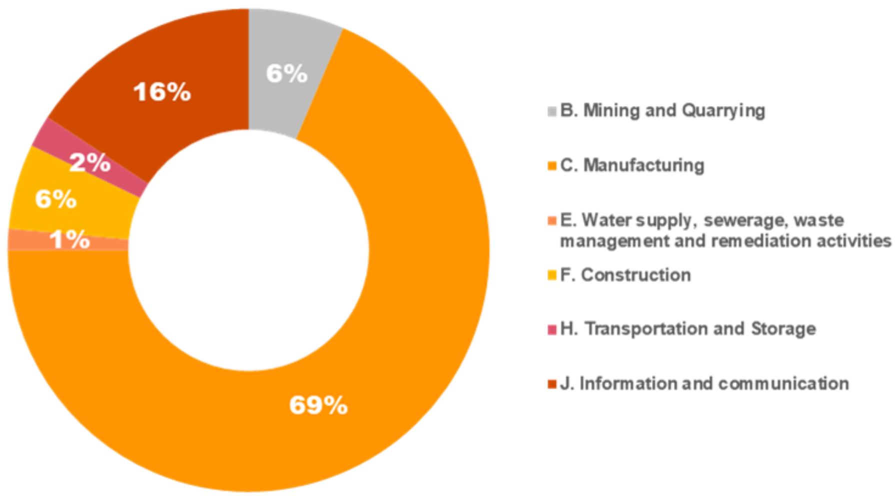


Figure 152: Industry 4.0 survey participants per Industry

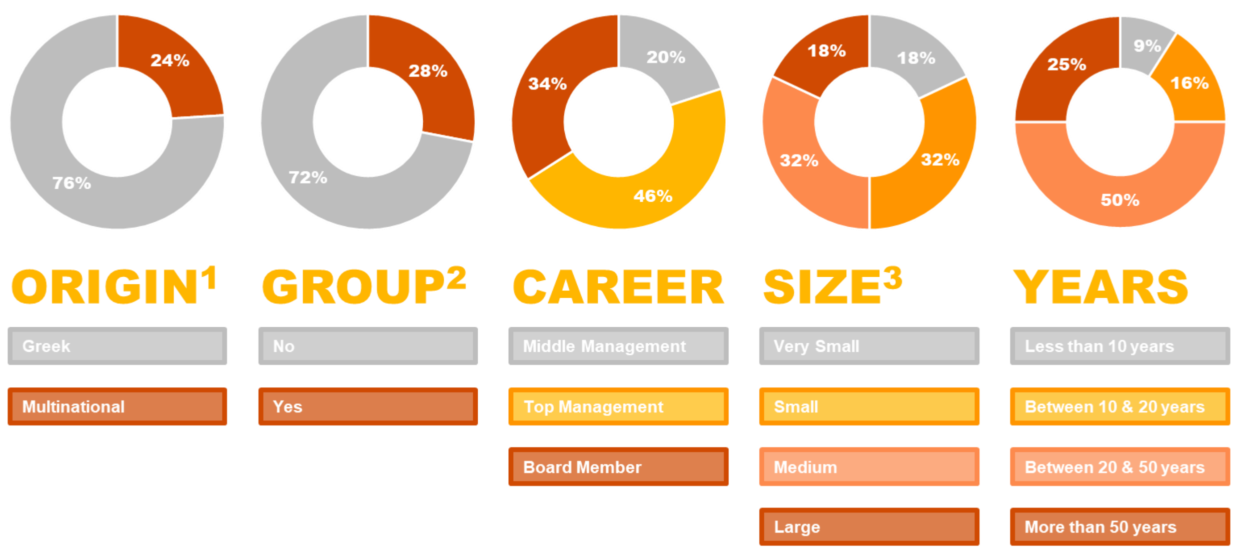


Figure 153: Industry 4.0 survey sample demographics

[1]. Greek: the company operates exclusively in Greek,
Multinational: the company operates in at least one country other than its home country
[2]. Yes: the company belongs to a larger Group of companies (either as the owner company or as a subsidiary),
No: the company does not belong to a larger group of companies
[3]. Based on characterisation of company size by number of employees from Eurostat
(Very Small – <10, Small – <50, Medium – <250, Large – >250)

10.2 Industry 4.0 Survey – Detailed Results per Question

In the pages below, we present the detailed results per Question of the Questionnaire on an aggregate level.

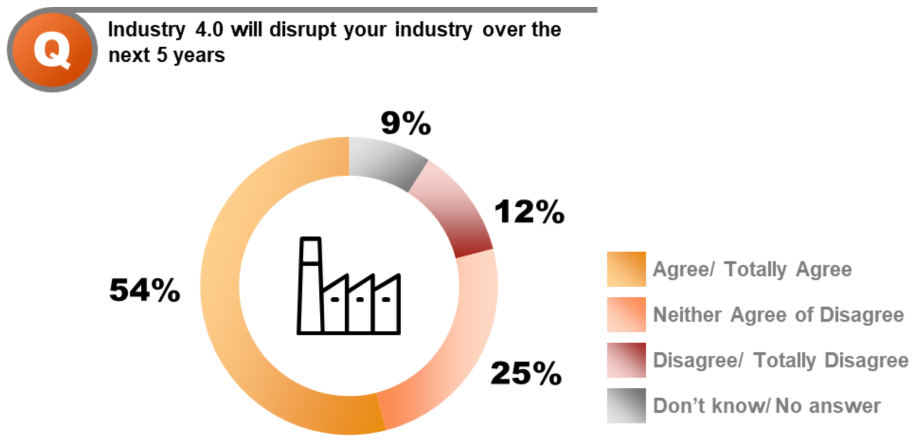


Figure 154: Greek executives' level of agreement regarding the disruption of their industry due to Industry 4.0, (%) – Source: Industry 4.0 survey

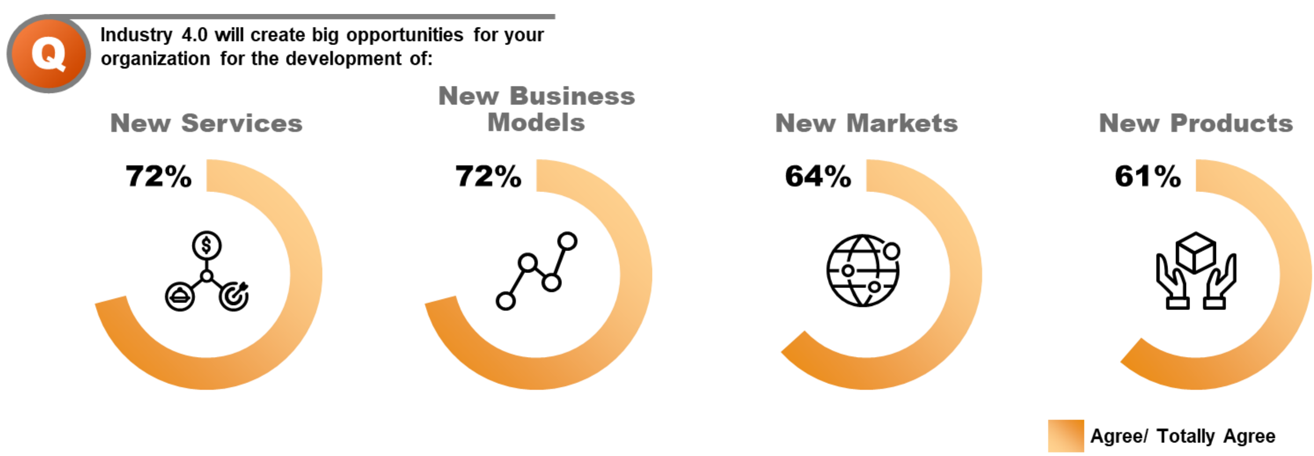


Figure 155: Greek executives' level of agreement regarding the opportunities that Industry 4.0 will open for their organisations, (%) – Source: Industry 4.0 survey

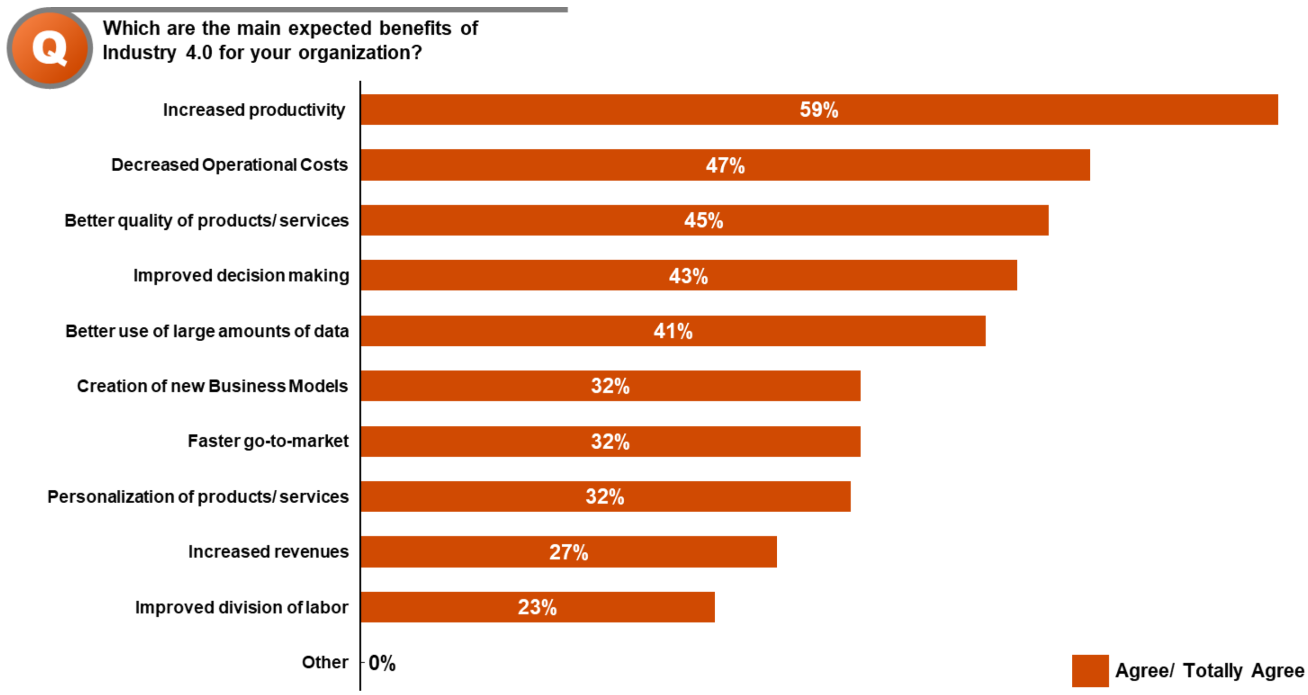


Figure 156: Greek executives' level of agreement regarding the benefits that Industry 4.0 will bring to their organisations, (%) – Source: Industry 4.0 survey

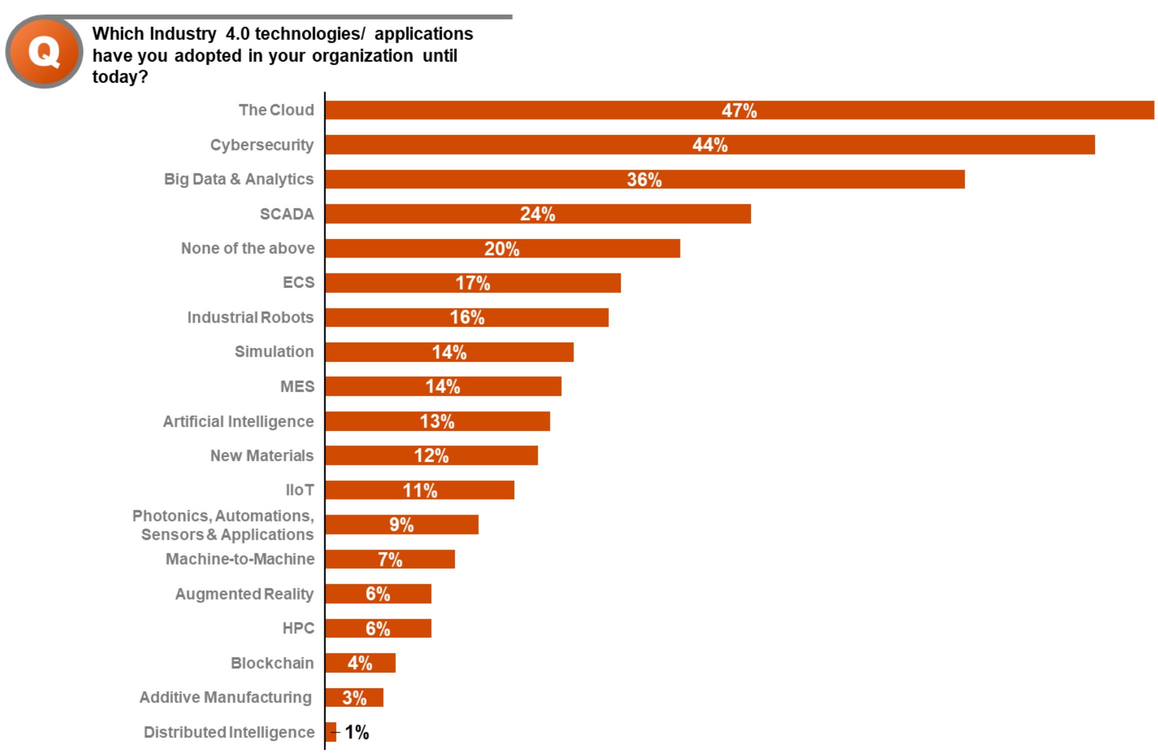


Figure 157: Key Industry 4.0 technologies/ applications that Greek executives have adopted in their organisations, (%) – Source: Industry 4.0 survey

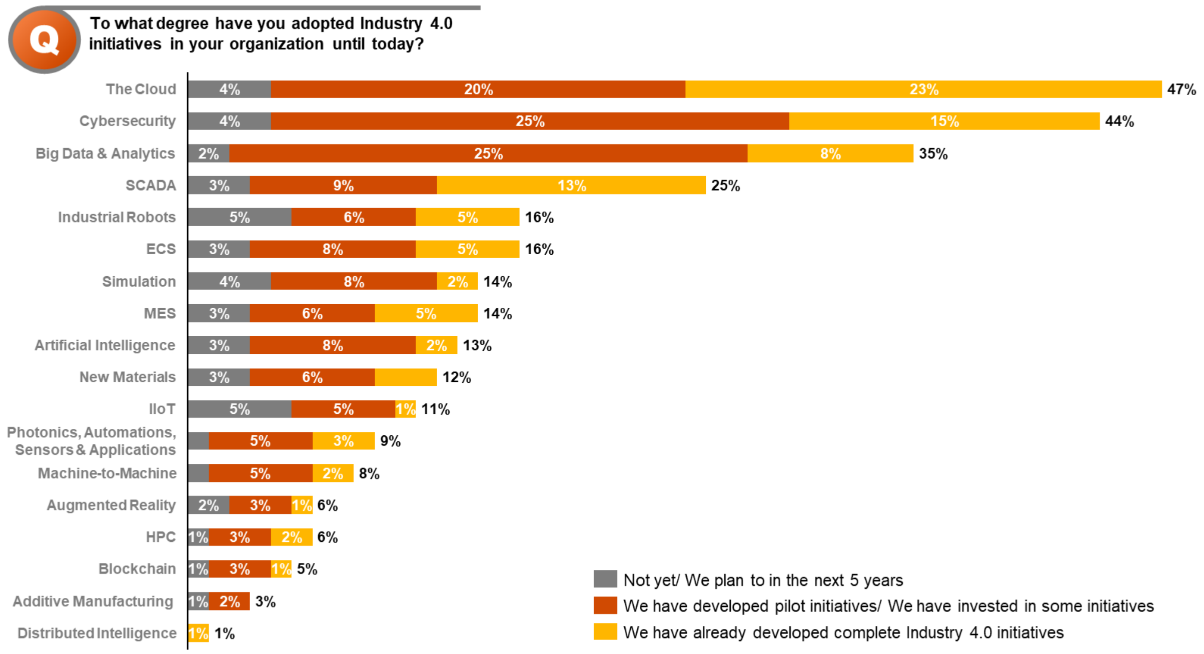


Figure 158: Organisation's degree of adoption of Industry 4.0 technologies/ applications, until today, (%) – Source: Industry 4.0 survey

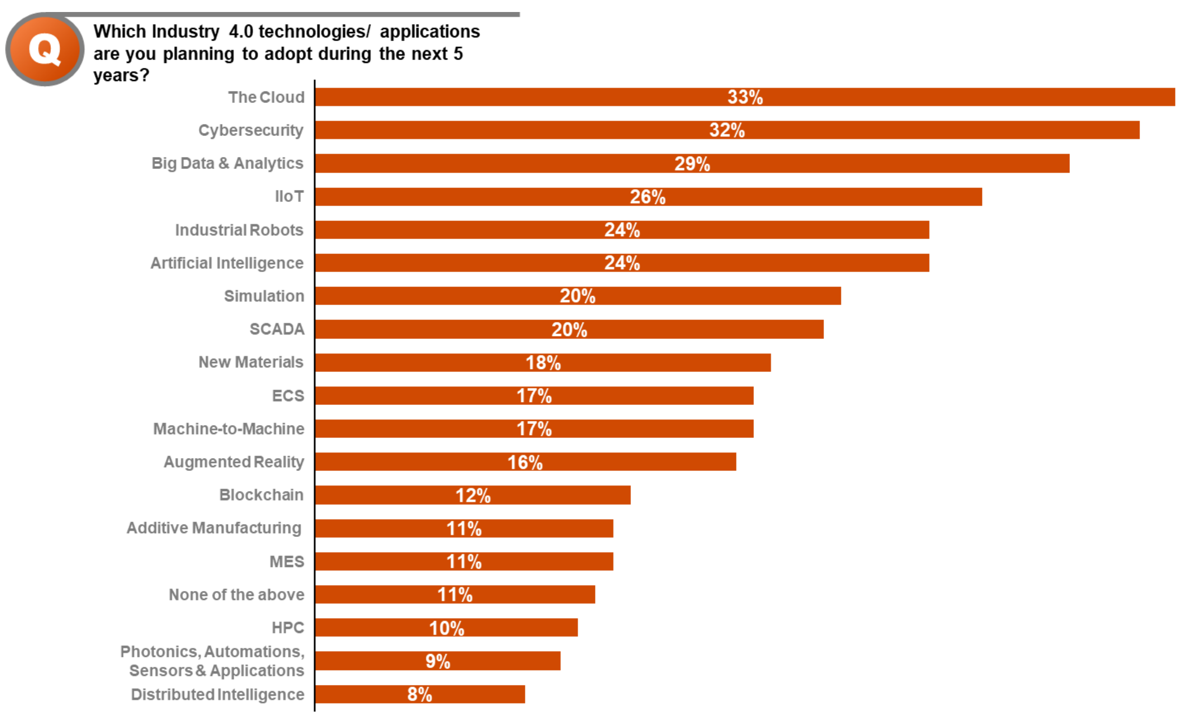


Figure 159: Key Industry 4.0 technologies/ applications that Greek executives plan to adopt in their organisations within the next 5 years, (%) –- Source: Industry 4.0 survey

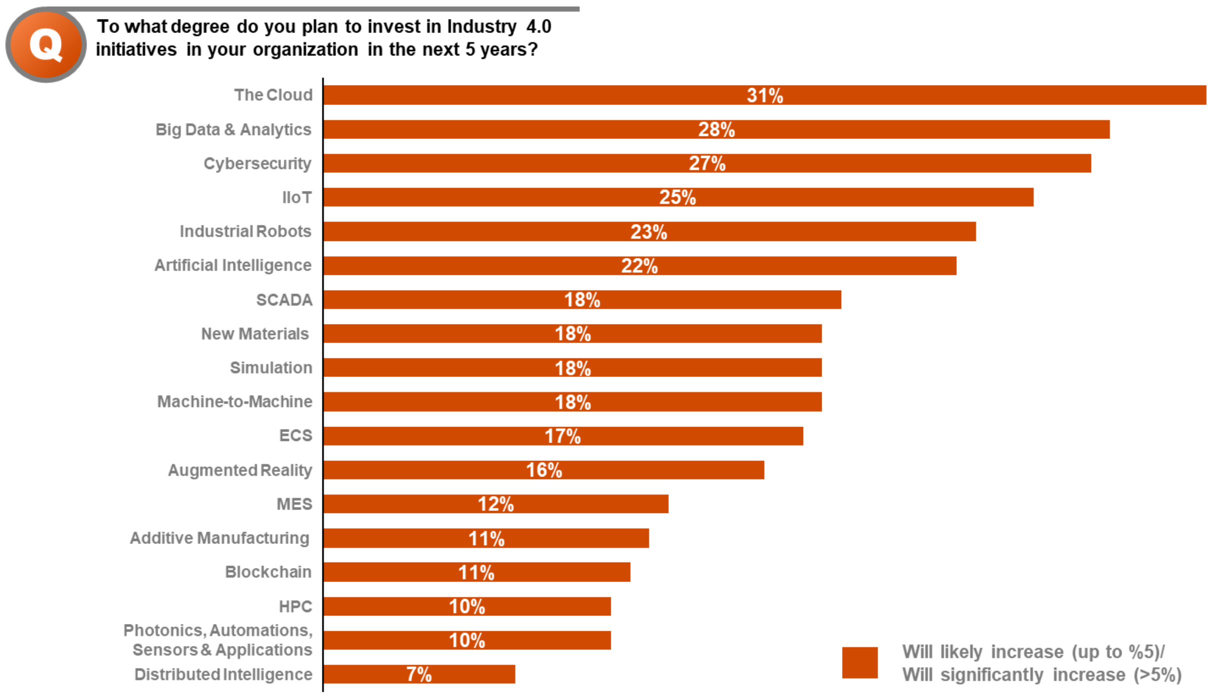


Figure 160: Organisation's planned degree of investment in Industry 4.0 initiatives, in the next 5 years, (%) – Source: Industry 4.0 survey

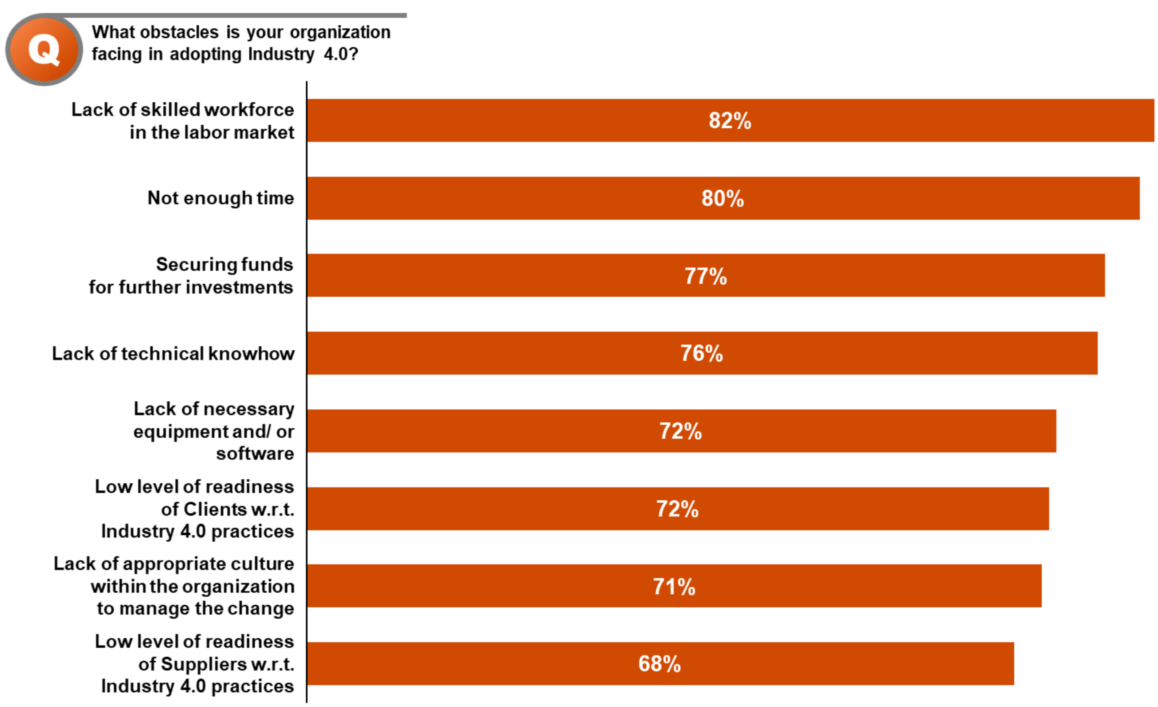


Figure 161: Key obstacles that Greek organisations face in adopting Industry 4.0, (%) – Source: Industry 4.0 survey

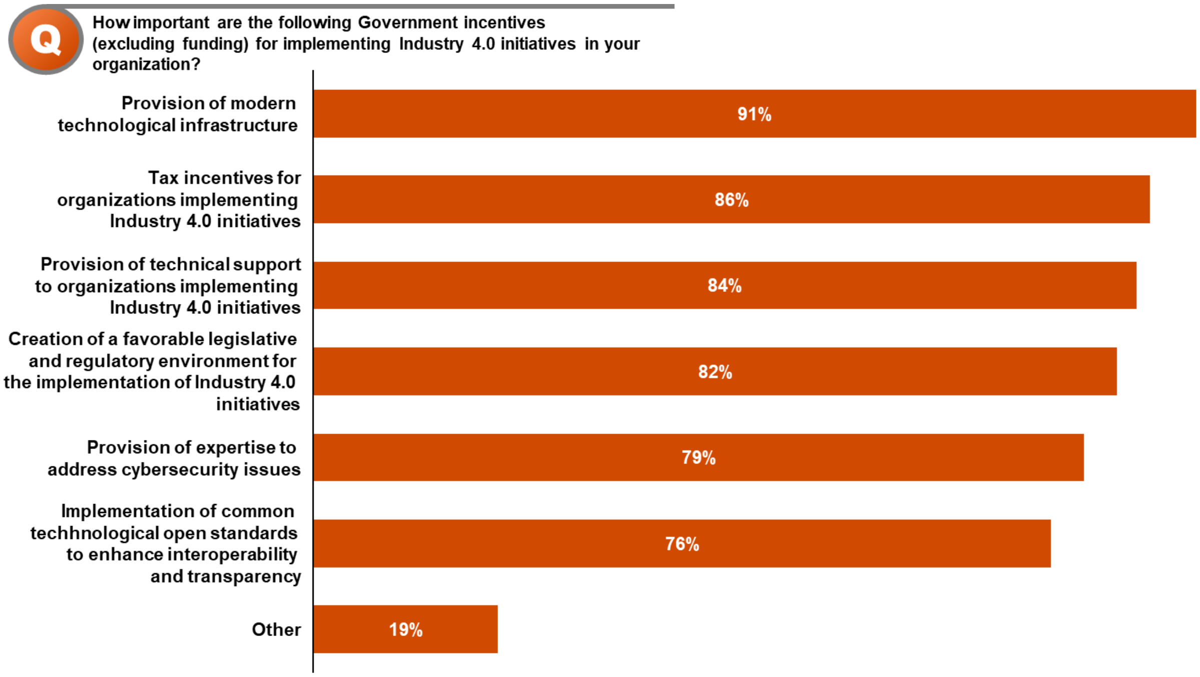


Figure 162: Important Government initiatives (excluding funding) that Greek executives wish to undertake in order to accelerate their organisations' digital transformation, (%) - Source: Industry 4.0 survey

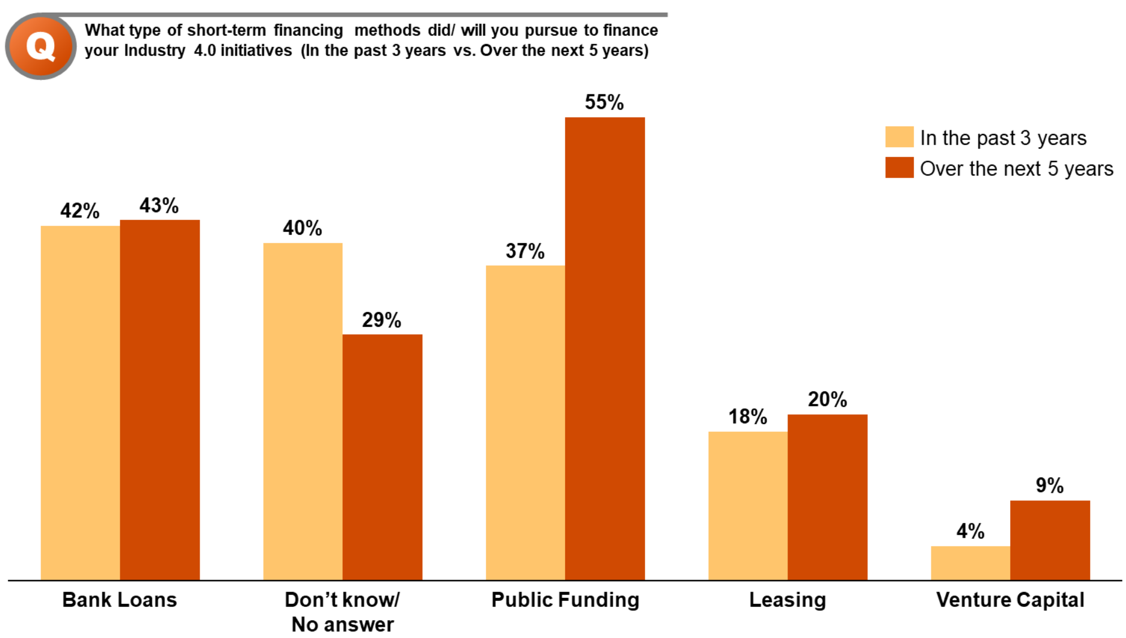


Figure 163: Short-term financing methods used/ to be used by Greek organisations during the last three years/ next five years, (%) – Source: Industry 4.0 survey

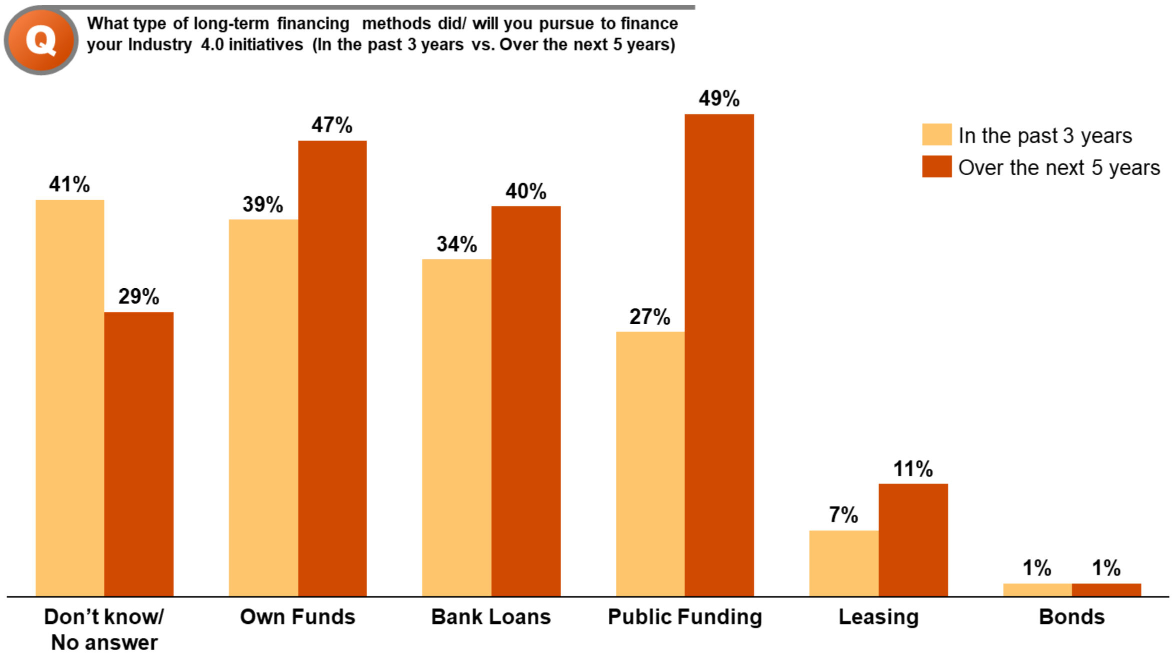


Figure 164: Long-term financing methods used/ to be used by Greek organisations during the last three years/ next five years, (%) – Source: Industry 4.0 survey

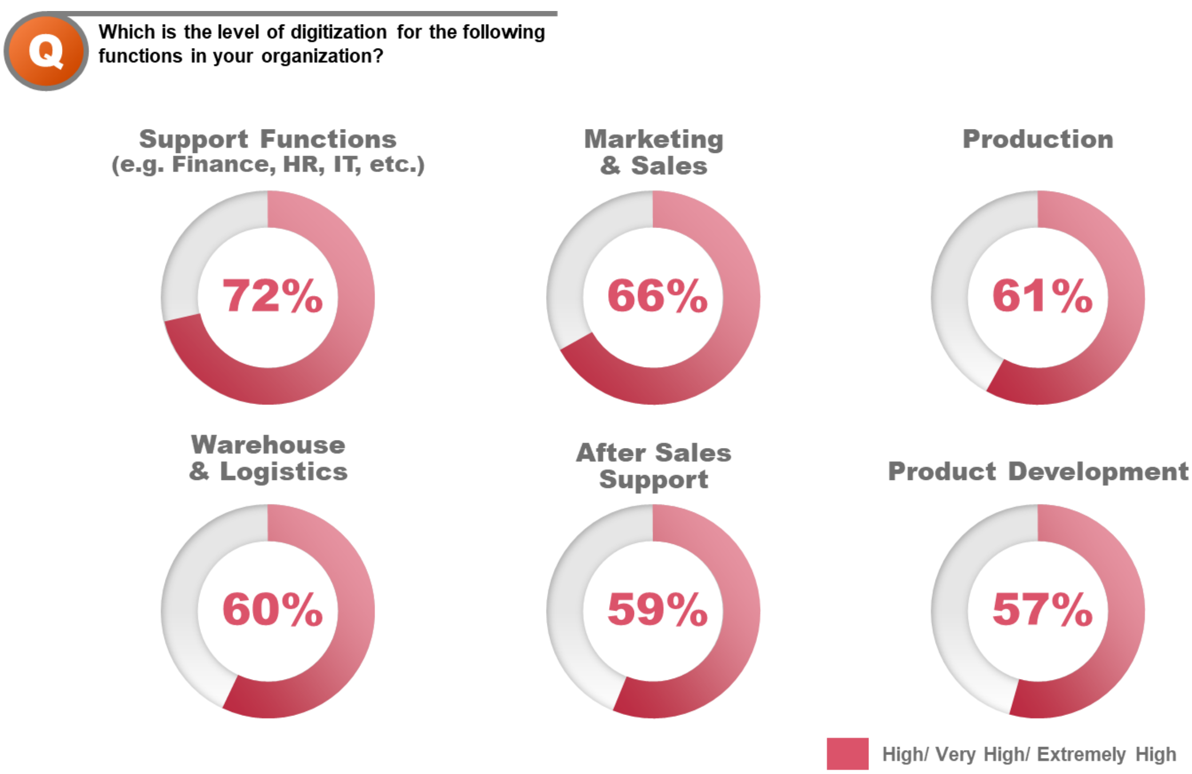


Figure 165: Greek executives' perception with regards to the level of digitisation of their organisation's functions, (%) – Source: Industry 4.0 survey

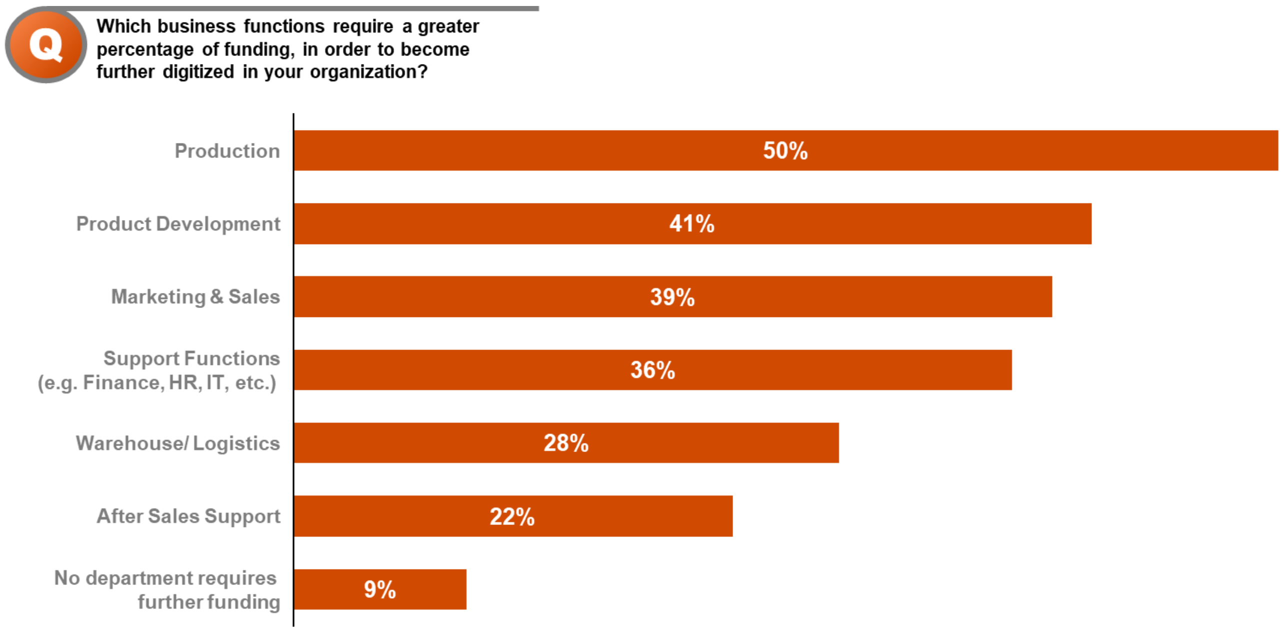


Figure 166: Funding required for further digitisation across different business functions of organisations, (%) – Source: Industry 4.0 survey

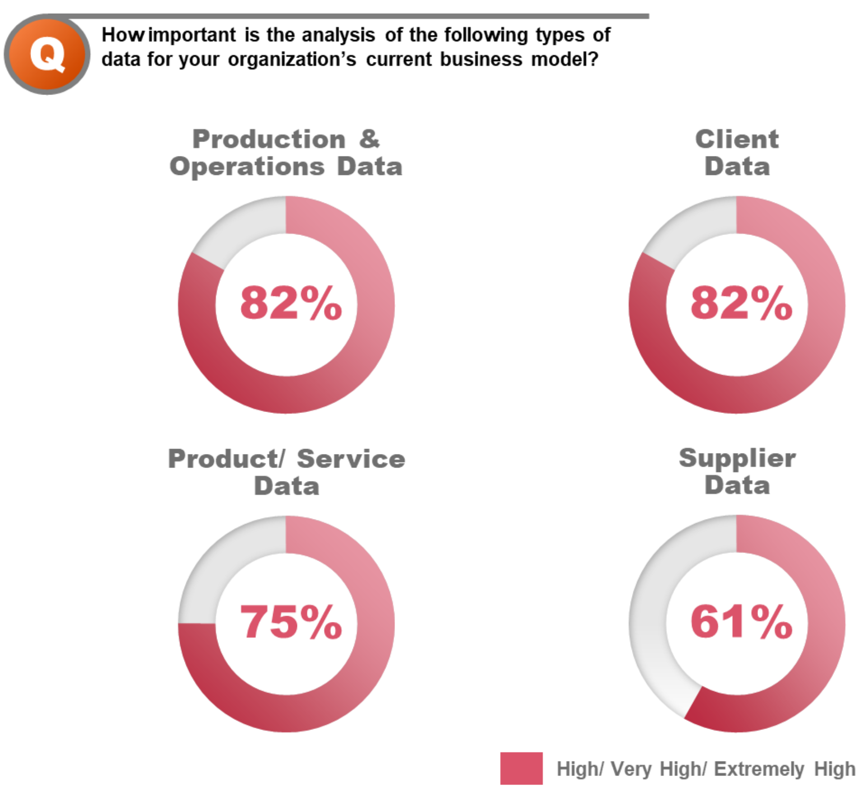


Figure 167: Level of importance of the analysis of different types of data, for the organisation's current business model, (%) – Source: Industry 4.0 survey

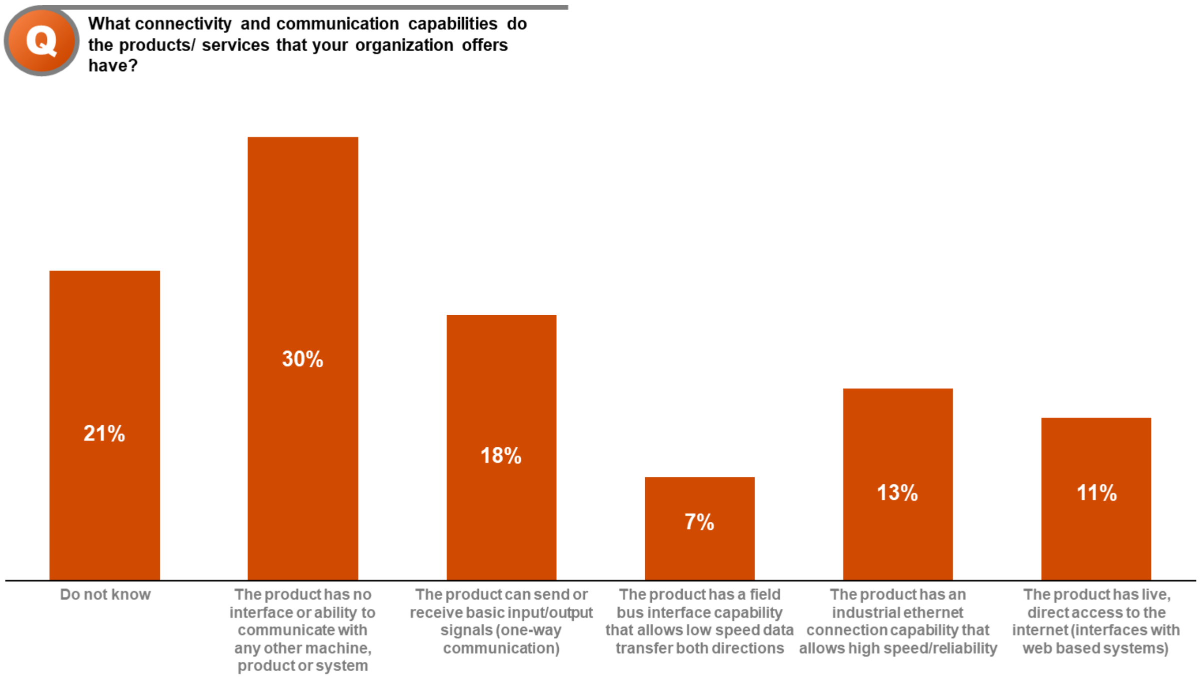


Figure 168: Degree of interconnectivity capabilities of products/ services that organisations offer, (%) – Source: Industry 4.0 survey

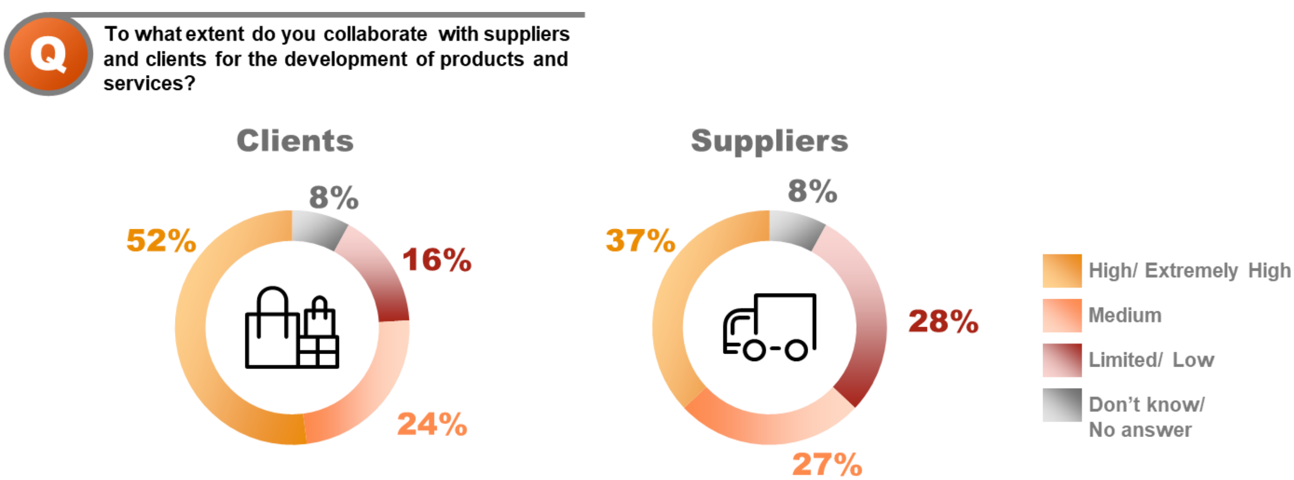


Figure 169: Degree of collaboration with partners/ suppliers for product/service development, (%) – Source: Industry 4.0 survey

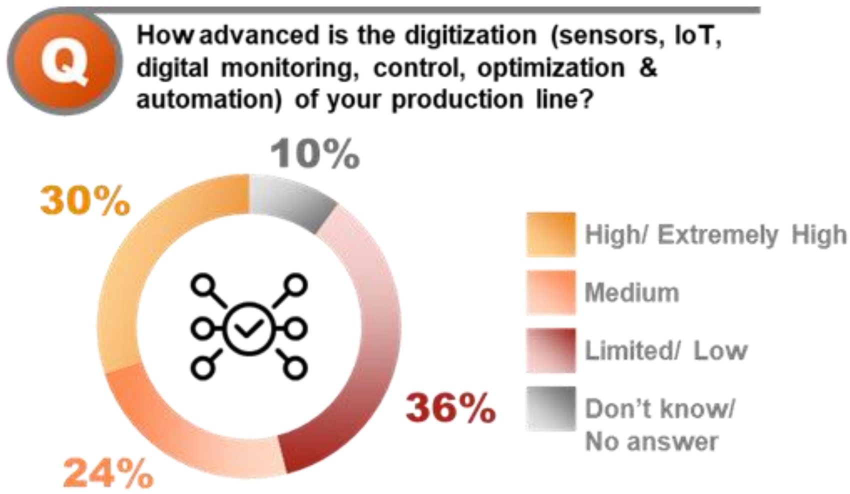


Figure 170: Degree of digitisation of the production line of organisations, (%) – Source: Industry 4.0 survey

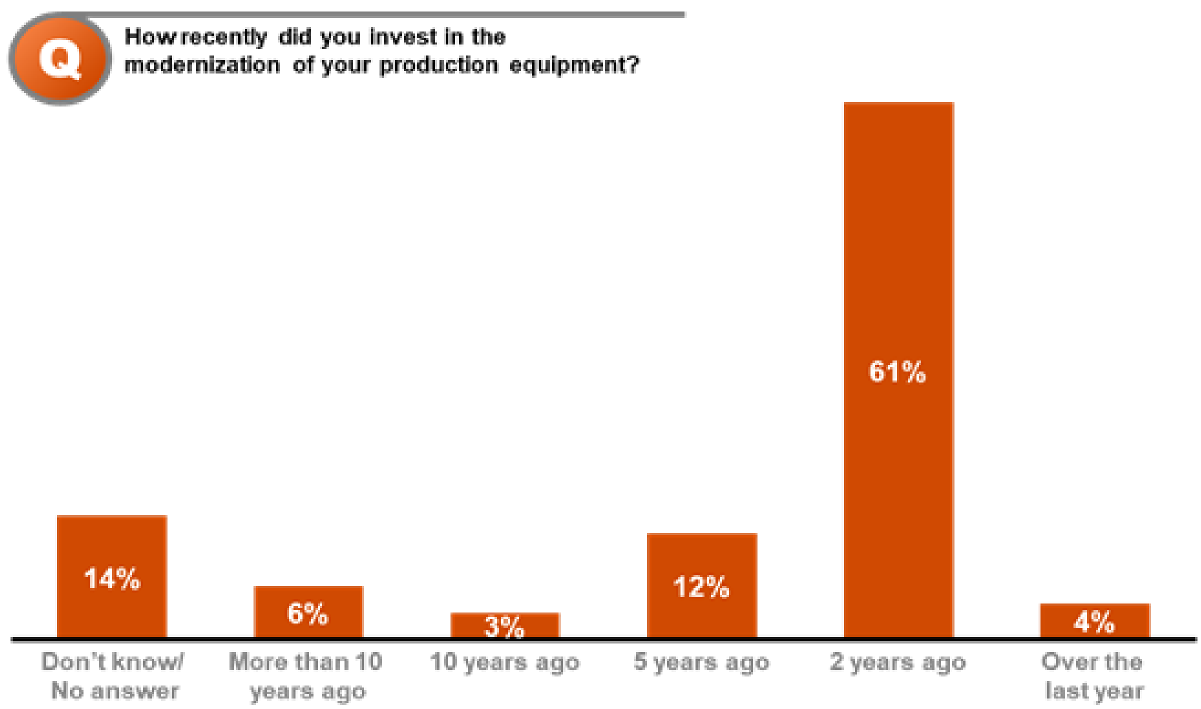


Figure 171: Last time organisations invested in the modernisation of their production equipment, (%) – Source: Industry 4.0 survey

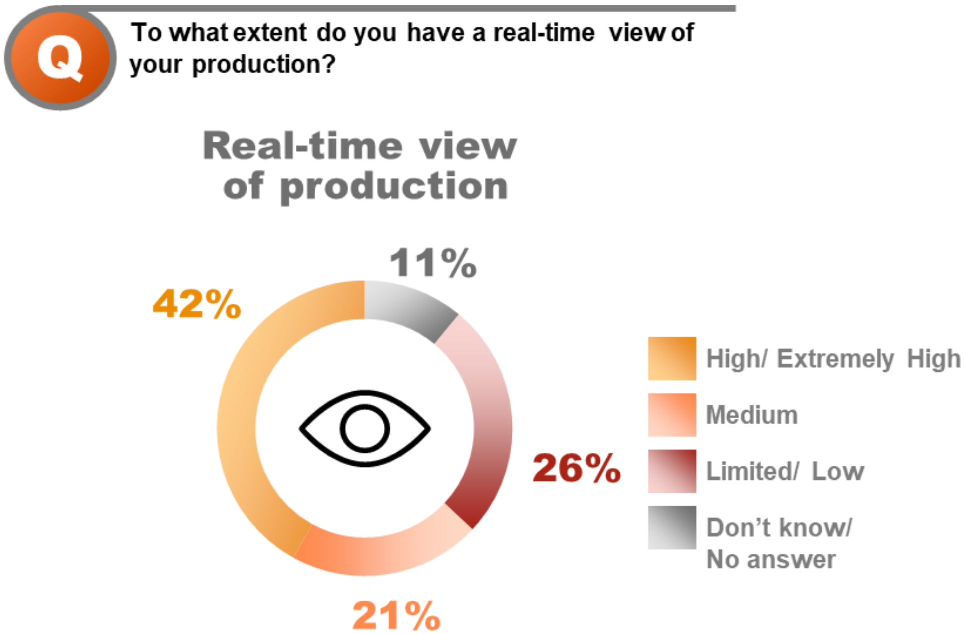


Figure 172: Degree of real-time view of production capacity, (%) – Source: Industry 4.0 survey

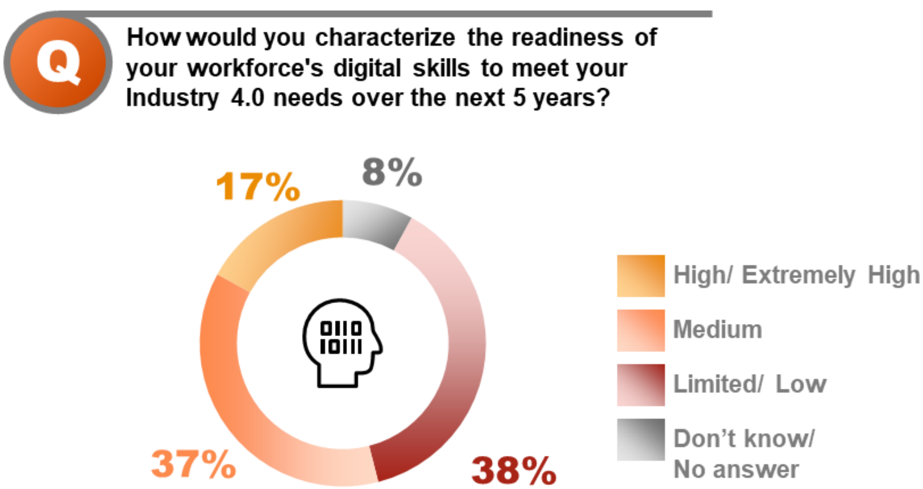


Figure 173: Degree of organisation's confidence in the current level of digital skills of their workforce, to meet Industry 4.0 challenges – Source: Industry 4.0 survey

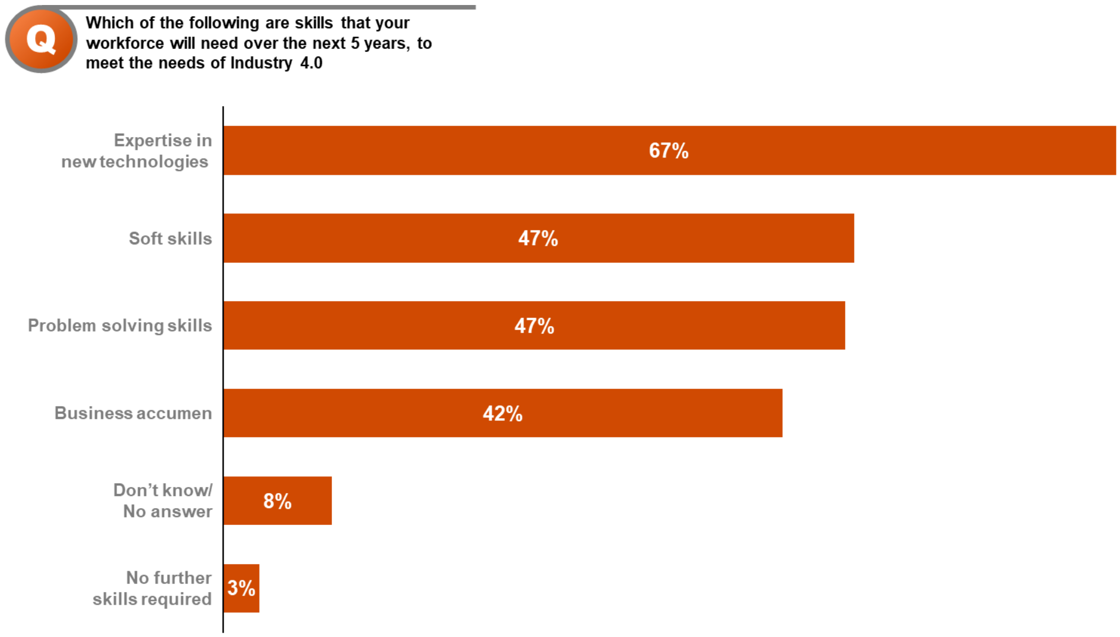


Figure 174: Level of importance that different types of skills will have with regards to Industry 4.0, in the next 5 years, (%) – Source: Industry 4.0 survey

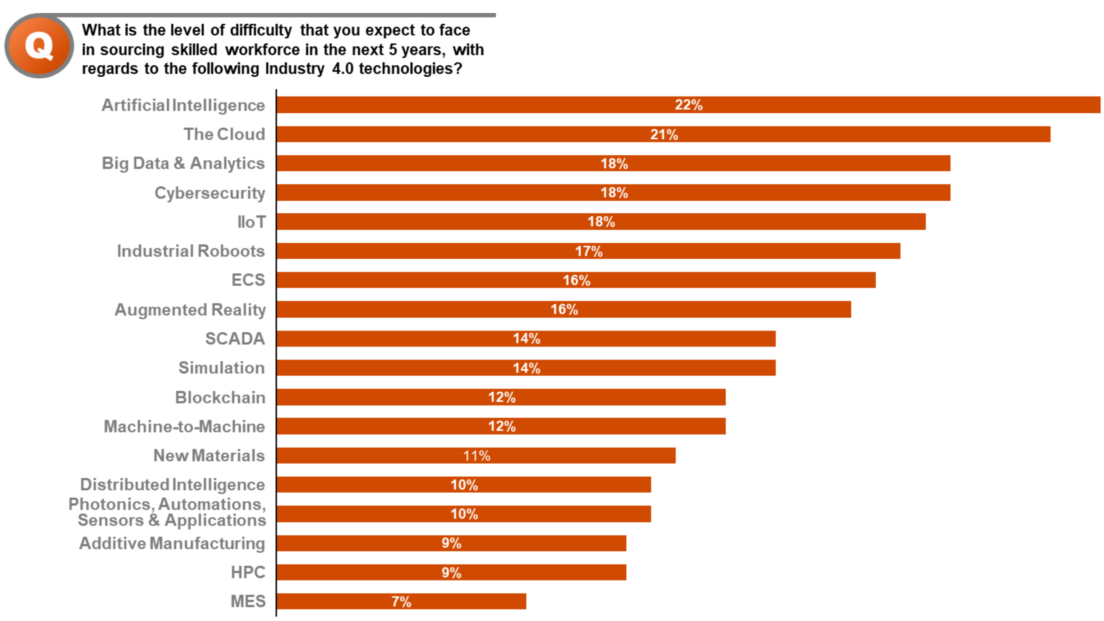


Figure 175: Level of difficulty that organisations expect to face in sourcing skilled workforce for adopting Industry 4.0 initiatives, in the next 5 years, (%) – Source: Industry 4.0 survey

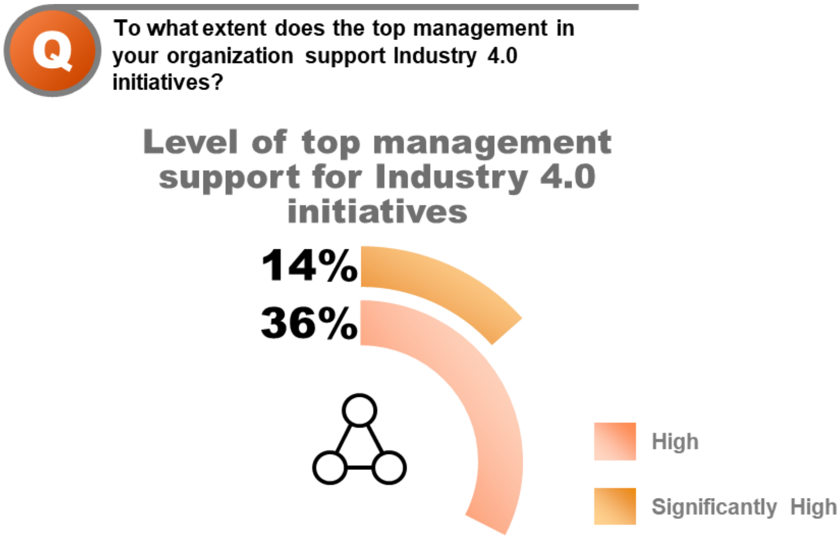


Figure 176: Degree of top management support for ongoing Industry 4.0 initiatives, % - Source: Industry 4.0 survey

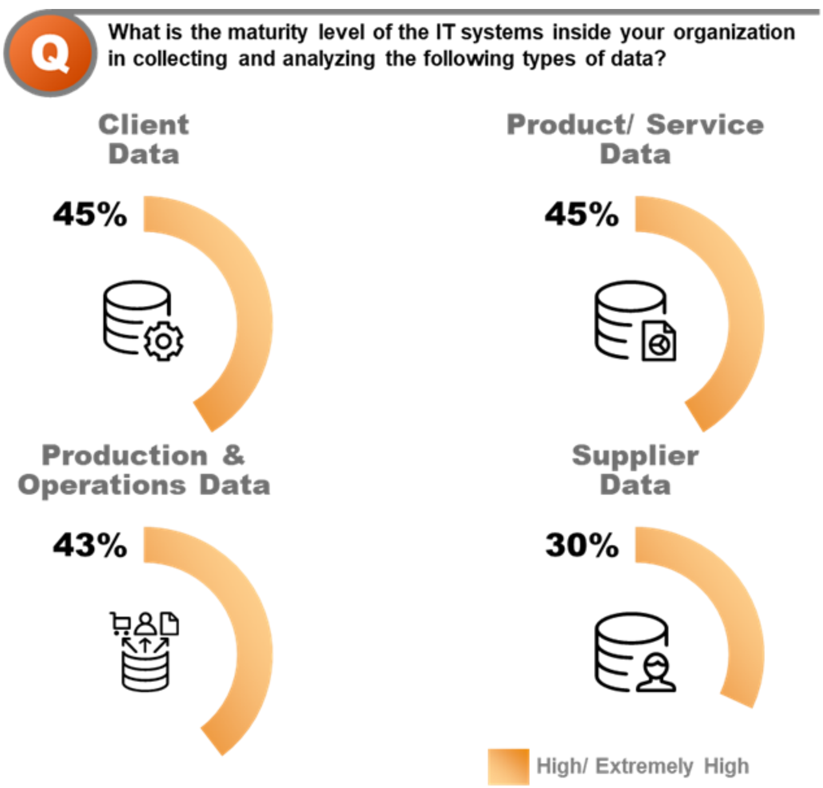


Figure 177: Level of IT systems maturity with regards to their capacity to collect and analyse data generated from different sources, (%) – Source: Industry 4.0 survey

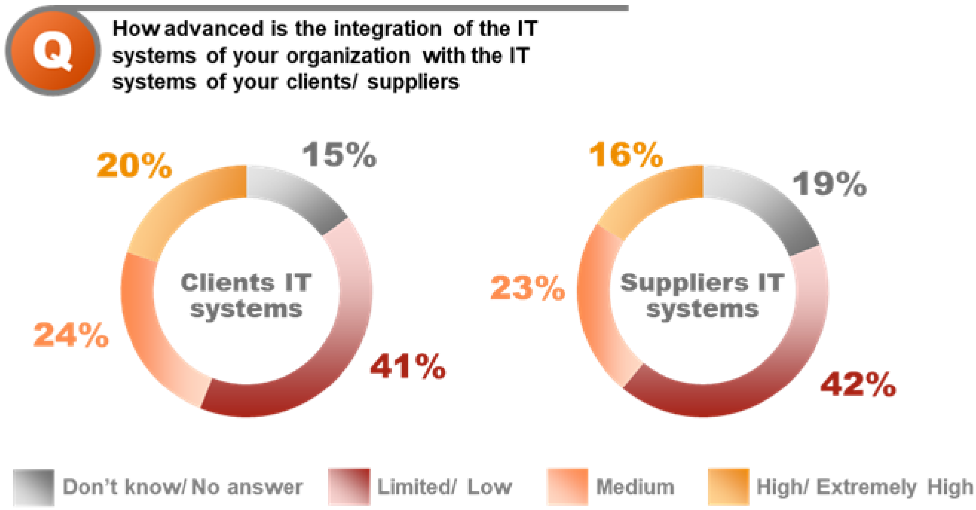


Figure 178: Degree of organisation's IT systems integration with IT systems of Clients/ Suppliers, (%) – Source: Industry 4.0 survey

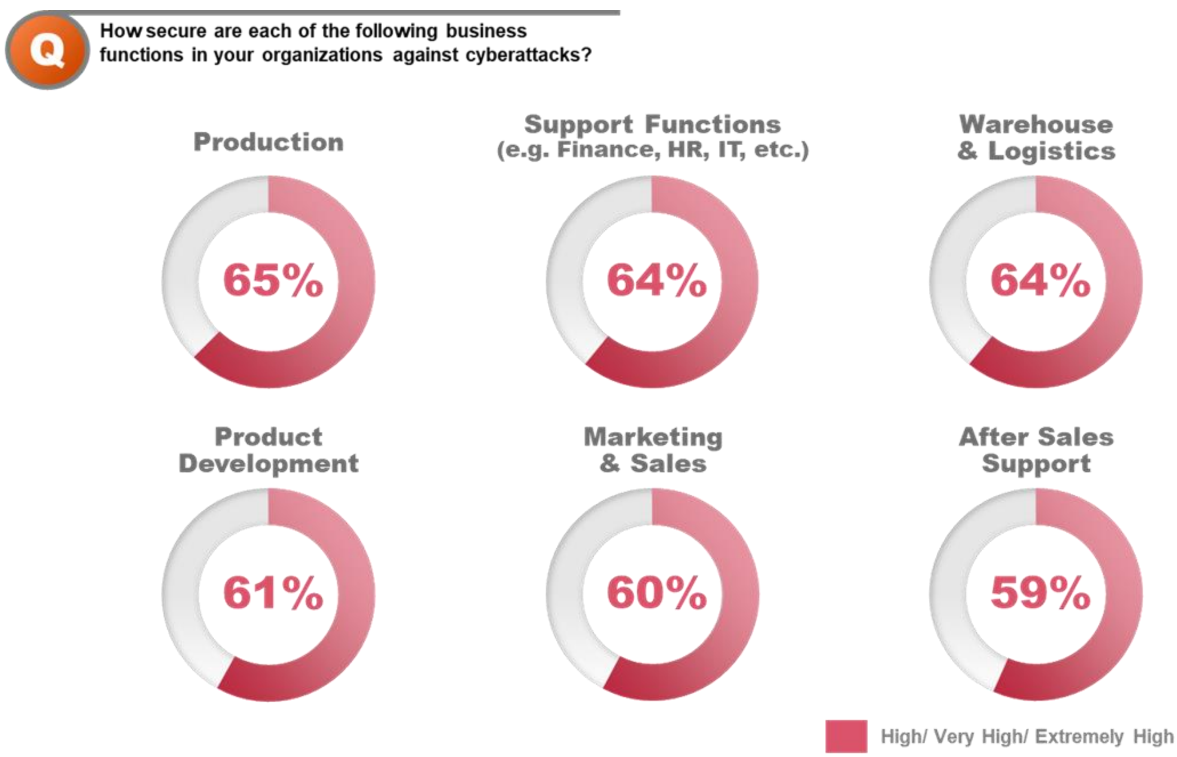


Figure 179: Degree of security against cyberattacks across different business functions, (%) – Source: Industry 4.0 survey

10.3 Industry 4.0 Survey – Detailed Results per Question by Origin of Organisation

In the pages below, we present the detailed results per Question and by Origin of the organisation (National/ Multinational)[594] of the Questionnaire. Key findings are presented below, before the detailed graphs.

- National and multinational enterprises appear to acknowledge to the same extent that Industry 4.0 will disrupt their industry in the next five years. In fact, both national and multinational enterprises perceive that Industry 4.0 will primarily enable them to introduce new services and new business models
- Both executives from national (57%) and multinational enterprises (67%) state the increased productivity as the top benefit of Industry 4.0 in their organisations. However, national enterprises consider as the second most important benefit the improved quality of their products and services. On the other hand, multinationals claim the improved decision making to be the second most important Industry 4.0 related benefit for them.
- Both national and multinational enterprises have initiated their Industry 4.0 transformation by adopting a set of Industry 4.0 technologies during the last years. In fact, both groups have primarily adopted cybersecurity, cloud and big data & analytics capabilities, albeit to a different extent. In fact, evidence shows that multinationals have adopted to a greater extent all select Industry 4.0 technologies. At the same time, alarmingly enough, 25% of the surveyed national enterprises claim to not have adopted any Industry 4.0 technology yet (contrary to only 6% of multinationals).
- A significant difference is evident with regards to the organisations' degree of adoption of their select Industry 4.0 technologies. Multinationals appear to have already developed complete Industry 4.0 initiatives for most of the technologies they currently focus on, contrary to national enterprises, which have mainly developed only pilot/ limited initiatives thus far
- In the future national enterprises plan to continue investing in cloud, cybersecurity and big data & analytics, while at the same time 1 out of 5 of them wish to experiment with Industrial Robots, Artificial Intelligence and IIoT. On the other hand, multinationals aim to primarily increase their focus and investments on big data& analytics as well as on IIoT, while they will also continue investing in cybersecurity and cloud capabilities.
- With regards to the obstacles that enterprises face in adopting Industry 4.0 technologies both national organisations and multinational enterprises cite the lack of digitally skilled workforce and the limited time for experimentation as the two most important ones that prevent their rapid digitisation.
- 9 out of 10 of both national and multinational enterprises agree that the deployment of modern technological infrastructure will be an important enabler for their digital transformation, while 8 out 10 of both groups place the provision of tax incentives for implementing Industry 4.0 technologies as the second most important enabler for their digitisation
- With regards to short-term financing methods for Industry 4.0 initiatives, approximately 4 out of 10 of the national enterprises either leveraged public funds or took a bank loan in the past 3 years. In the next five years, 6 out of 10 of them plan to leverage short-term public funds, while 5 out of 10 aim to

[594] Greek: the company operates exclusively in Greece, Multinational: the company operates in at least one country other than its home country

take a short-term bank loan. Regarding multinationals, 33% leveraged short-term public funds in the last 3 years for Industry 4.0 initiatives, while only 25% of them were granted a short-term bank loan. In the future, more multinationals aim to apply for public funds (4 out of 10), while 1 out of 4 plans to apply for a short-term bank loan.

- With regards to long-term financing methods for Industry 4.0 technologies, during the last 3 years approximately 4 out of 10 of the national enterprises either took a bank loan or used their own funds. In the next five years, 5 out of 10 aim to either take a bank loan, leverage public funds, or continue using their own funds. Regarding multinationals, 3 out of 10% leveraged their own funds in the last 3 years for Industry 4.0 initiatives, while only 2 out of 10 leveraged public funds or took a bank loan. The same picture holds also for the future, with 4 out of 10 continue investing in their own funds, while 3 out of 10 plans to leverage public funds or apply for a bank loan.
- Multinational enterprises demonstrate a higher level of digitisation across all functions against their national counterparts. This is also indicated by the high degree of digitisation across their production lines, as 50% of them (against only 25% of the national enterprises) stated that they possess a fully digitised production line in their premises. In addition, 53% of them claimed to have real-time view of their production against only 39% of their national peers.
- 50% of multinational enterprises, against 33% of the national ones perceive that their workforce is well equipped and ready to meet the upcoming Industry 4.0 needs.

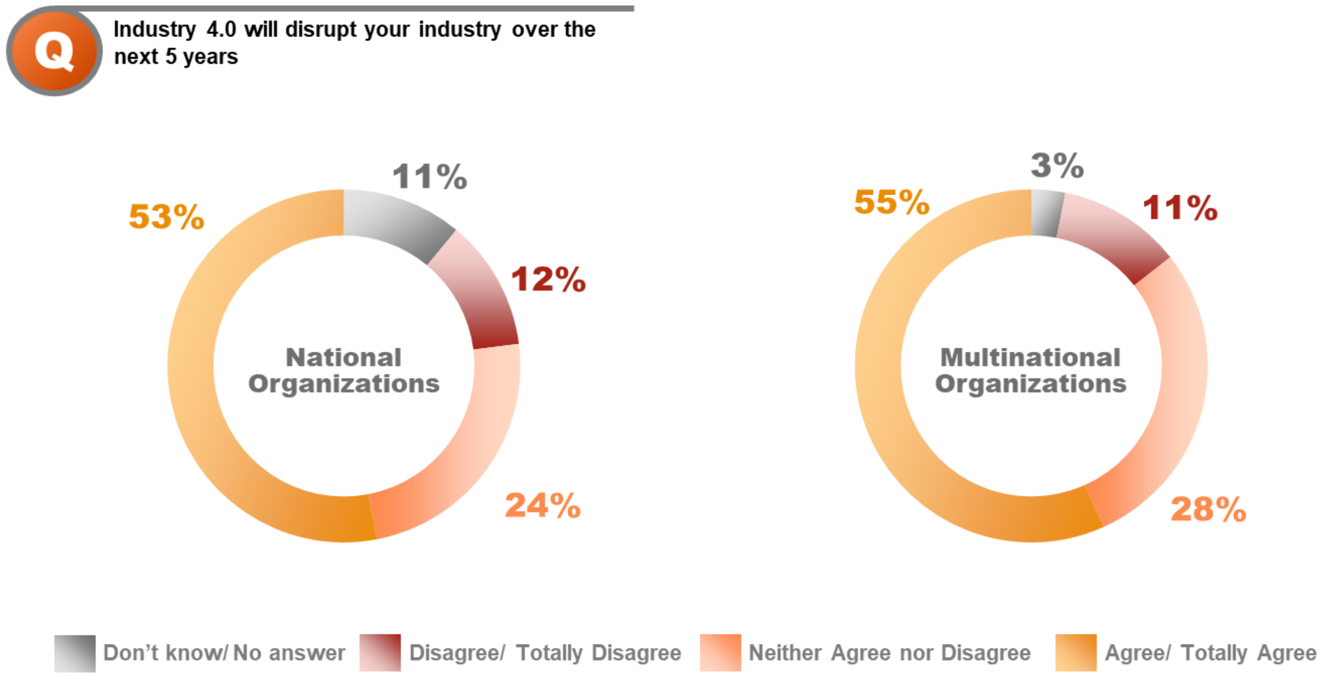


Figure 181: Greek executives' level of agreement regarding the disruption of their industry due to Industry 4.0, by Origin, (%) – Source: Industry 4.0 survey

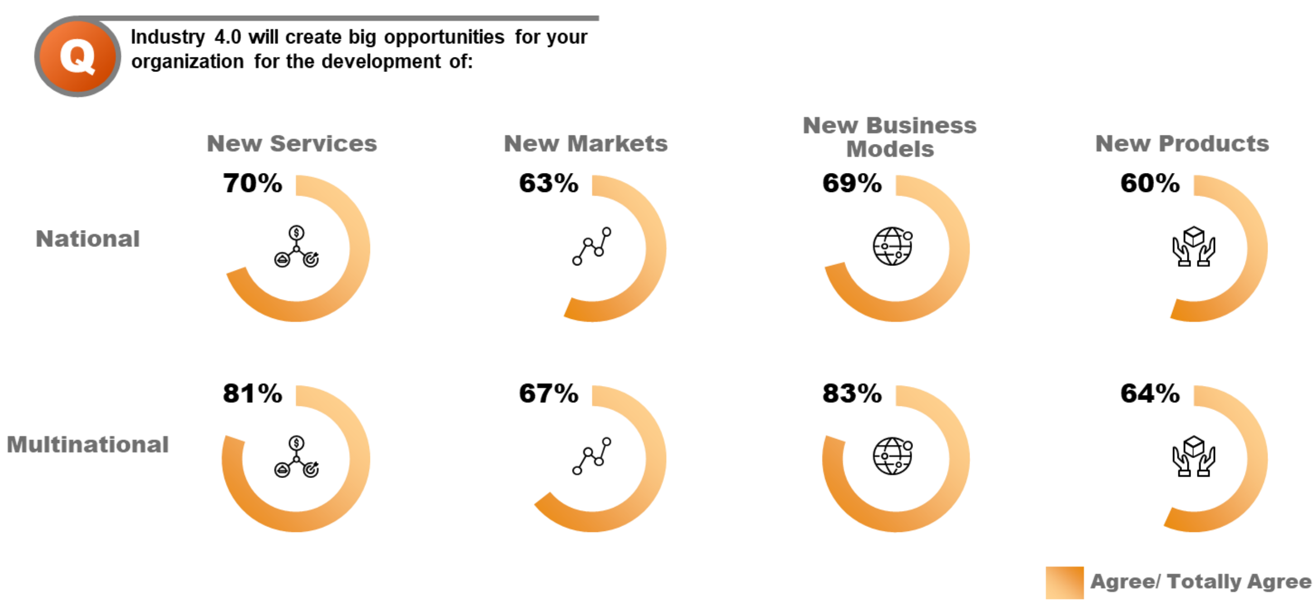


Figure 180: Greek executives' level of agreement regarding the opportunities that Industry 4.0 will open for their organisations, by Origin, (%) – Source: Industry 4.0 survey

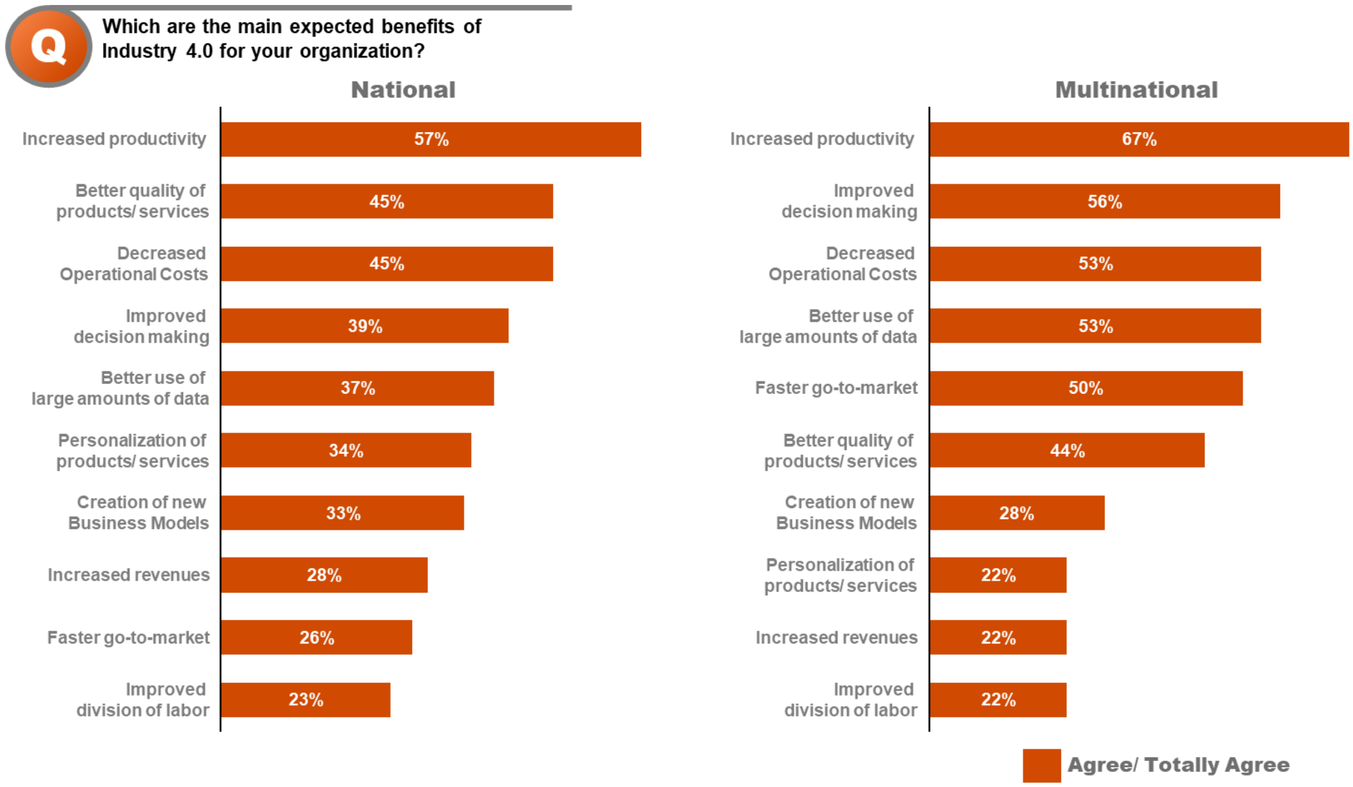


Figure 182: Greek executives' level of agreement regarding the benefits that Industry 4.0 will bring to their organisations, by Origin, by Origin, (%) – Source: Industry 4.0 survey

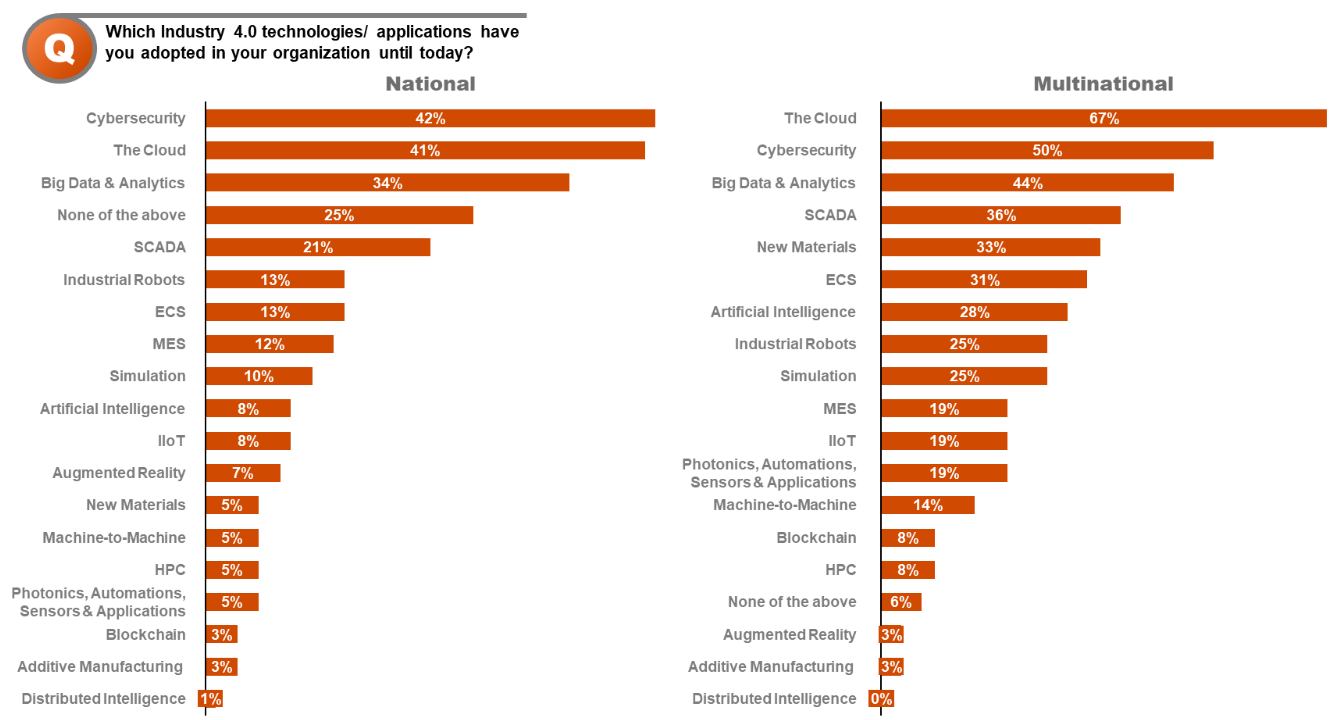


Figure 183: Key Industry 4.0 technologies/ applications that Greek executives have adopted in their organisations, by Origin, by Origin, (%) – Source: Industry 4.0 survey

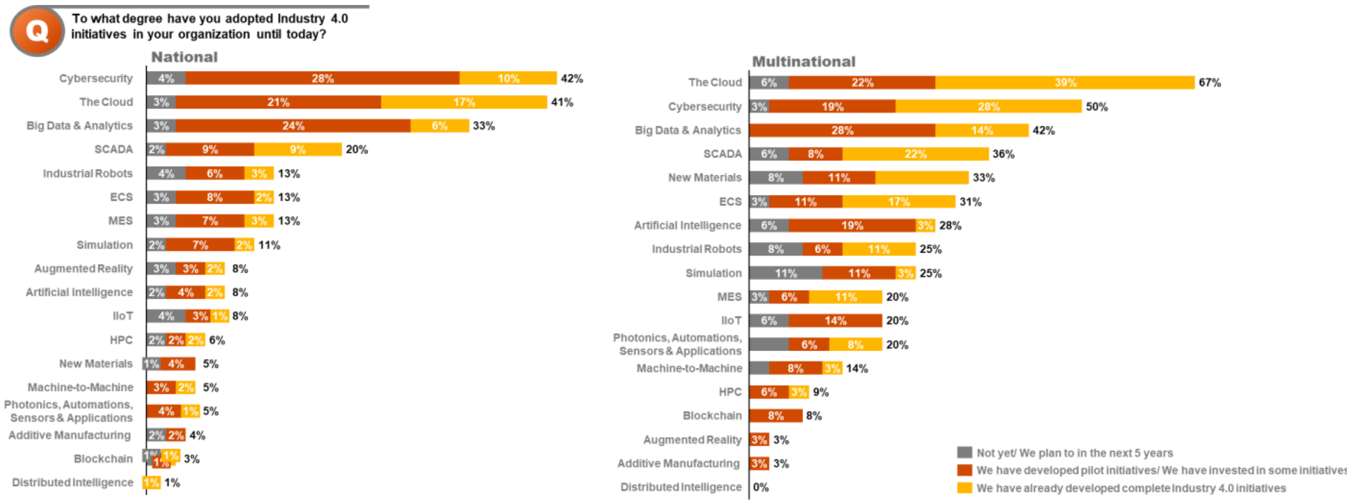


Figure 184: Organisation's degree of adoption of Industry 4.0 technologies/ applications, until today, by Origin, (%) – Source: Industry 4.0 survey

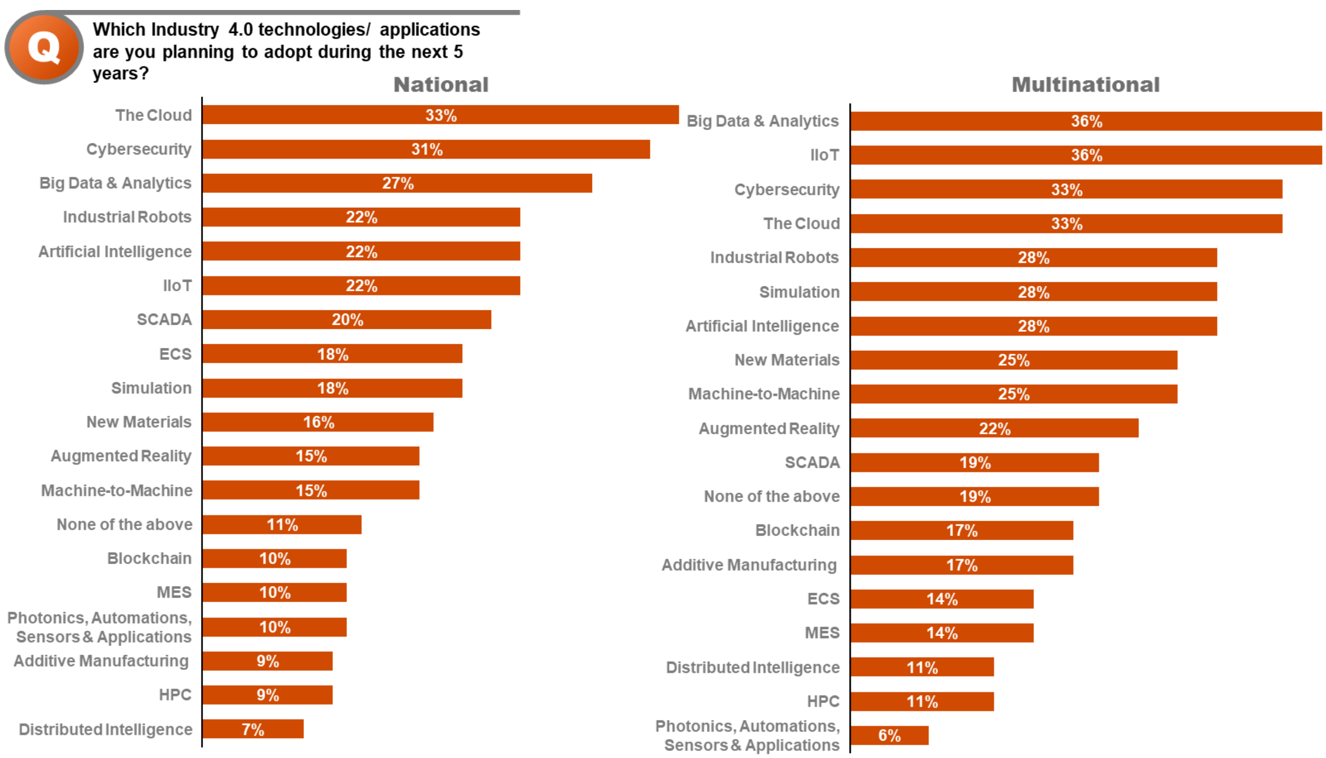


Figure 185: Key Industry 4.0 technologies/ applications that Greek executives plan to adopt in their organisations within the next 5 years, by Origin, (%) — Source: Industry 4.0 survey

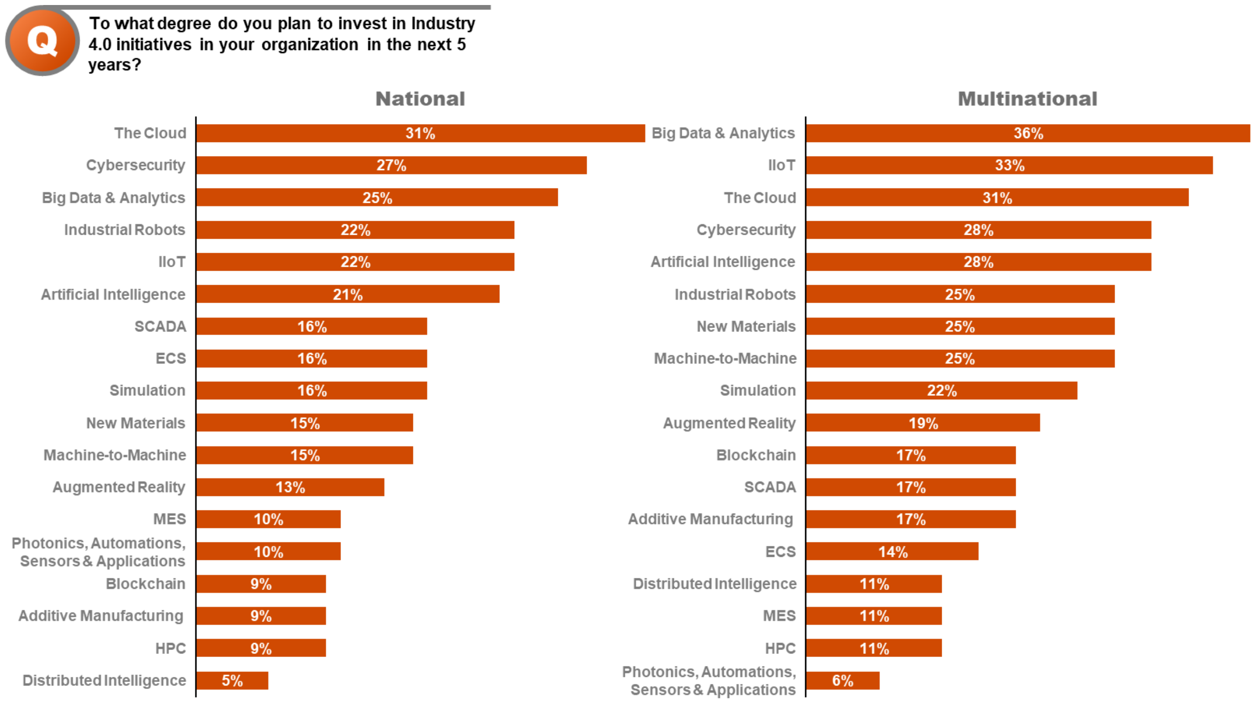


Figure 186: Organisation's planned degree of investment in Industry 4.0 initiatives, in the next 5 years, by Origin, (%) – Source: Industry 4.0 survey

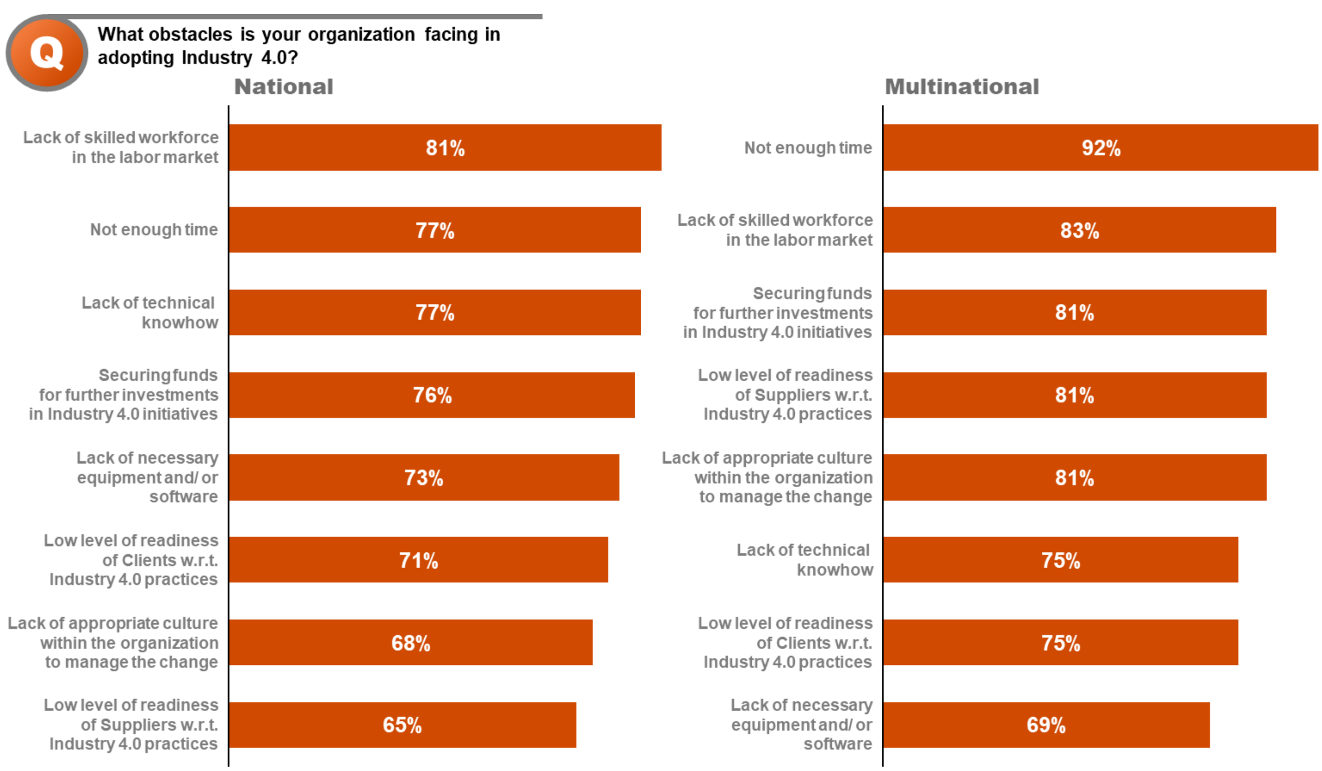


Figure 187: Key obstacles that Greek organisations face in adopting Industry 4.0, by Origin, (%) – Source: Industry 4.0 survey

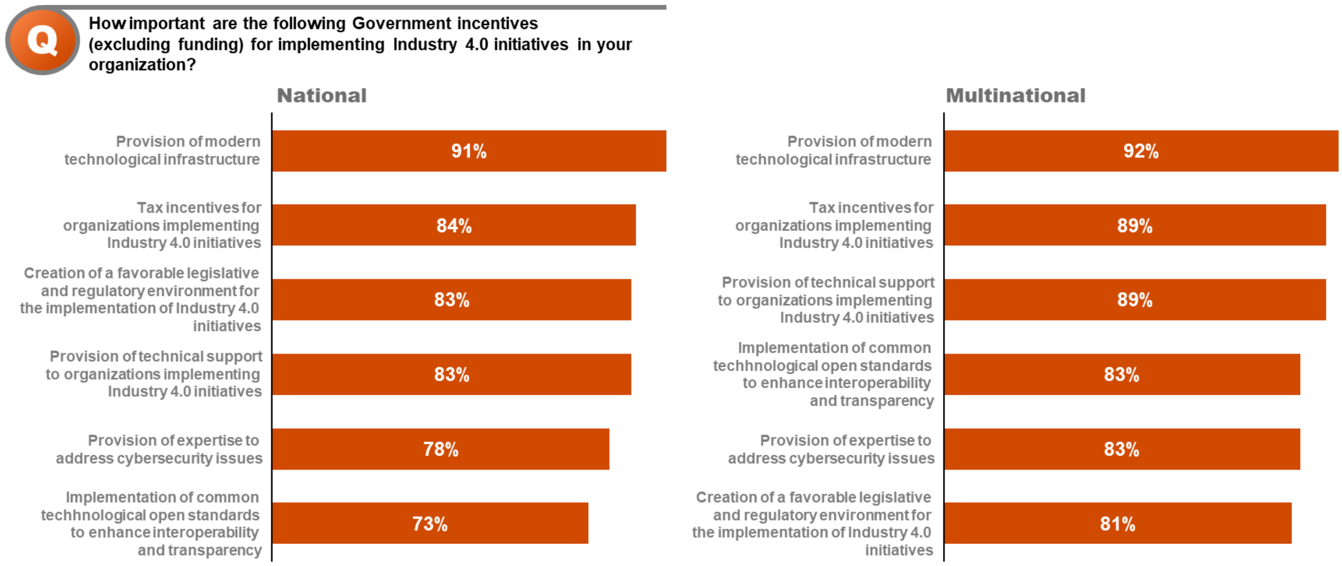


Figure 188: Important Government initiatives (excluding funding) that Greek executives wish to undertake in order to accelerate their organisations' digital transformation, by Origin, (%) - Source: Industry 4.0 survey

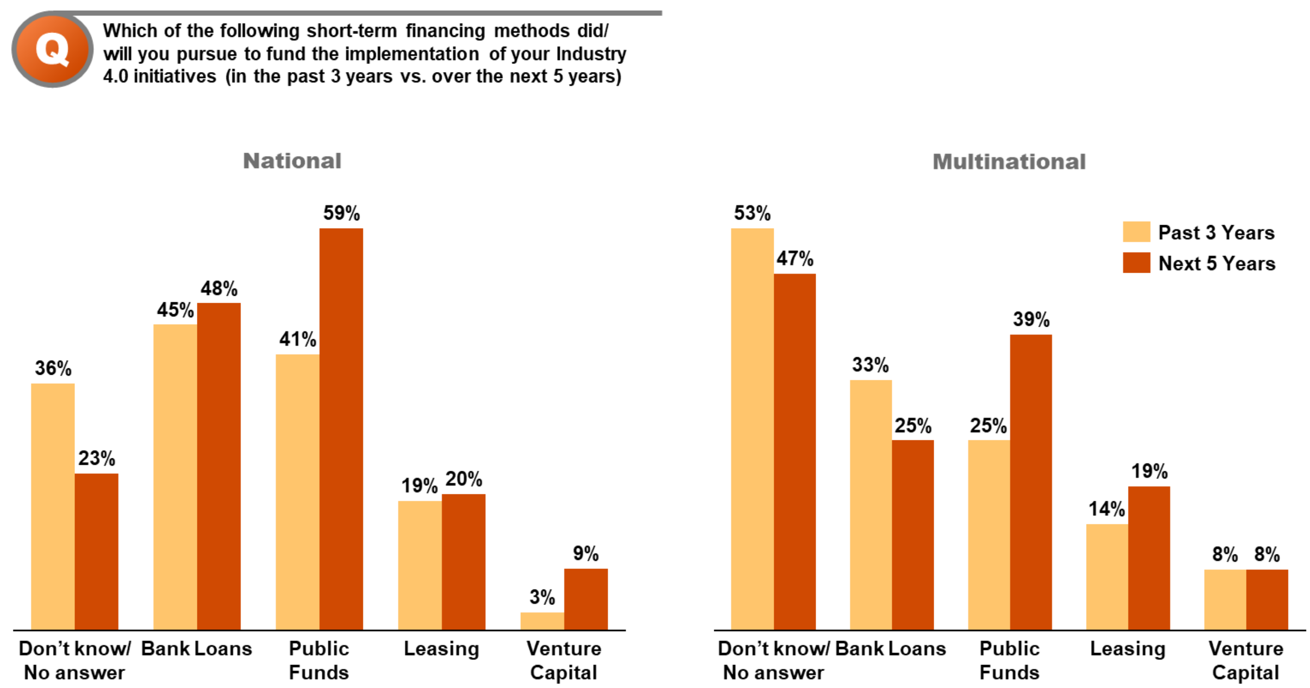


Figure 189: Short-term financing methods used/ to be used by Greek organisations during the last three years/ next five years, by Origin, (%) – Source: Industry 4.0 survey

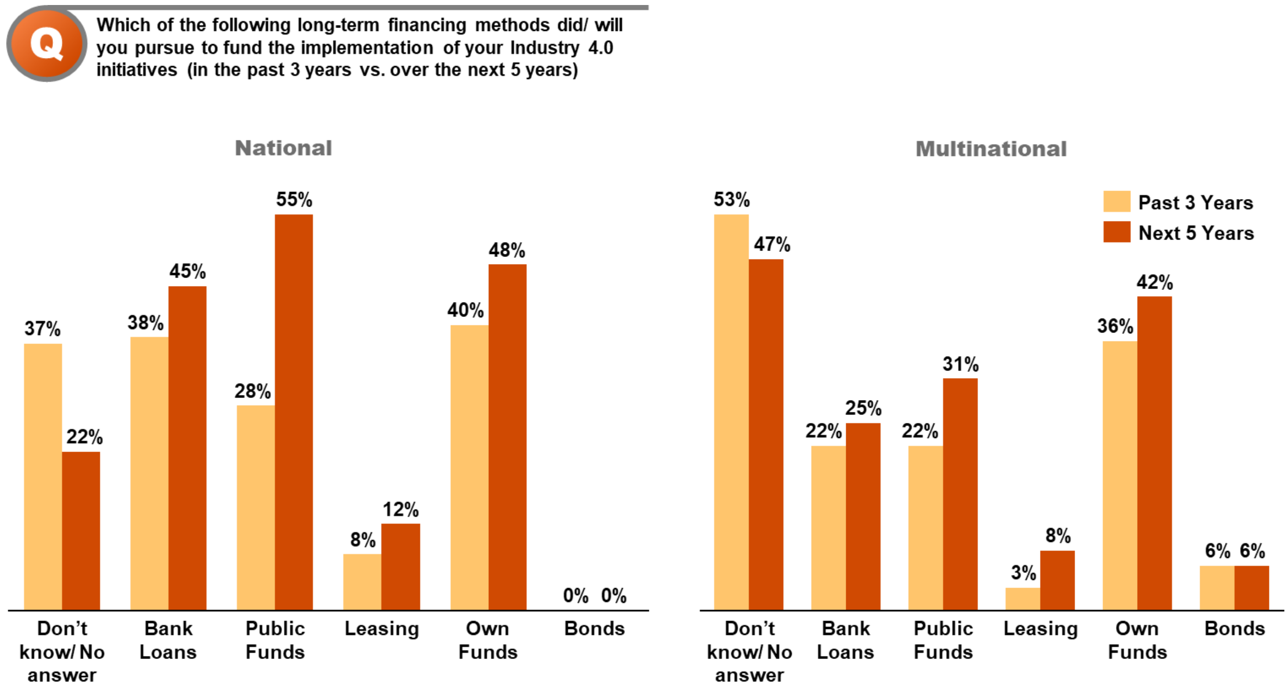


Figure 190: Long-term financing methods used/ to be used by Greek organisations during the last three years/ next five years, by Origin, (%) – Source: Industry 4.0 survey

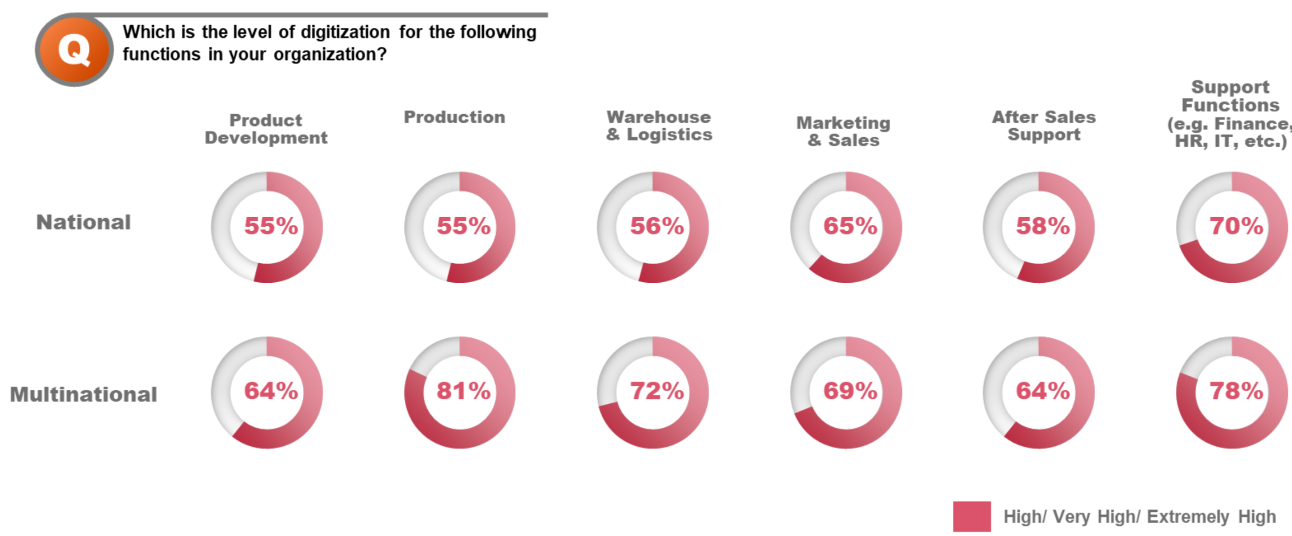


Figure 191: Greek executives' perception with regards to the level of digitisation of their organisation's functions, by Origin, (%) – Source: Industry 4.0 survey

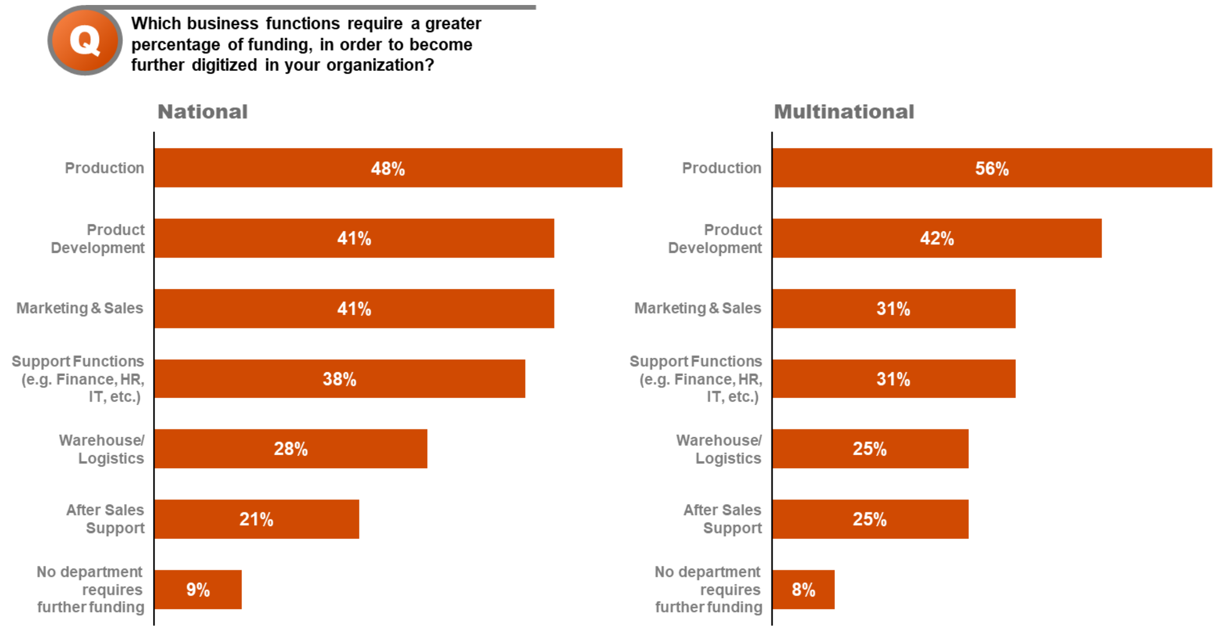


Figure 192: Funding required for further digitisation across different business functions of organisations, by Origin, (%) – Source: Industry 4.0 survey

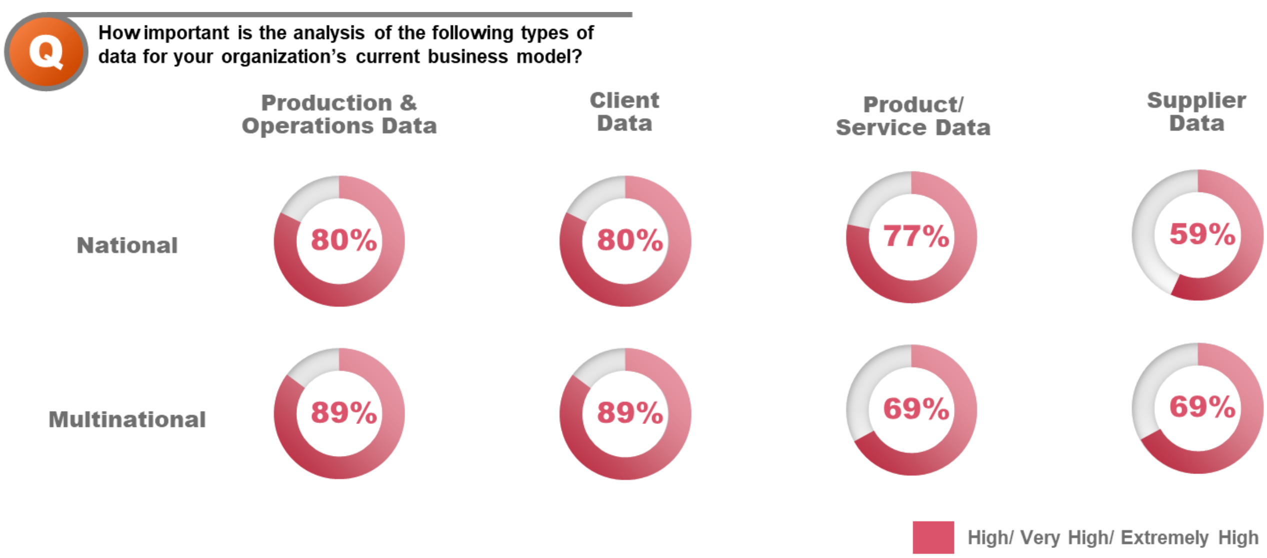


Figure 193: Level of importance of the analysis of different types of data, for the organisation's current business model, by Origin, (%) – Source: Industry 4.0 survey

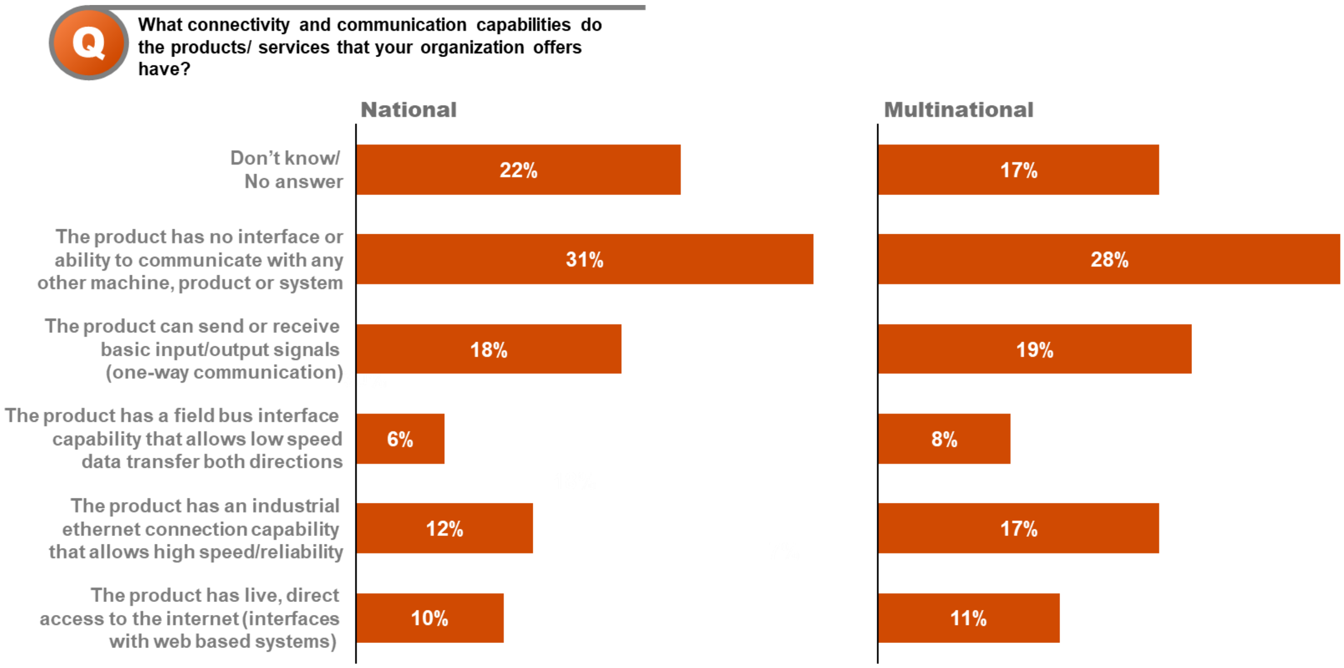


Figure 194: Degree of interconnectivity capabilities of products/ services that organisations offer, by Origin, (%) – Source: Industry 4.0 survey

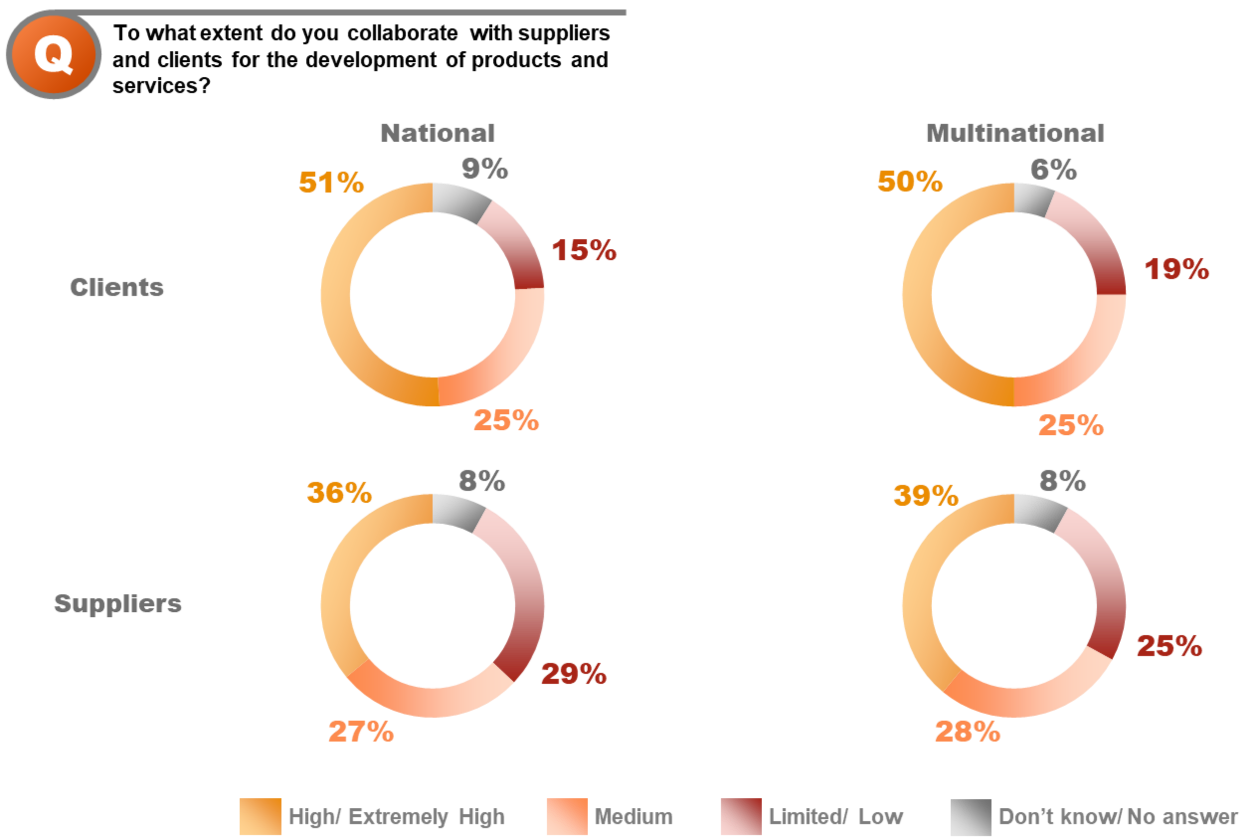


Figure 195: Degree of collaboration with partners/ suppliers for product/service development, by Origin, (%) – Source: Industry 4.0 survey

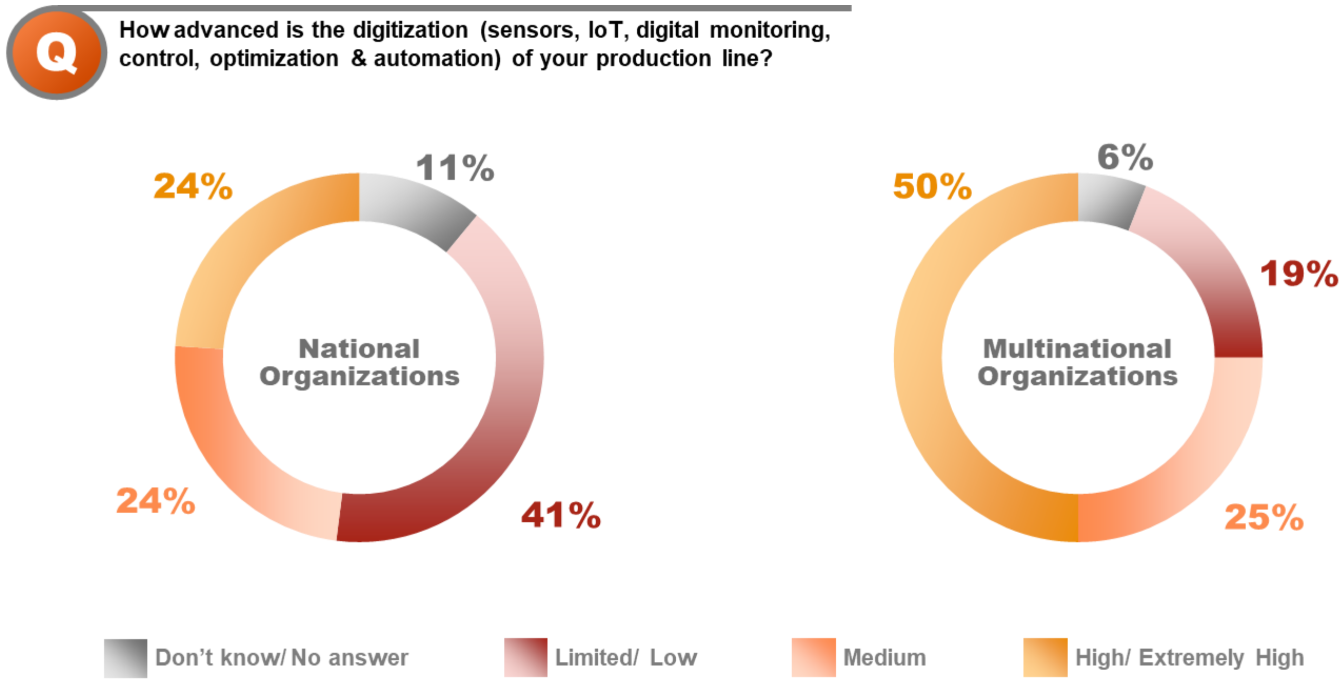


Figure 196: Degree of digitisation of the production line of organisations, by Origin, (%) – Source: Industry 4.0 survey

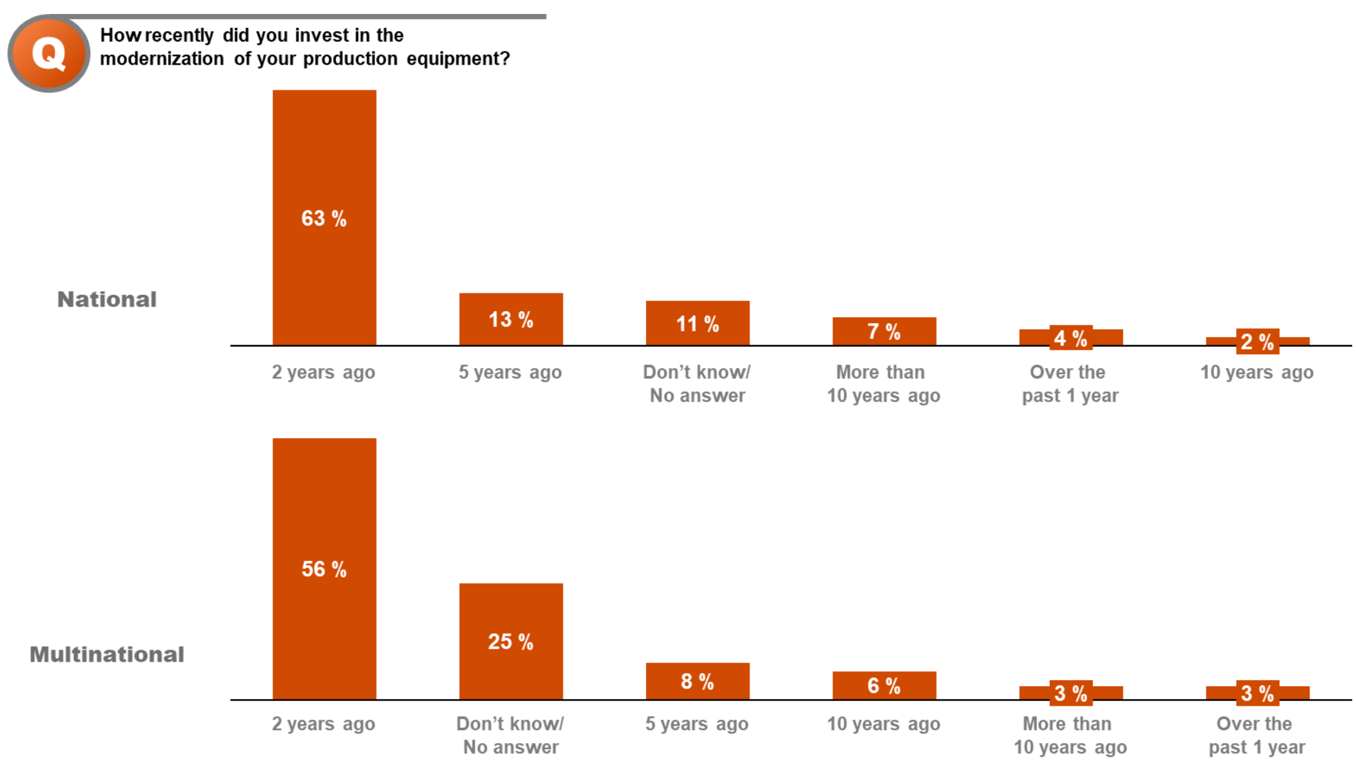


Figure 197: Last time organisations invested in the modernisation of their production equipment, by Origin, (%) – Source: Industry 4.0 survey

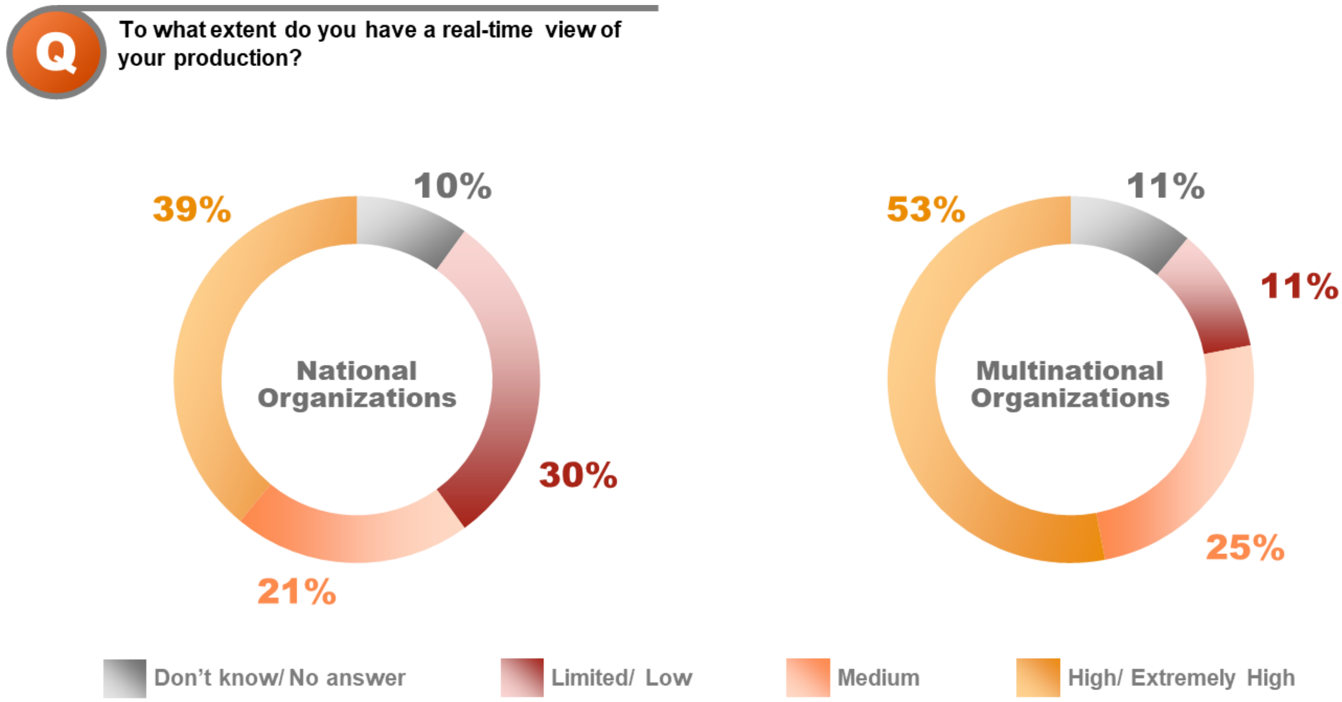


Figure 198: Degree of real-time view of production capacity, by Origin, (%) – Source: Industry 4.0 survey

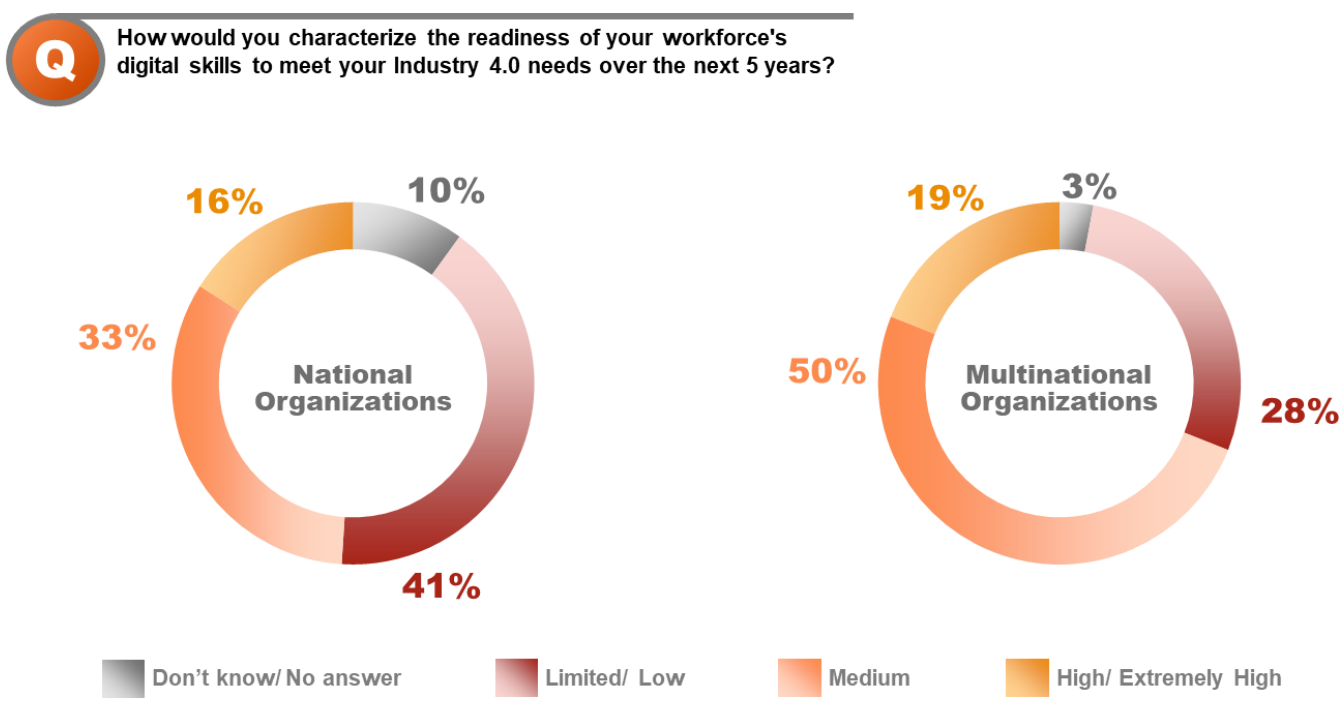


Figure 199: Degree of organisation's confidence in the current level of digital skills of their workforce, to meet Industry 4.0 challenges, by Origin, (%) – Source: Industry 4.0 survey

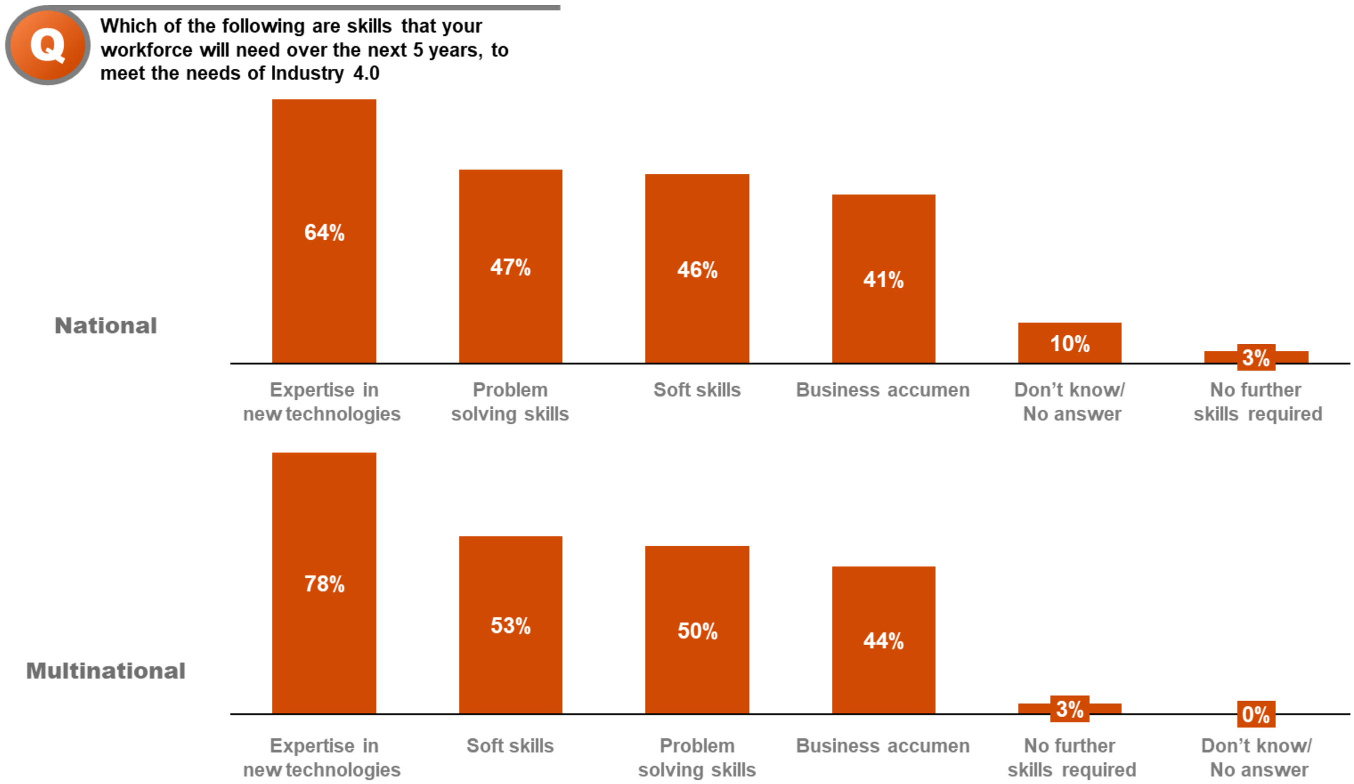


Figure 200: Level of importance that different types of skills will have with regards to Industry 4.0, in the next 5 years, by Origin, (%) – Source: Industry 4.0 survey

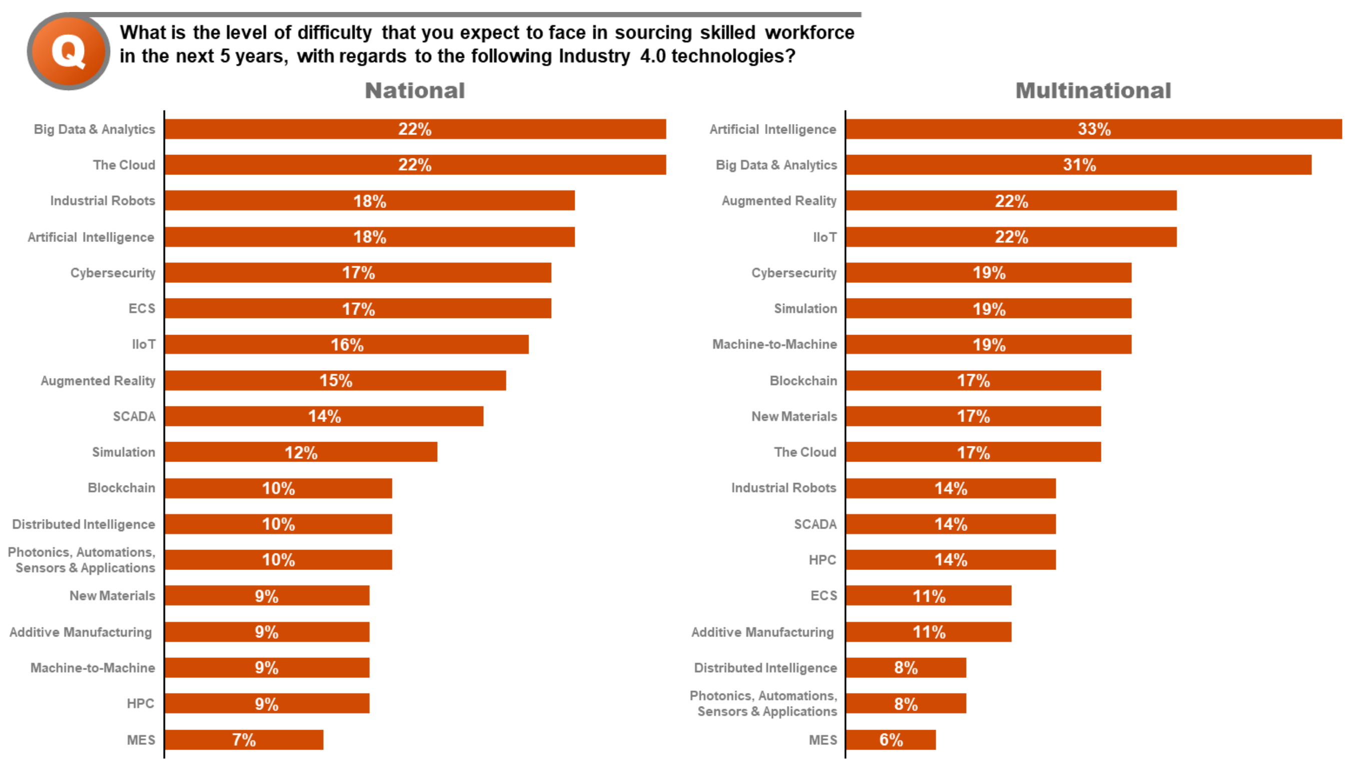


Figure 201: Level of difficulty that organisations expect to face in sourcing skilled workforce for adopting Industry 4.0 initiatives, in the next 5 years, by Origin, (%) – Source: Industry 4.0 survey

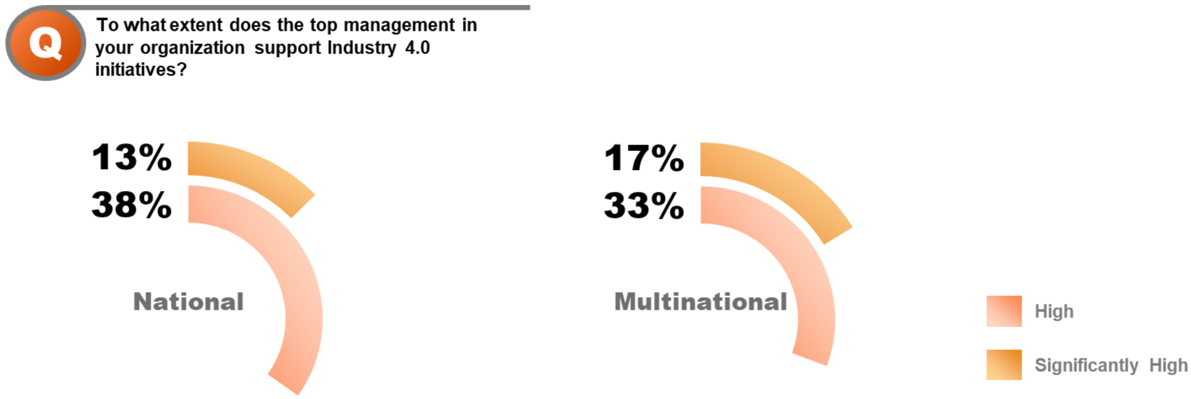


Figure 202: Degree of top management support for ongoing Industry 4.0 initiatives, by Origin, (%) - Source: Industry 4.0 survey

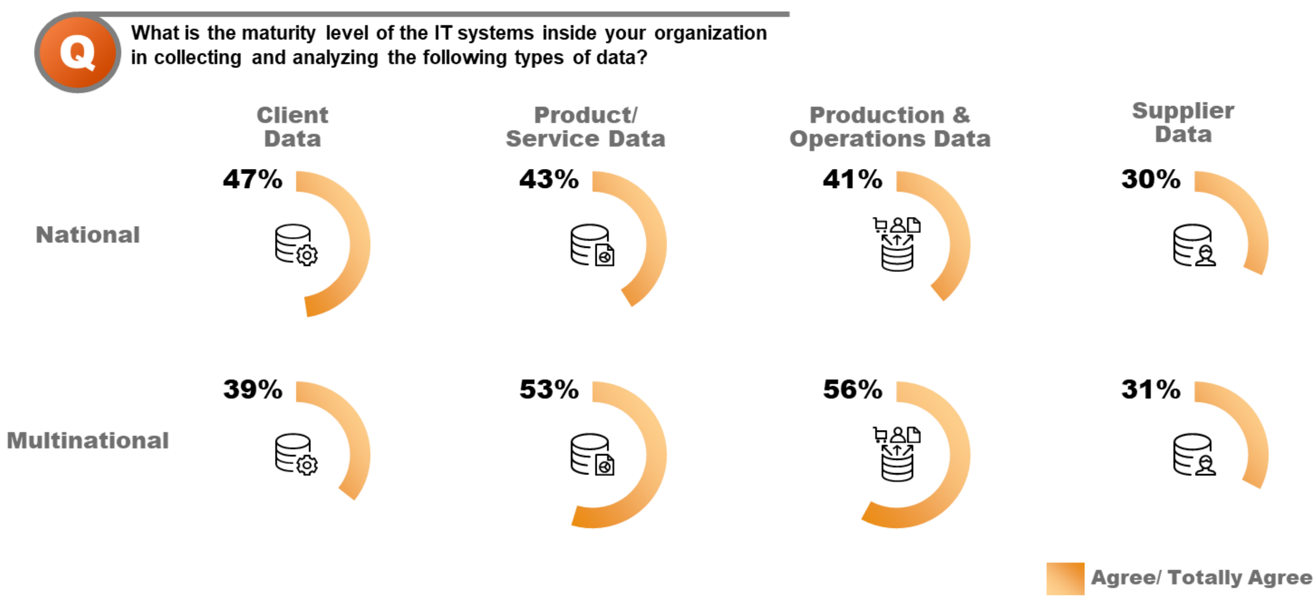


Figure 203: Level of IT systems maturity with regards to their capacity to collect and analyse data generated from different sources, by Origin, (%) – Source: Industry 4.0 survey

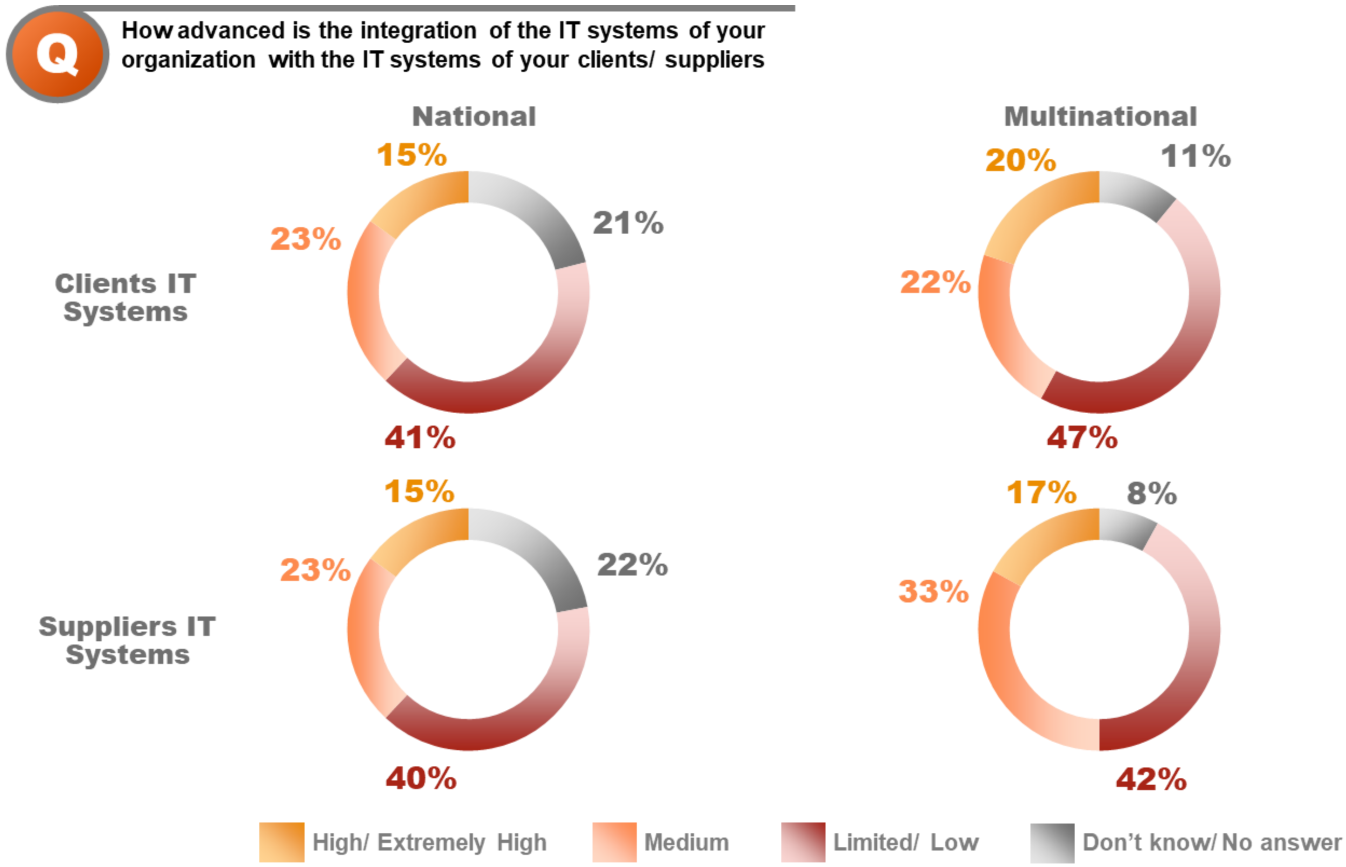


Figure 204: Degree of organisation's IT systems integration with IT systems of Clients/ Suppliers, by Origin, (%) – Source: Industry 4.0 survey

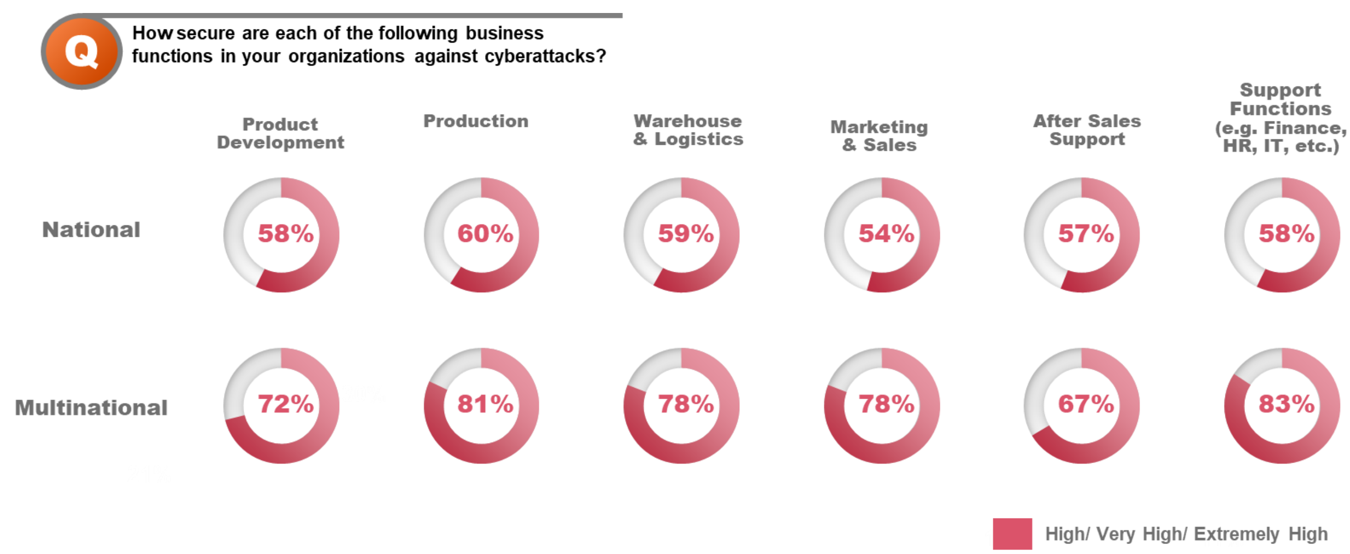


Figure 205: Degree of security against cyberattacks across different business functions, by Origin, (%) – Source: Industry 4.0 survey

10.4 Industry 4.0 Survey – Detailed Results per Question by Size of Organisation

In the pages below, we present the detailed results per Question and by Size of the organisation (Very Small, Small, Medium, Large)[595] of the Questionnaire. Key findings are presented below, before the detailed graphs.

- Over 50% of very small, small and large enterprises expect that Industry 4.0 will disrupt their industry over the next 5 years. This is also true for more than 40% of Medium-sized enterprises of our sample.
- Enterprises of different size place a different emphasis on the expected benefits from leveraging Industry 4.0. Namely, executives of very small and small enterprises aim to leverage Industry 4.0 to improve their products' quality and increase their top line. At the same time, executives of medium and large enterprises aim to implement Industry 4.0 technologies to optimize their productivity and improve their decision making.
- Cloud, Cybersecurity and Big Data Analytics are the Industry 4.0 technologies that small, medium and large enterprises have mostly adopted until today. An alarming 37% of very Small organisations stated that they have not adopted any Industry 4.0 technology until today.
- In the next five years, all enterprises plan to continue investing on cloud, cybersecurity and big data analytics. Nevertheless, small enterprises state that they will primarily focus their investments on IIoT
- Interestingly enough, enterprises of different size state various key reasons as main obstacles that prevent them from rotating to Industry 4.0. While all of them position the lack of digital skills in the market amongst the top three obstacles they currently face, very small enterprises state also the limited available funding and the low level of readiness of their clients as their main inhibitors, while small ones mention the lack of provided technical know-how as an equally important obstacle for them. On the other hand, medium and large enterprise perceive the lack of time for active experimentation on Industry 4.0 technologies as the top blocking point for their rotation to digital.
- Very small, small and medium enterprises position the deployment of modern technological infrastructure as the most important Government incentive that would accelerate their digital transformation. On the other hand, large enterprises state that relevant tax incentives would be the most beneficiary for their digitisation.
- Public funding has been the preferable short-term financing method for very small and small enterprises during the last three years. On the contrary, medium and large enterprises mainly leveraged bank loans for Industry 4.0 investments during the last years. Within the next five years, the majority of very small, small and medium enterprises aim to leverage public funding for their digitisation, while large enterprises will continue using bank loans as their primary source of funding.
- With regards to long-term financing, during the last three years very small, small and medium enterprises based their digitisation efforts primarily on their own funds, while large enterprises used bank loans. In the next five years, the majority of the very small, small and medium enterprises aim

[595] Based on characterisation of company size by number of employees from Eurostat (Very Small – <10, Small – <50, Medium – <250, Large – >250)

to leverage public funding for their Industry 4.0 rotation, while large ones state that they will primarily use their own funds to support their Industry 4.0 efforts.

- The larger the size of the enterprise, the higher the degree of digitisation across its functions. In addition, 89% of the large enterprises state the highest level of digitisation across their production, while 71% of small and 78% of medium sized enterprises demonstrate their highest level of digitisation across their support functions. On the other hand, very small enterprises appear to focus more on the digitisation of their marketing & sales functions, since 63% of them claimed this to be their highest digitised function.
- Greek enterprises claim to have initiated a close collaboration with their clients to co-create customized products & services. Very small and small enterprises appear to lead the way in product co-creation, with 59% of both groups stating that they collaborate closely with their client to design and produce customized products.
- Despite their recent revamping of their production IT landscape, surveyed enterprises demonstrate a low level of digitisation across their production lines. Out of these, the very small and small enterprises appear to be the worst positioned. In fact, only 15% of the very small and 20% of the small enterprises stated that the digitisation of their production line was high, compared to 27% of medium and 70% of large enterprises.
- Large enterprises appear to be at the forefront of collecting and analysing data from clients, suppliers, productions, operations and their own products and services compared to other segments.
- All enterprises demonstrate low confidence with regards to their workforce's readiness to address the emerging Industry 4.0 needs. In fact, 67% across the small enterprises, 61% across the medium ones and 63% across the large ones indicate that their current workforce possesses limited digital skills. This percentage is significant lower for very small enterprises (45%).
- Enterprises across all groups recognize big data analytics capabilities to be one of the most difficult skills to be sourced in the future.

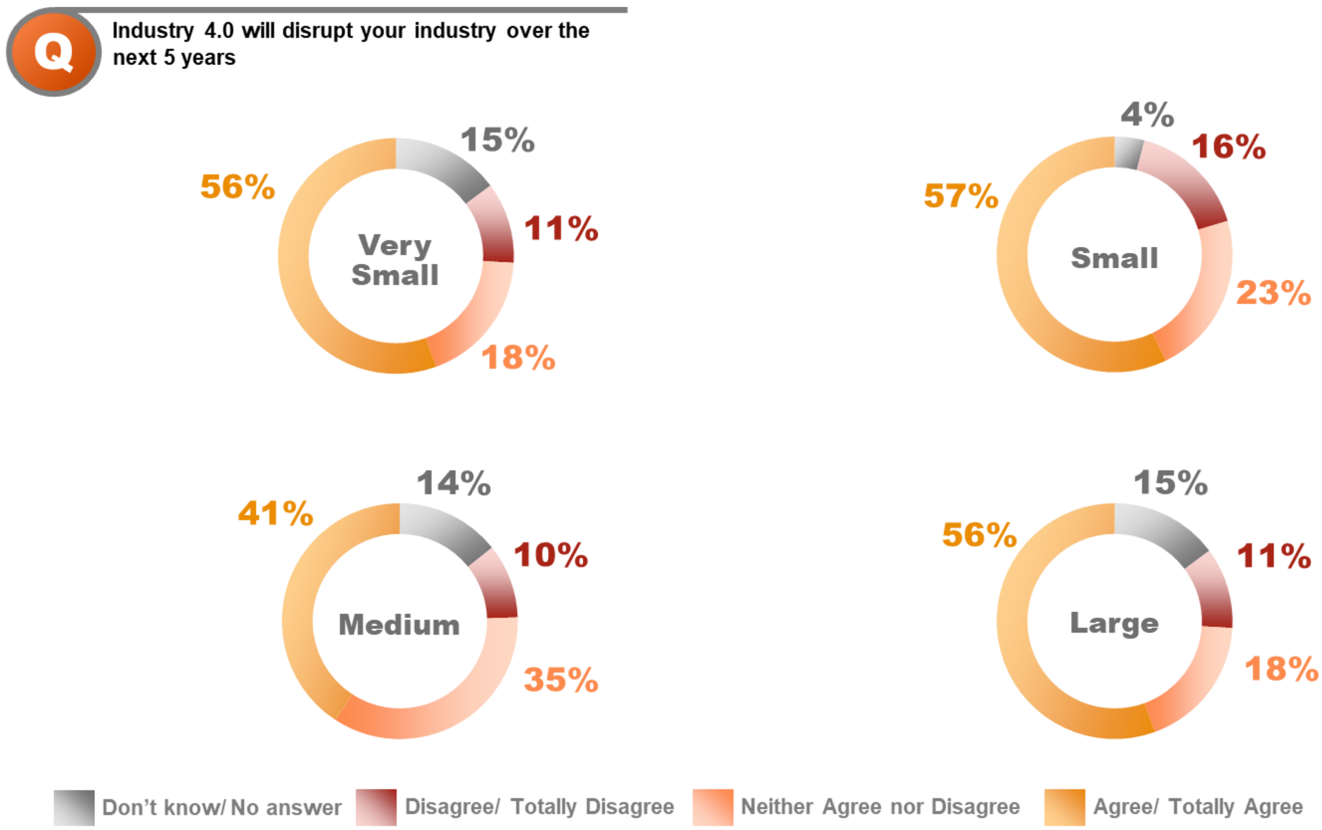


Figure 206: Greek executives' level of agreement regarding the disruption of their industry due to Industry 4.0, by Size, (%) – Source: Industry 4.0 survey

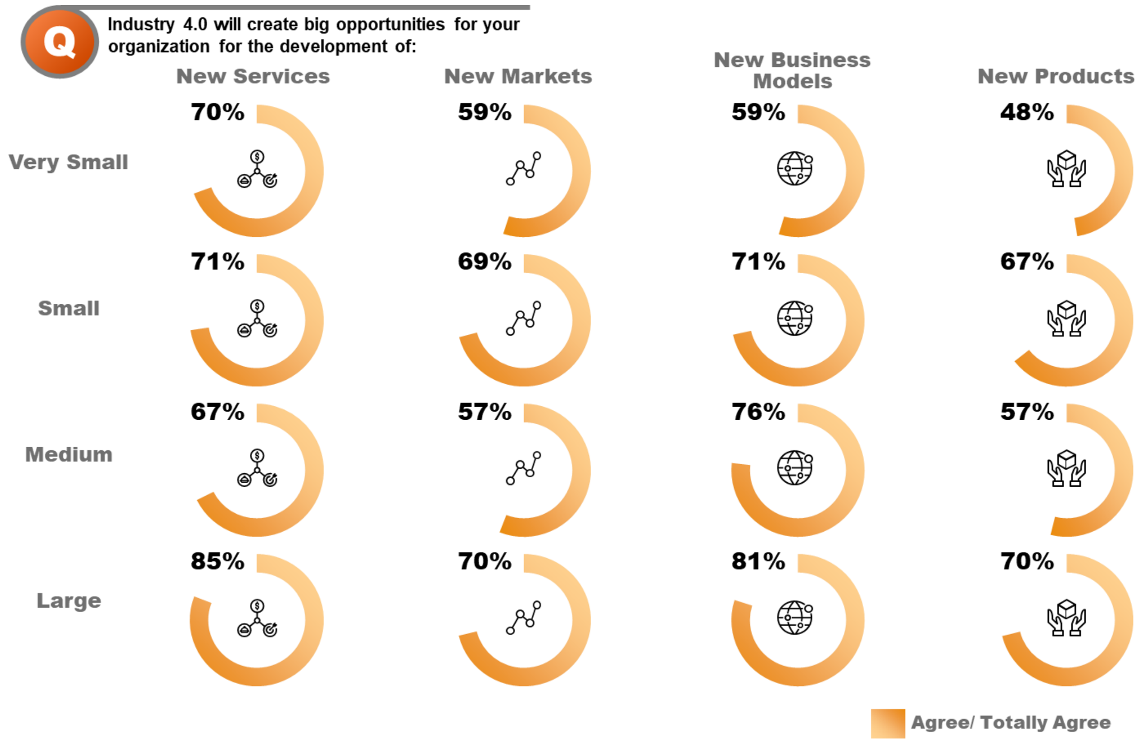


Figure 207: Greek executives' level of agreement regarding the opportunities that Industry 4.0 will open for their organisations, by Size, (%) – Source: Industry 4.0 survey

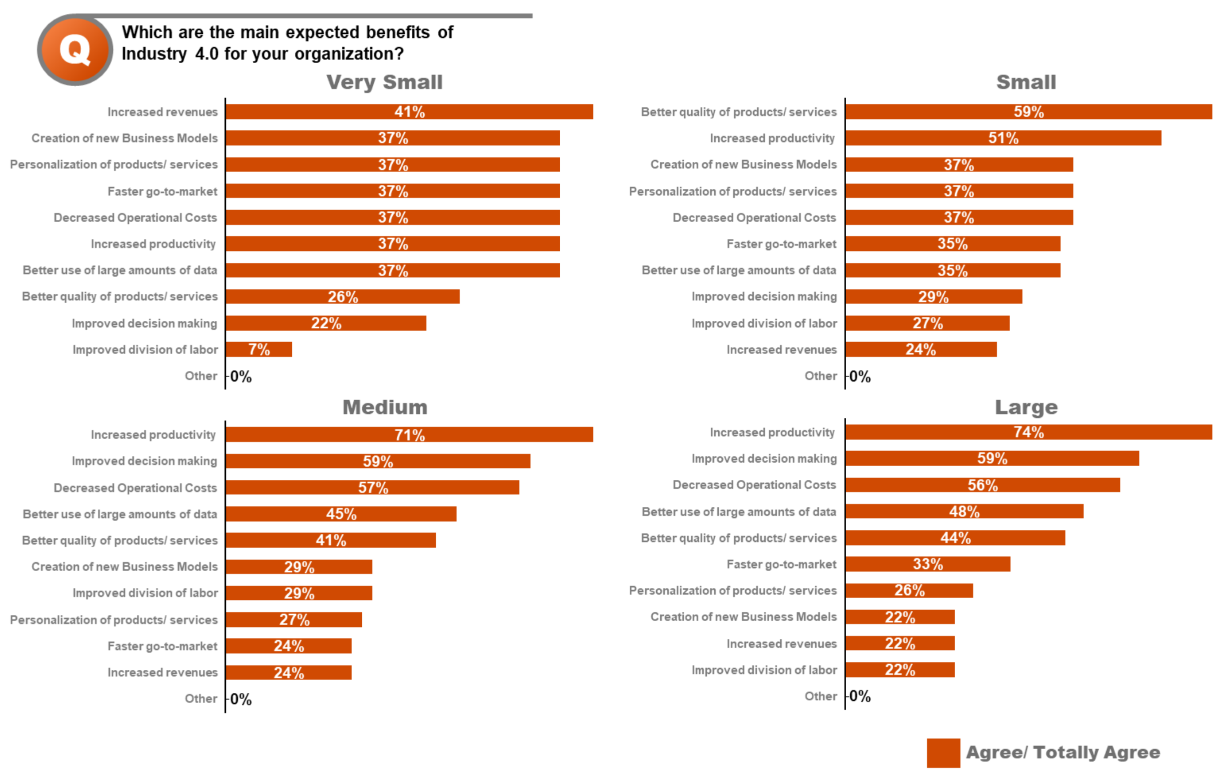


Figure 208: Greek executives' level of agreement regarding the benefits that Industry 4.0 will bring to their organisations, by Size, (%) – Source: Industry 4.0 survey

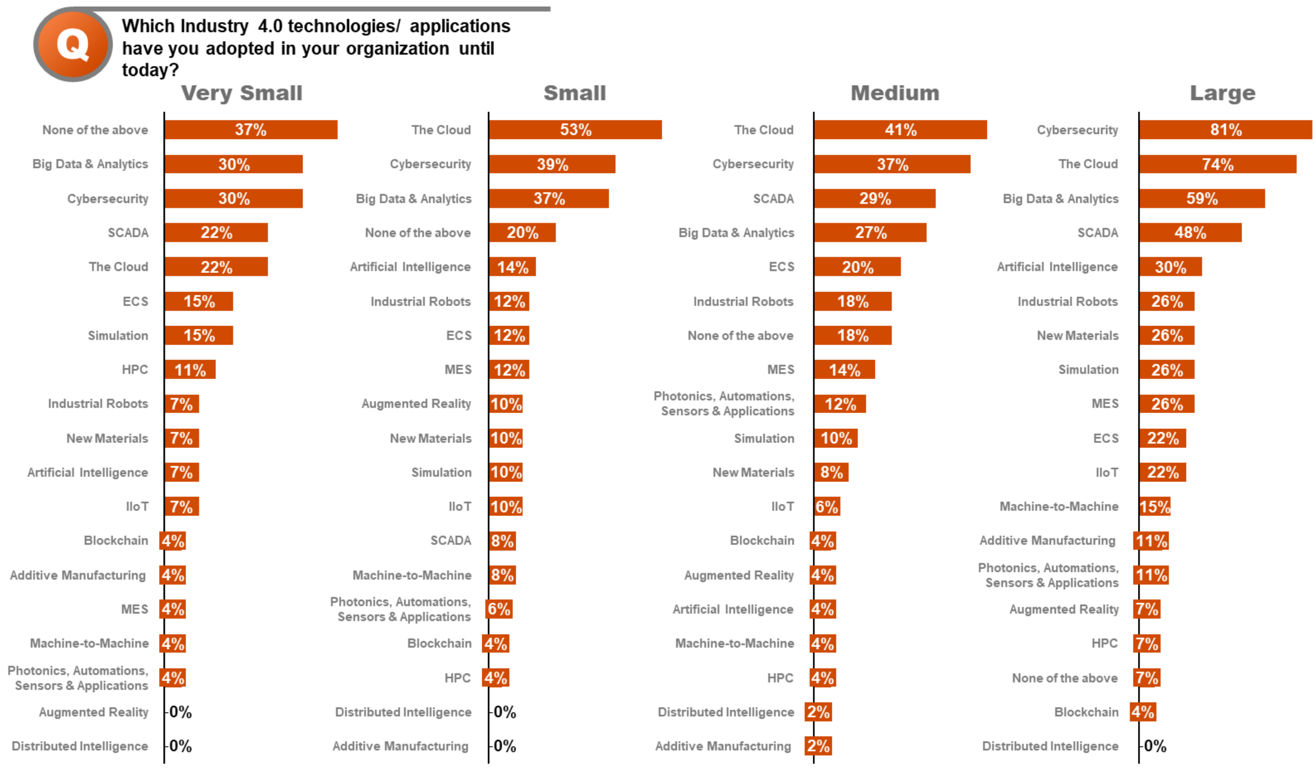


Figure 209: Key Industry 4.0 technologies/ applications that Greek executives have adopted in their organisations, by Size, (%) – Source: Industry 4.0 survey

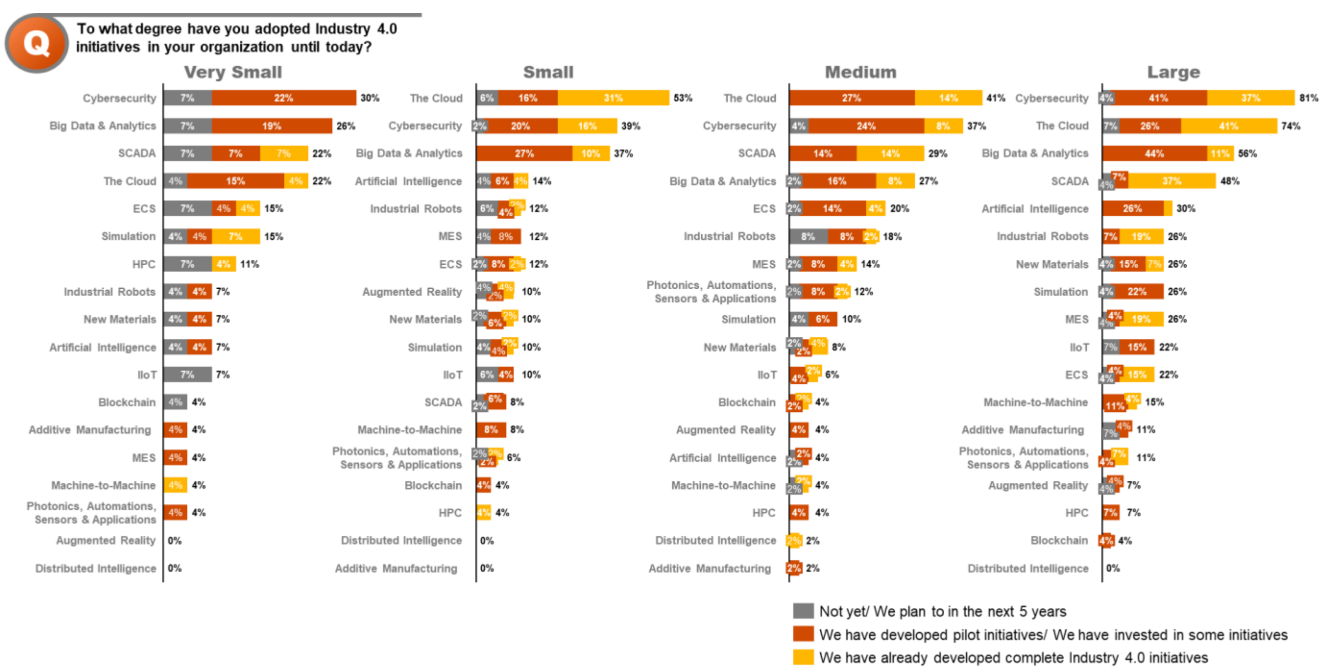


Figure 210: Organisation's degree of adoption of Industry 4.0 technologies/ applications, until today, by Size, (%) – Source: Industry 4.0 survey

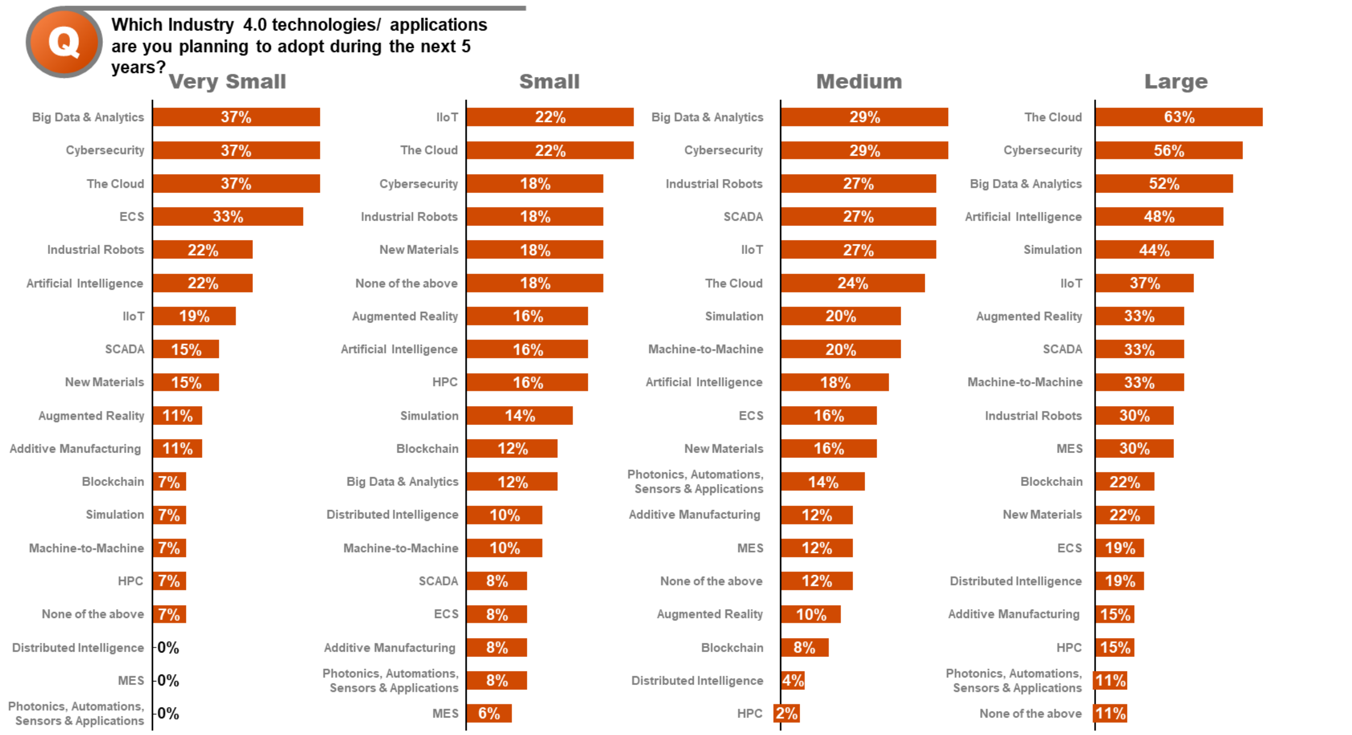


Figure 211: Key Industry 4.0 technologies/ applications that Greek executives plan to adopt in their organisations within the next 5 years, by Size, (%) — Source: Industry 4.0 survey

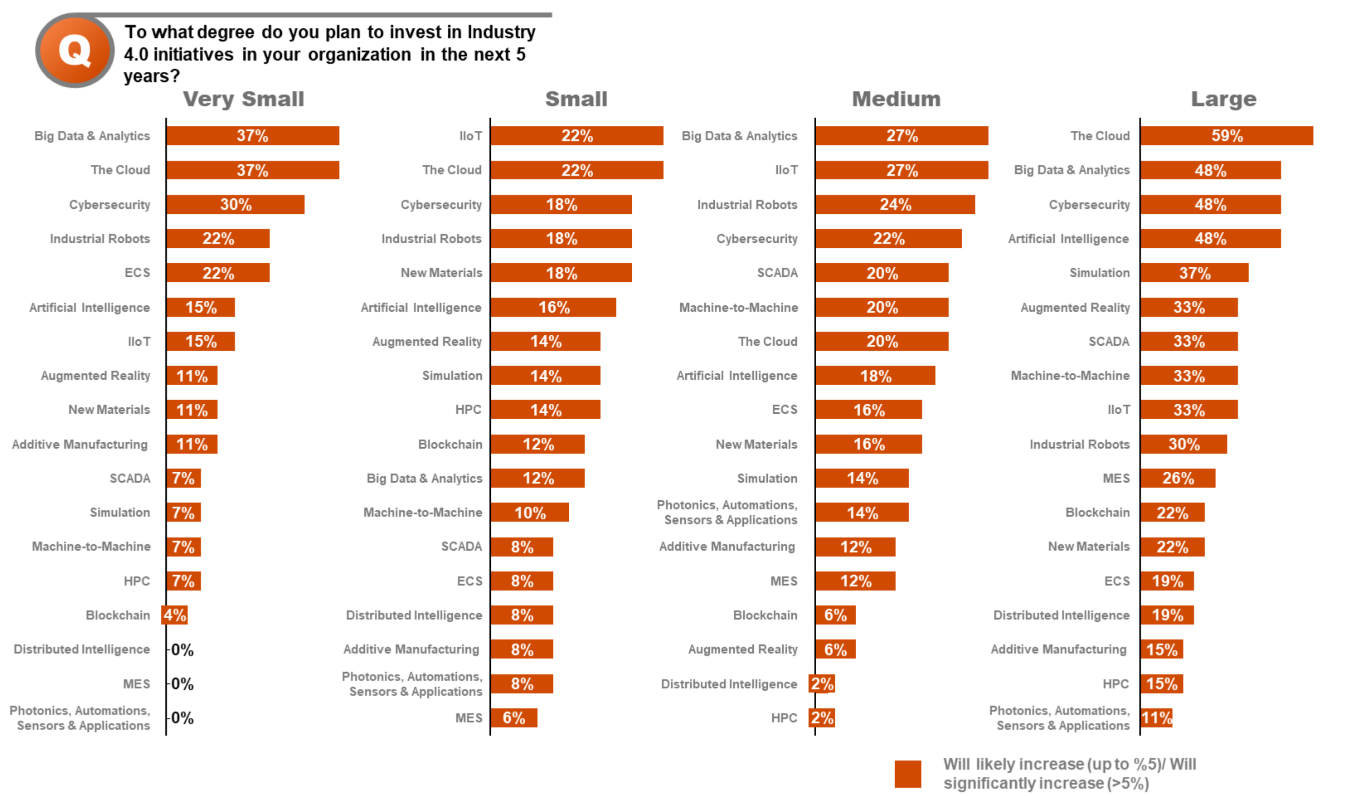


Figure 212: Organisation's planned degree of investment in Industry 4.0 initiatives, in the next 5 years, by Size, (%) – Source: Industry 4.0 survey

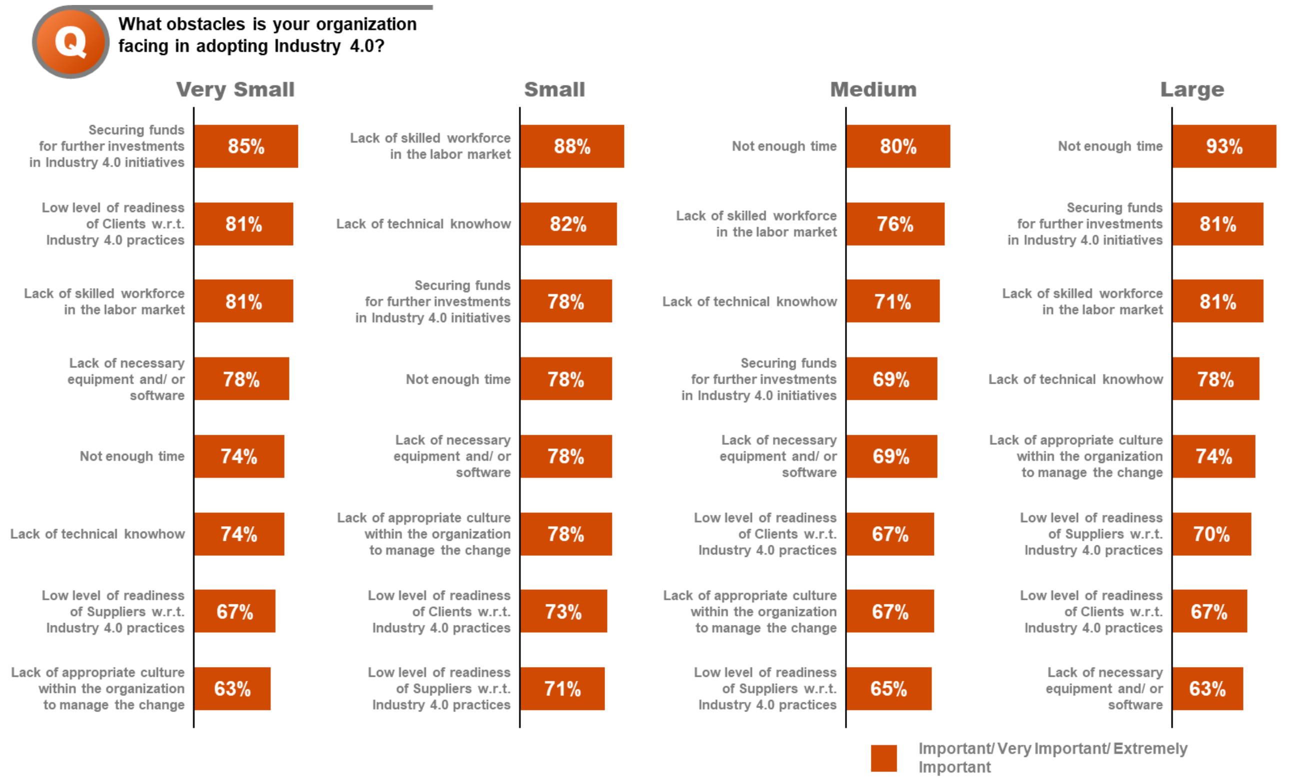


Figure 213: Key obstacles that Greek organisations face in adopting Industry 4.0, by Size, (%) – Source: Industry 4.0 survey

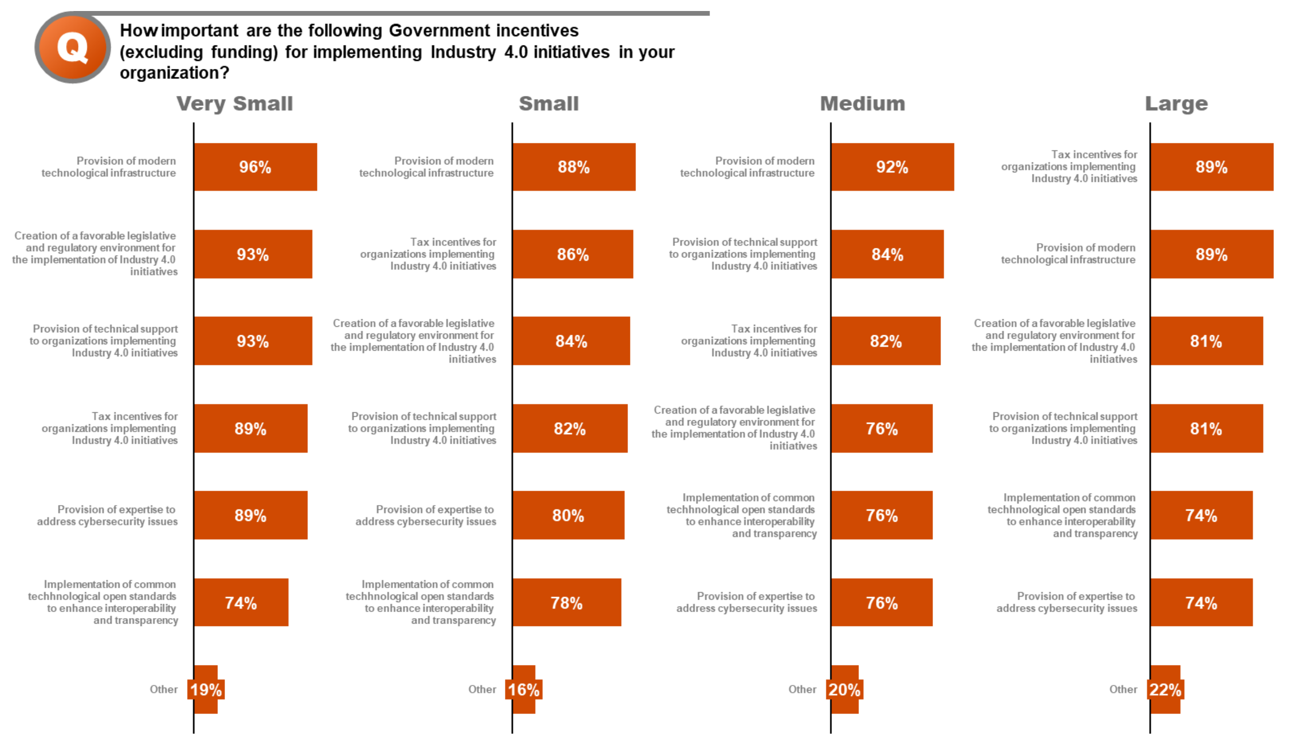


Figure 214: Important Government initiatives (excluding funding) that Greek executives wish to undertake in order to accelerate their organisations' digital transformation, by Size, (%) - Source: Industry 4.0 survey

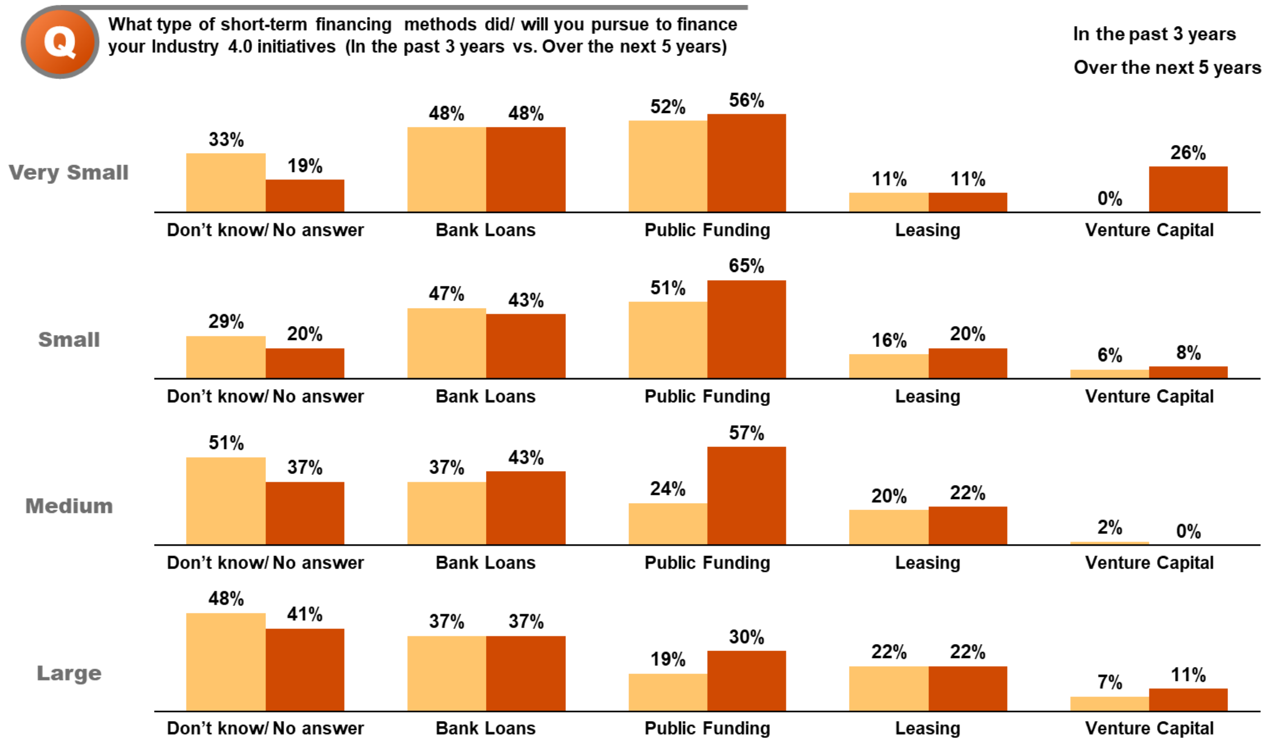


Figure 215: Short-term financing methods used/ to be used by Greek organisations during the last three years/ next five years, by Size, (%) – Source: Industry 4.0 survey

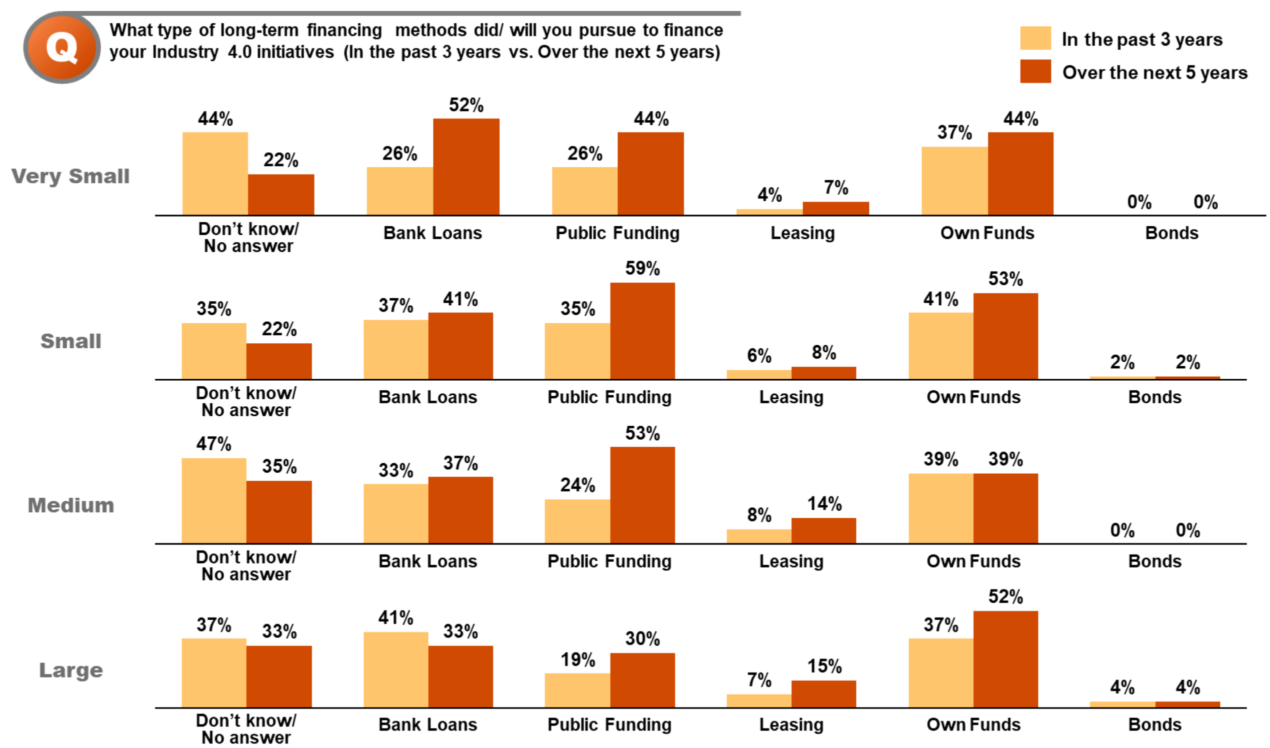


Figure 216: Long-term financing methods used/ to be used by Greek organisations during the last three years/ next five years, by Size, (%) – Source: Industry 4.0 survey

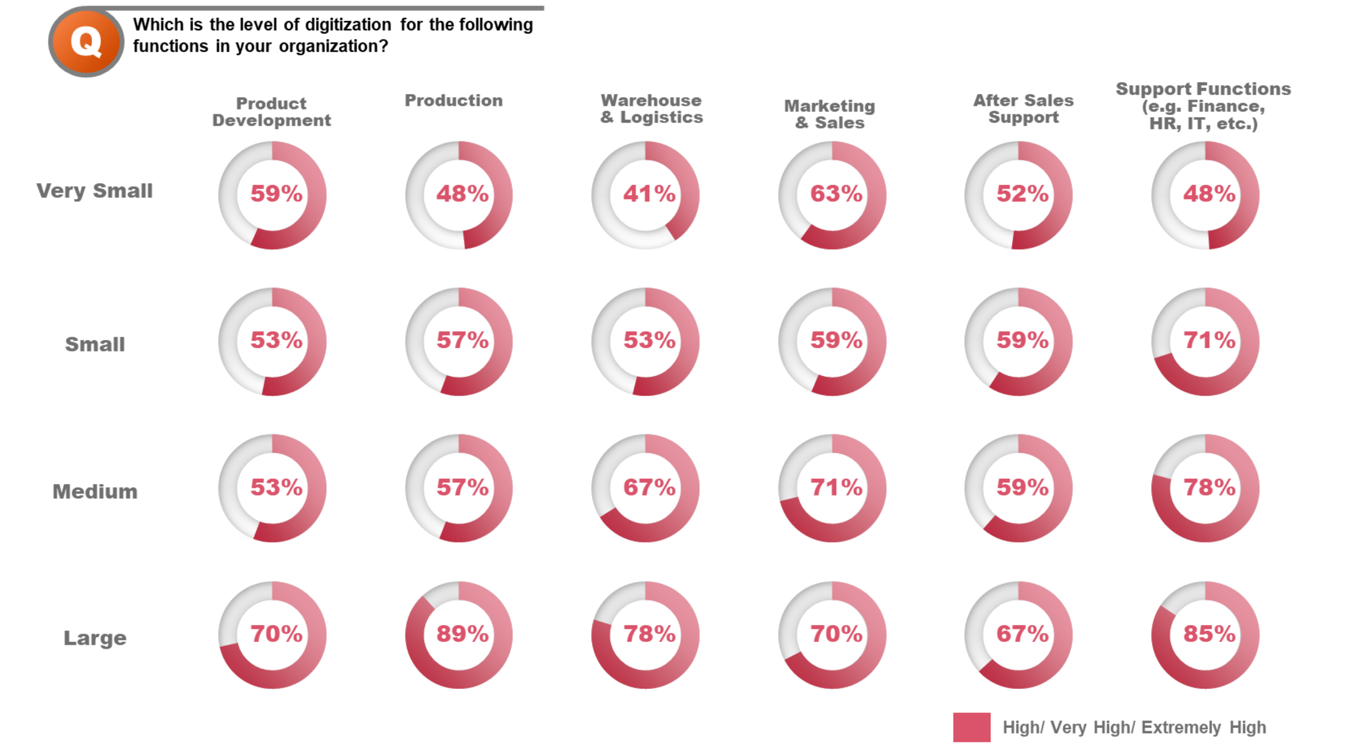


Figure 217: Greek executives' perception with regards to the level of digitisation of their organisation's functions, by Size, (%) – Source: Industry 4.0 survey

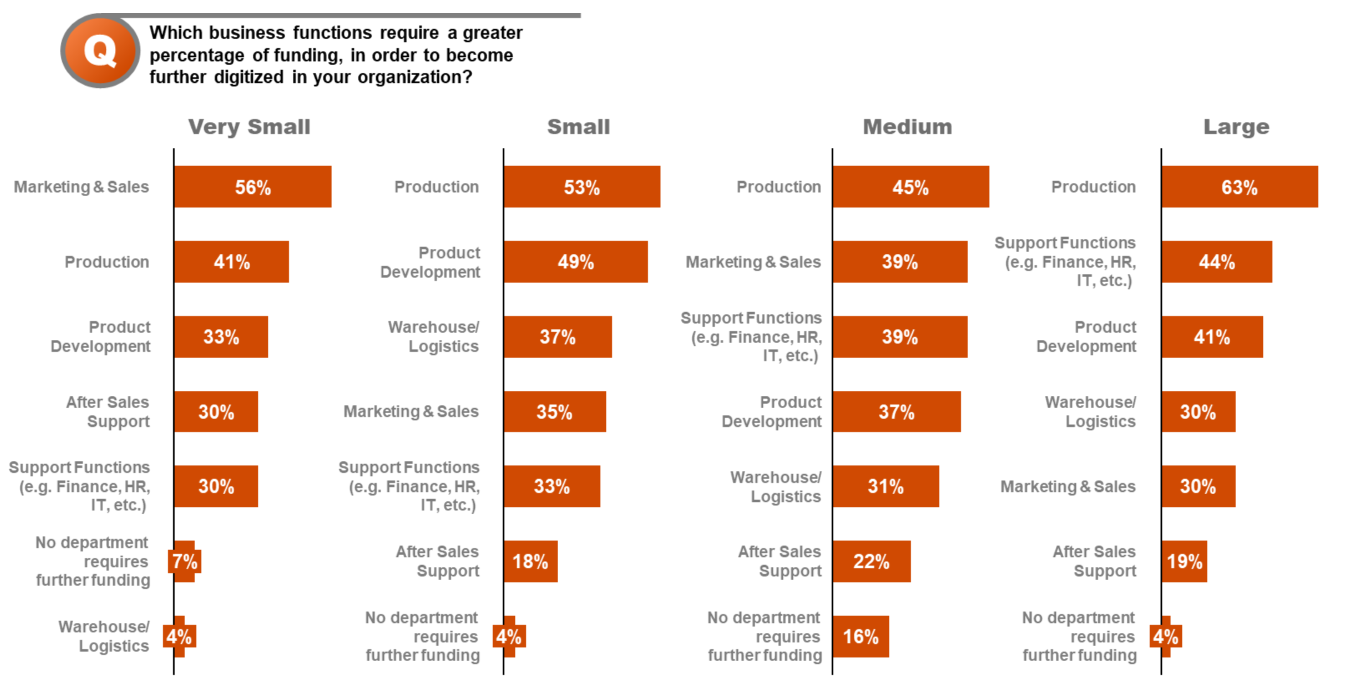


Figure 218: Funding required for further digitisation across different business functions of organisations, by Size, (%) – Source: Industry 4.0 survey

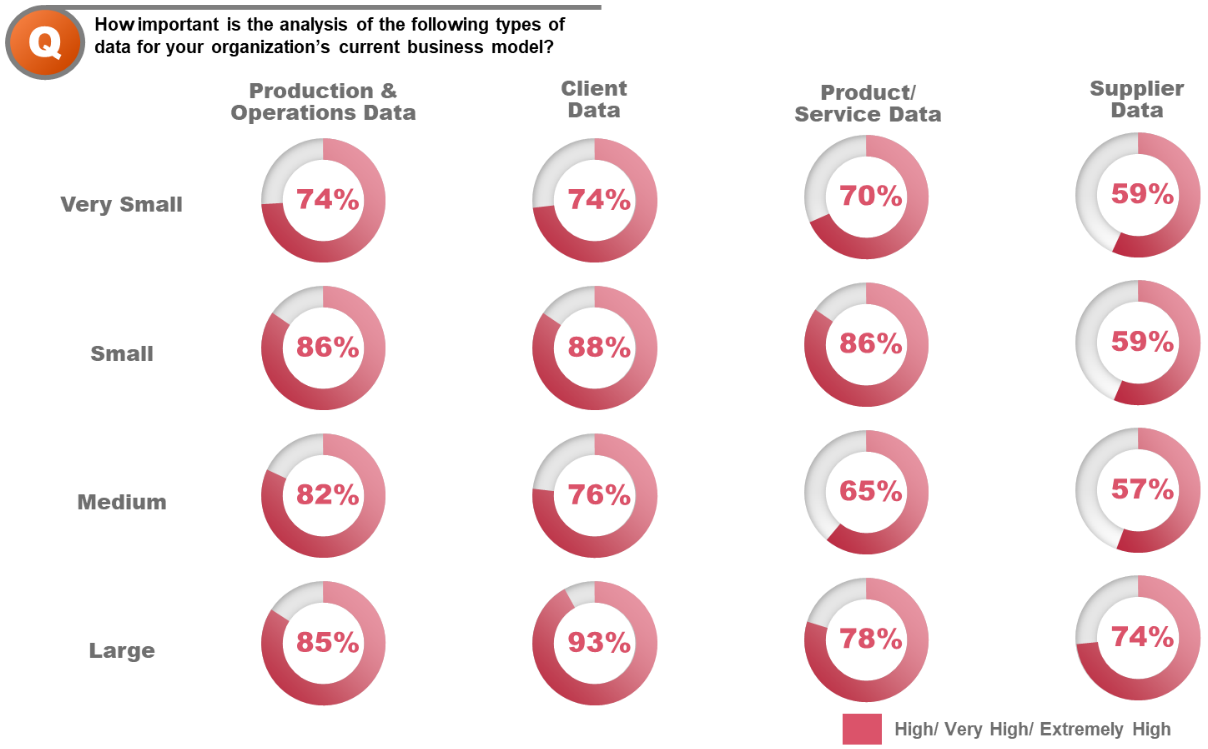


Figure 219: Level of importance of the analysis of different types of data, for the organisation's current business model, by Size, (%) – Source: Industry 4.0 survey

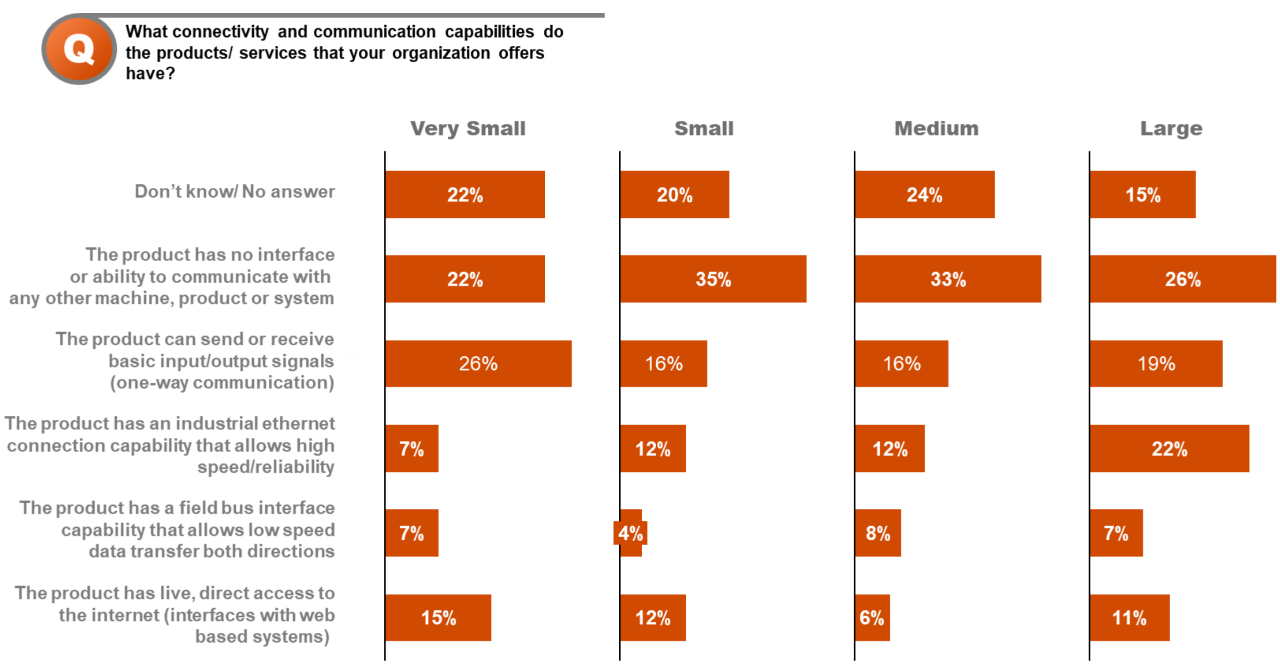


Figure 220: Degree of interconnectivity capabilities of products/ services that organisations offer, by Size, (%) – Source: Industry 4.0 survey

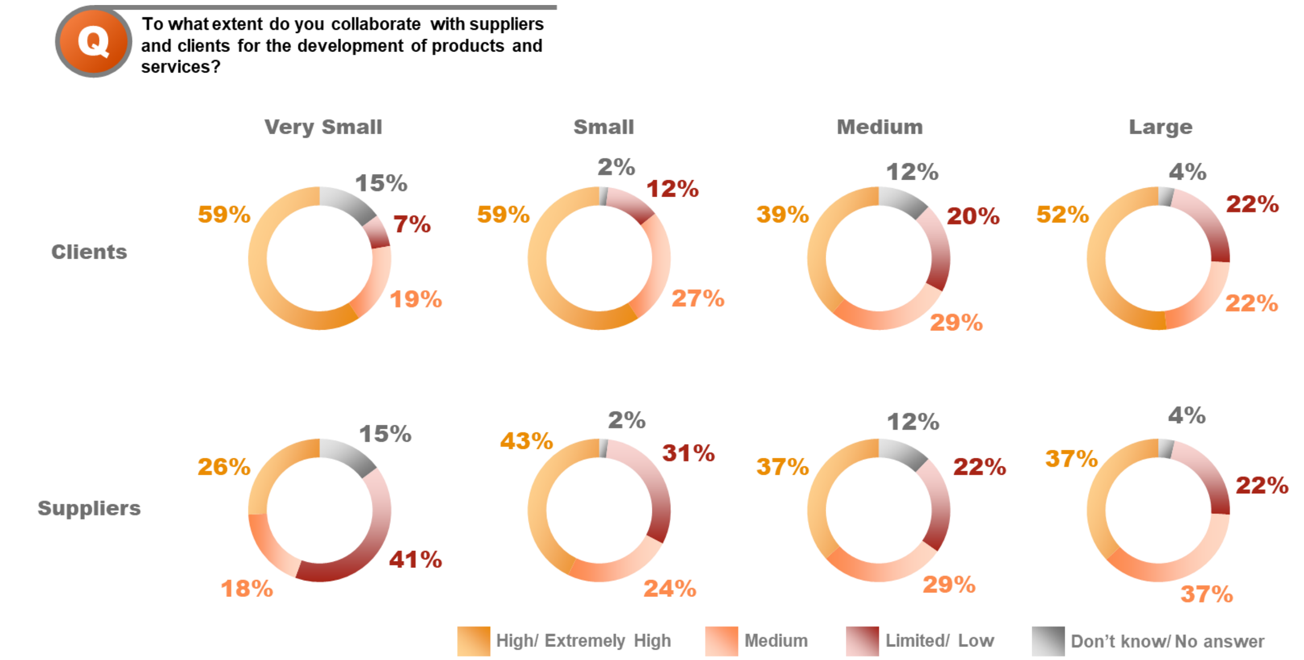


Figure 221: Degree of collaboration with partners/ suppliers for product/service development, by Size, (%) – Source: Industry 4.0 survey

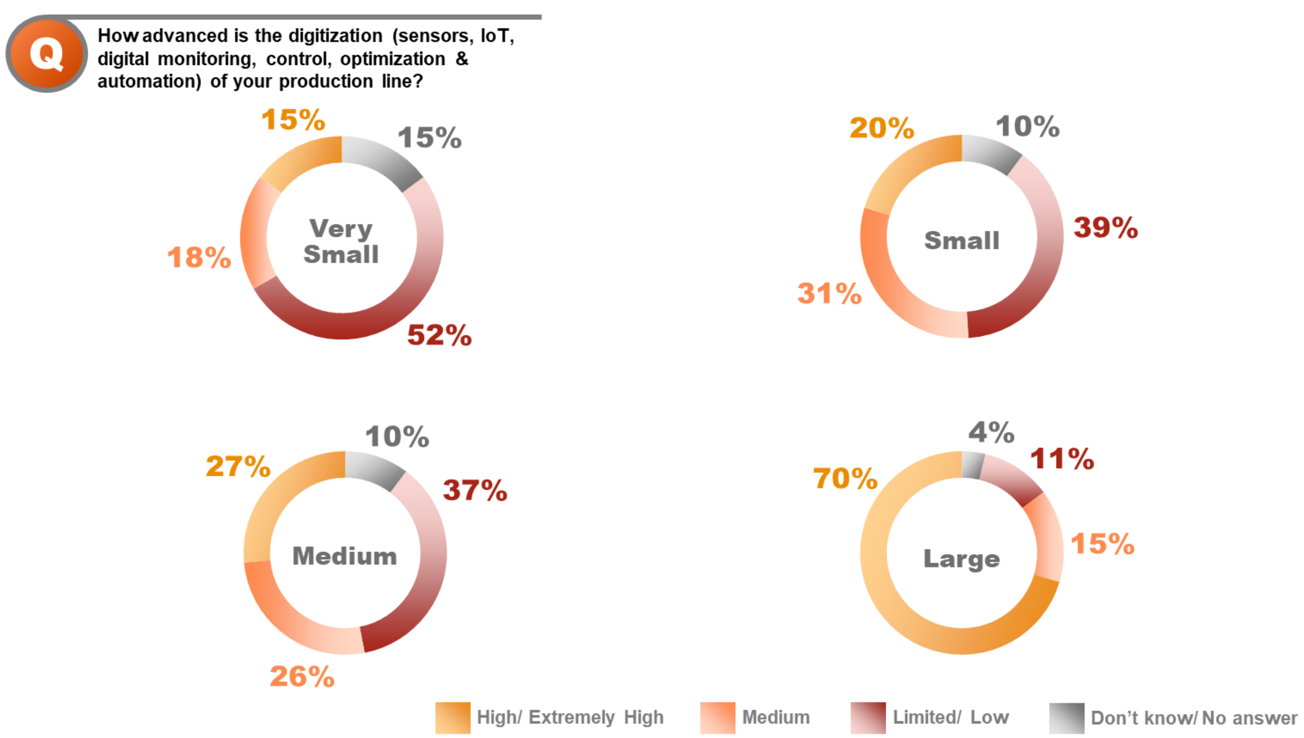


Figure 222: Degree of digitisation of the production line of organisations, by Size, (%) – Source: Industry 4.0 survey

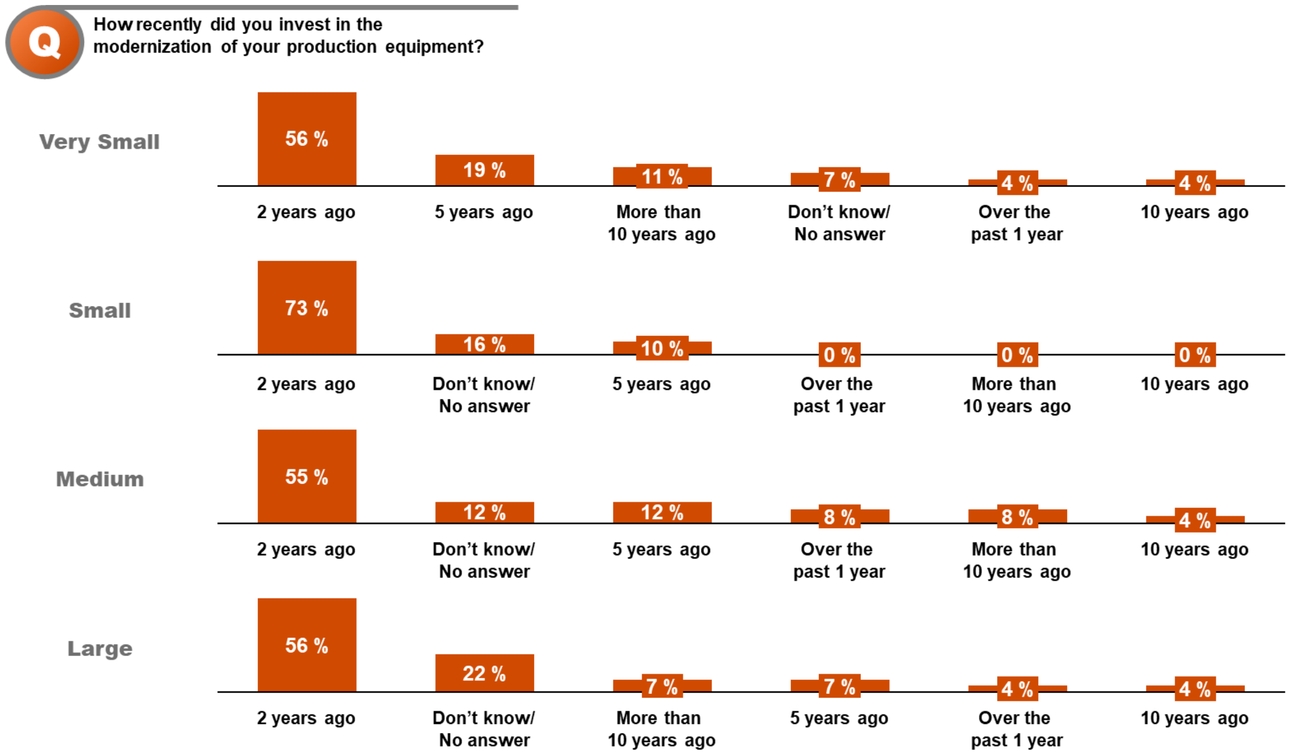


Figure 223: Last time organisations invested in the modernisation of their production equipment, by Size, (%) – Source: Industry 4.0 survey

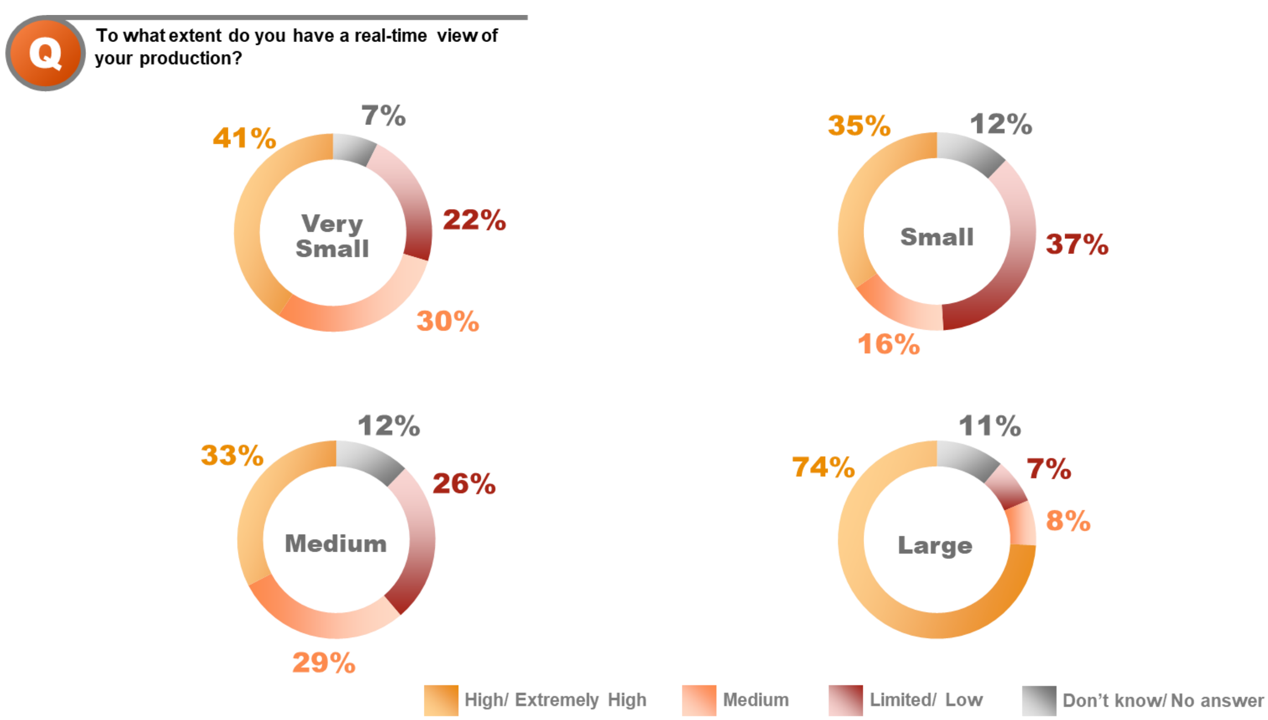


Figure 224: Degree of real-time view of production capacity, by Size, (%) – Source: Industry 4.0 survey

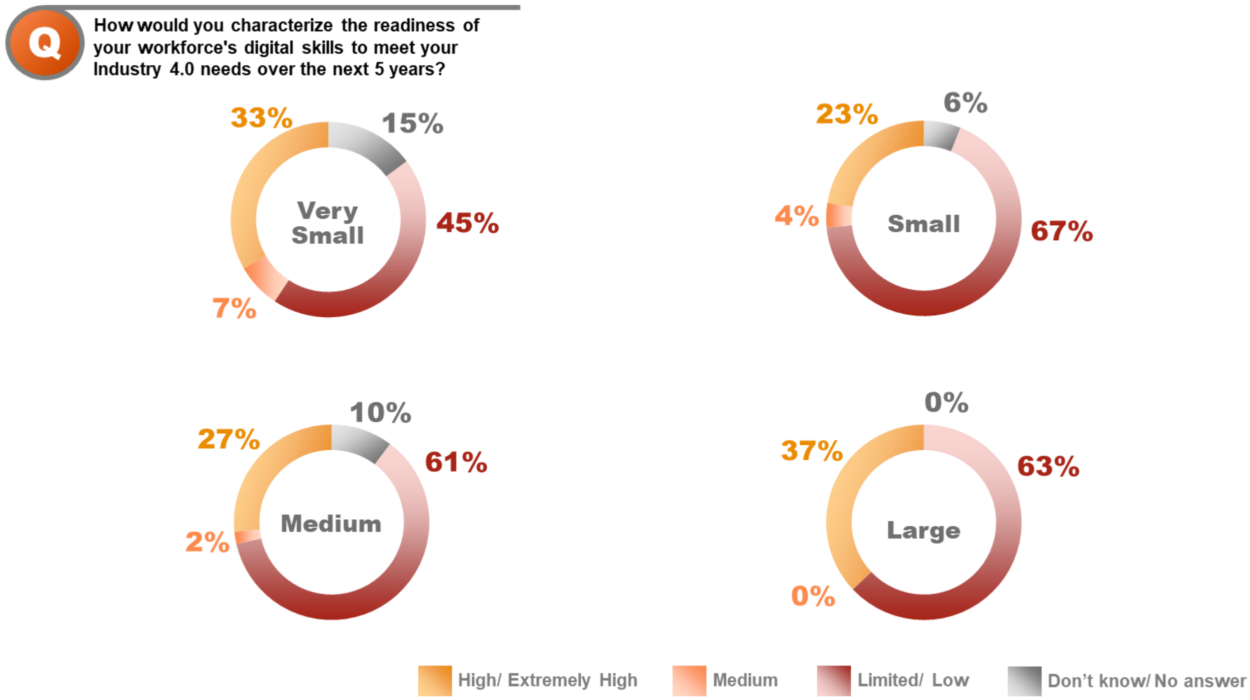


Figure 225: Degree of organisation's confidence in the current level of digital skills of their workforce, to meet Industry 4.0 challenges, by Size, (%) – Source: Industry 4.0 survey

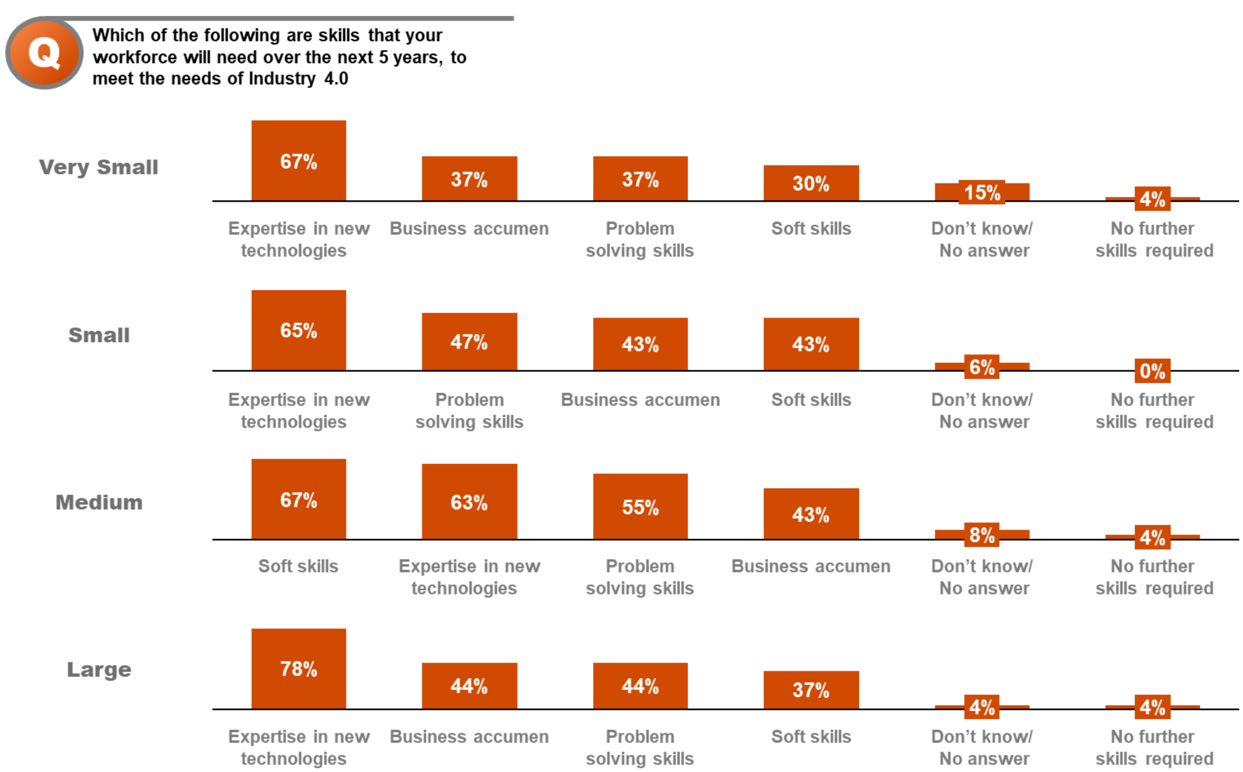


Figure 226: Level of importance that different types of skills will have with regards to Industry 4.0, in the next 5 years, by Size, (%) – Source: Industry 4.0 survey

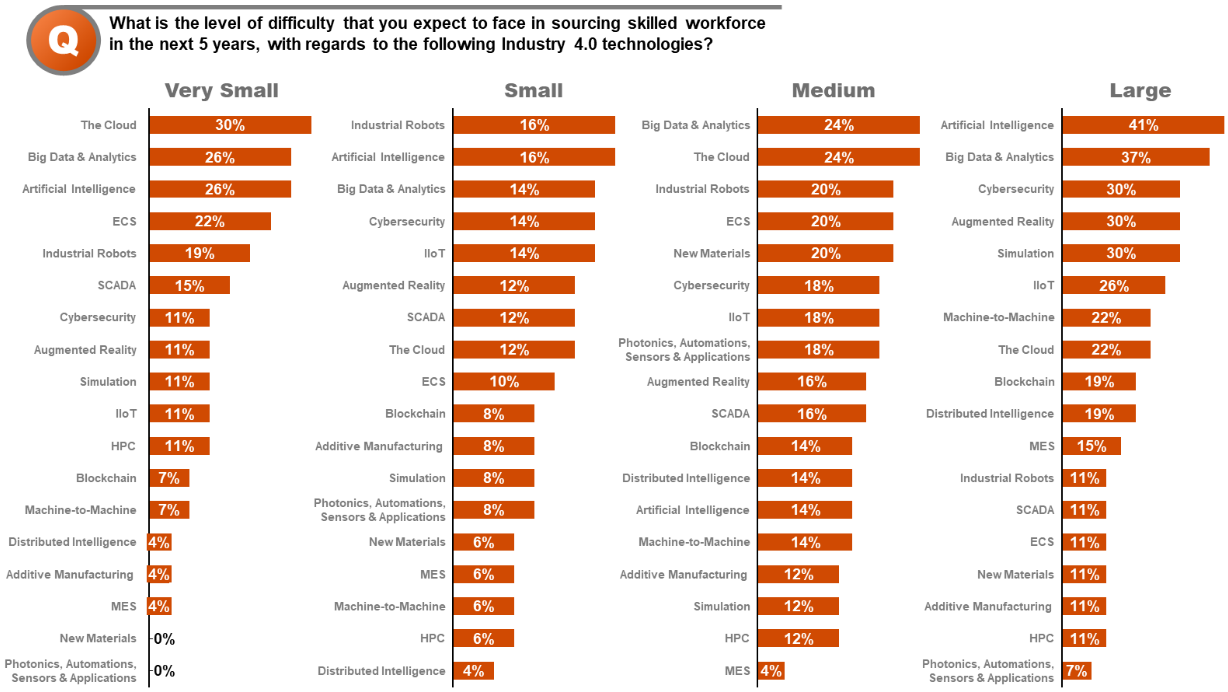


Figure 227: Level of difficulty that organisations expect to face in sourcing skilled workforce for adopting Industry 4.0 initiatives, in the next 5 years, by Size, (%) – Source: Industry 4.0 survey

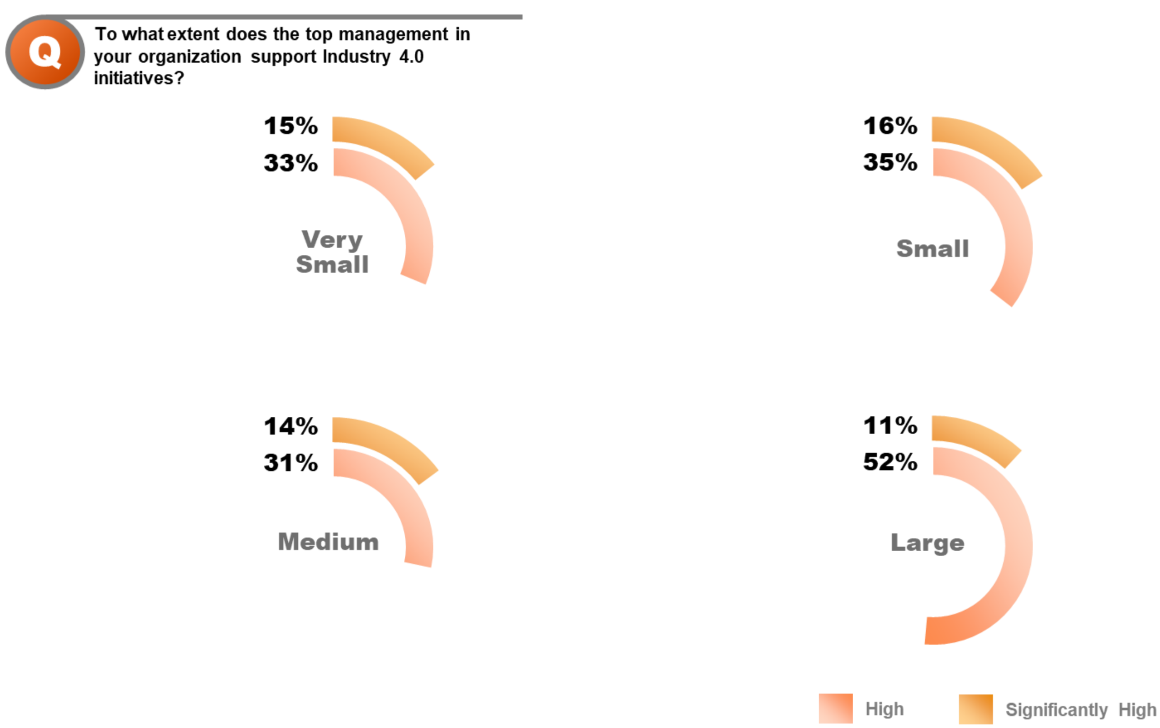


Figure 228: Degree of top management support for ongoing Industry 4.0 initiatives, by Size, (%) - Source: Industry 4.0 survey

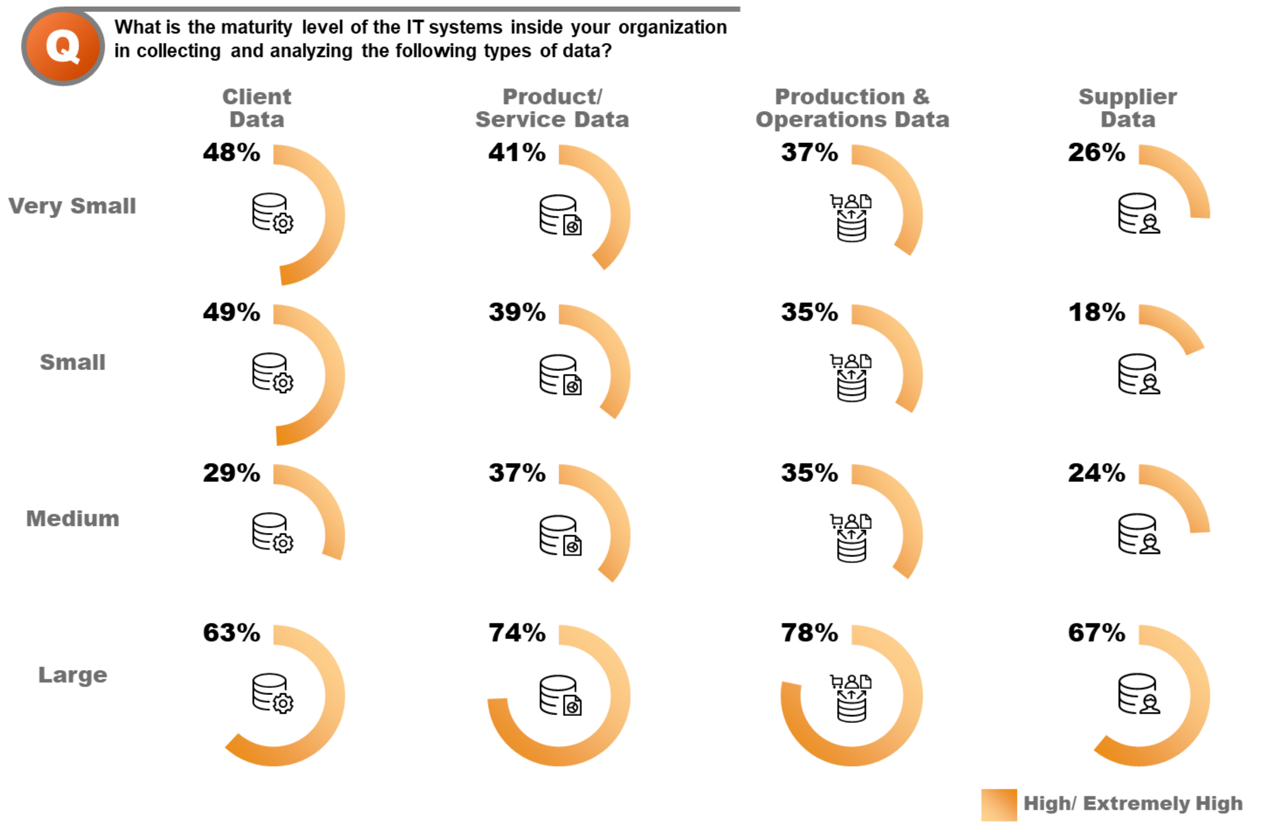


Figure 229: Level of IT systems maturity with regards to their capacity to collect and analyse data generated from different sources, by Size, (%) – Source: Industry 4.0 survey

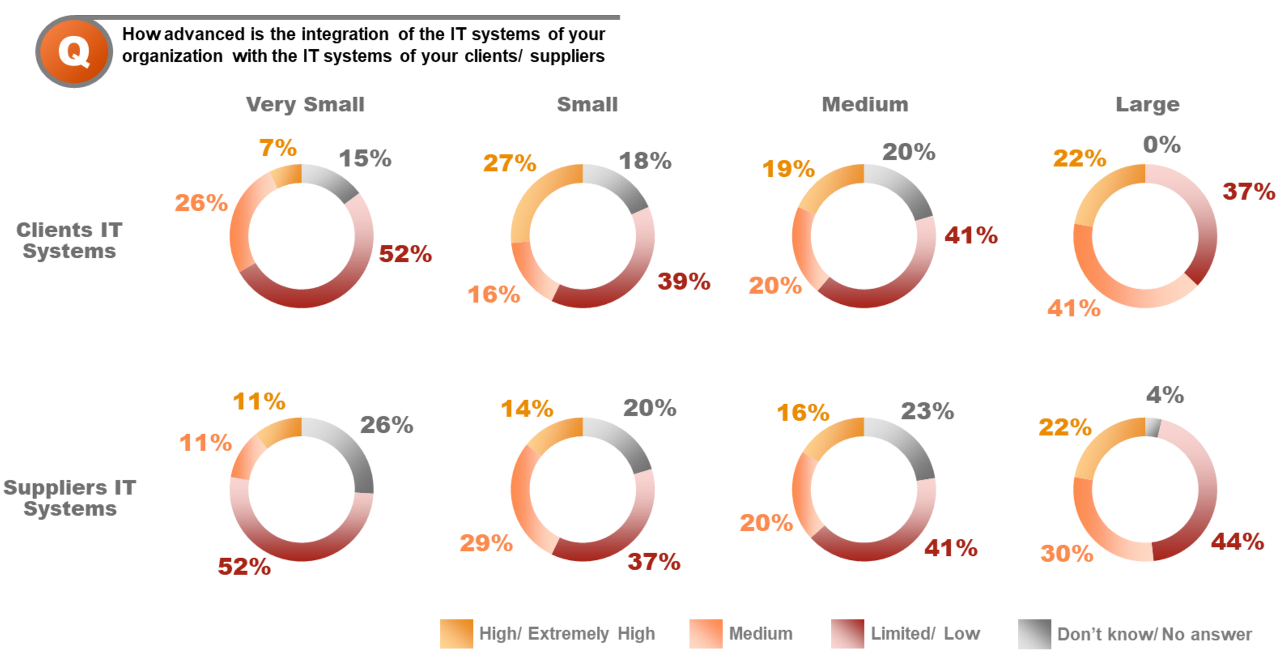


Figure 230: Degree of organisation's IT systems integration with IT systems of Clients/ Suppliers, by Size, (%) – Source: Industry 4.0 survey

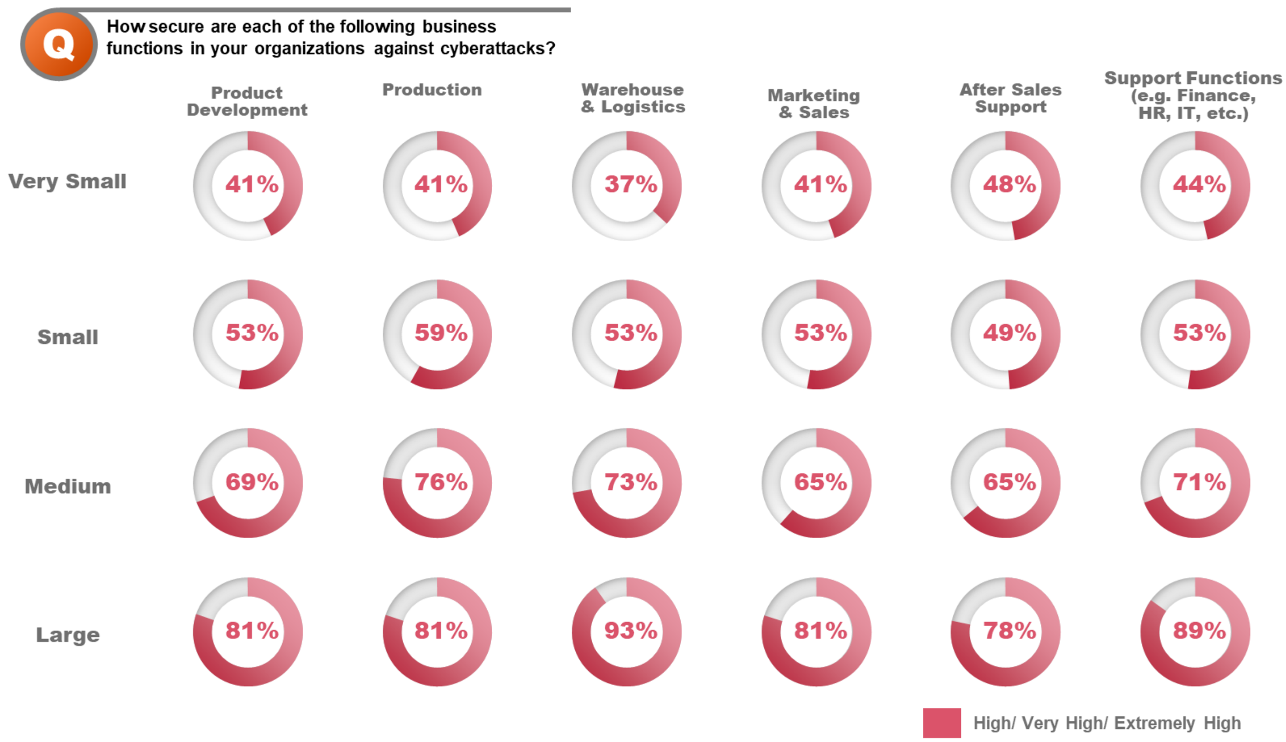


Figure 231: Degree of security against cyberattacks across different business functions, by Size, (%) – Source: Industry 4.0 survey

10.5 Industry 4.0 Survey – Detailed Results per Question by Years of Operation of Organisation

In the pages below, we present the detailed results per Question and by Years of Operation of the organisation (0-10 years, 10-20 years, 20-50 years, Over 50 years) of the Questionnaire. Key findings are presented below, before the detailed graphs.

- 6 out of 10 of executives from enterprises with 10-20 and 50+ years of operation believe that Industry 4.0 will disrupt their Industry over the next few years. 1 out of 2 of executives from enterprises with up to 10 years of operation and from enterprises with 20-50 years of operation believe the same thing.
- Enterprises with 0-10, 20-50 & 50+ years of operation seem to find the biggest opportunities from I4.0 in the development of New Services and New Business Models, while enterprises with 10-20 years of operation also depict New Markets as an opportunity in the upcoming years
- Enterprises with 50+ years of operation perceive to a great extent (74%) that the most important Industry 4.0 related benefit will be the increase of their productivity. The same is also perceived by enterprises with 10-20 and with 20-50 years of operation, albeit at a lower extent (48% and 58% respectively). On the other hand, 1 out of 2 of enterprises with up to 10 years of operation consider the improved decision making to be the most important benefit from leveraging Industry 4.0 technologies.
- The majority of enterprises with 10-20, 20-50 and over 50 years of operation have already adopted cloud, cybersecurity and big data analytics capabilities during the last years. Big data analytics and cloud capabilities have also been adopted by the majority of enterprises with less than 10 years of operation. Nevertheless, it is important to mention that 31% of those claims to not have adopted any Industry 4.0 technology yet. Looking into the next years, this picture becomes even worse, since the same percentage of enterprises with less than 10 years of operation (31%) state that they don’t plan to make any Industry 4.0 technologies.
- Within the next five years, enterprises with 10-20 years of operation plan to primarily invest in Artificial Intelligence, SCADA and ECS systems, while enterprises with 20-50 years of operation aim to continue investing on cybersecurity, cloud and big data analytics capabilities. Finally, enterprises with more than 50 years of operation will continue focusing on cloud capabilities, while at the same time they will experiment more with simulation and industrial robots.
- Lack of skilled workforce in the market is a theme that enterprises across all groups acknowledge as a key obstacle in adopting Industry 4.0 technologies. The limited time to experiment and test new Industry 4.0 technologies as well as the longer payback period for Industry 4.0 technologies is highlighted as the primary obstacle by 8 out of 10 of enterprises with 20-50 and over 50 years of operation. At the same time, 76% of the enterprises with 20-50 years of operation state as their primary obstacle the limited available funding for relevant initiatives. Finally, 7 out of 10 of enterprises with less than 10 years of operation also state the lack of necessary hardware and software equipment as an important inhibitor that prevents their rotation to Industry 4.0.
- Enterprises across all groups acknowledge the provision of digital infrastructure as one of the top two incentives that Government could provide to accelerate the enterprises digital transformation. At the same time, enterprises with less than 10 years of operation as well as those with 20-50 and

over 50 years of operation position the provision of technical support to organisations as the second most important Governmental incentive towards their digitisation. On the other hand, enterprises with 20-50 years of operation state the provision of tax incentives for their digitisation as the most important governmental incentive.

- With regards to short-term financing for Industry 4.0 initiatives, during the last three years most enterprises with less than 10 years of operation and those with 10-20 years of operations were primarily supported by public funding to initiate their digital transformation. On the other hand, "older" enterprises with more than 20 years of operations mainly leveraged bank loans for their rotation to Industry 4.0. In the next five years, enterprises from all groups aim primarily to leverage public funding to continue and accelerate their digitisation, while bank loans will consist the second most important source of financing.
- With regards to long-term financing for Industry 4.0 initiatives, during the last three years most enterprises across all groups used their own funds to initiate their digital transformation. In the next five years, this is about to change for some groups. Most enterprises with less than 10 years of operation plan to apply for a bank loan, while the majority of enterprises with 20-50 years of operation plan to primarily leverage public funding. On the other hand, enterprise with 10-20 and with over 50 years of operation will continue support their digitisation efforts on their own funds and assets.
- Enterprises with more years of operation appear to demonstrate a higher degree of digitisation across all of their functions. In the future enterprises across all groups plan to primarily intensify their digitisation efforts across their production.
- An interesting fact is highlighted with regards to the degree of digitisation of enterprises' products and services. 1 out of 3 of enterprises with less than 10 years of operation claim to produce "smart", interconnected products, while 1 out of 4 of enterprises with 10-20 years of operation state that their products and services can send or receive basic input/ output signals. At the same time, most enterprises with over 20 years of operation state that their products have no interface or ability interconnect with any other machine, product or system.
- The longer the years of operation of an enterprise, the more digitally advanced its production line appears to be. Only 7% of enterprises with 0-10 years of operation stated that the degree digitisation of their production line was high/ extremely high compared to 16%, 33% and 42% of enterprises with 10-20, 20-50 and 50+ years of operation respectively
- Enterprises across all groups recognize their workforce's limited readiness to meet the future Industry 4.0 needs over the next years, albeit to a different extent. In more detail, 55%, 56%, 62% and 63% of enterprises with less than 10 years, 10-20, 20-50 and over 50 years of operation claim that their employees currently demonstrate limited digital skills to address future Industry 4.0 demand.
- Enterprises across all groups recognize big data analytics capabilities to be one of the most difficult skills to be sourced in the future.

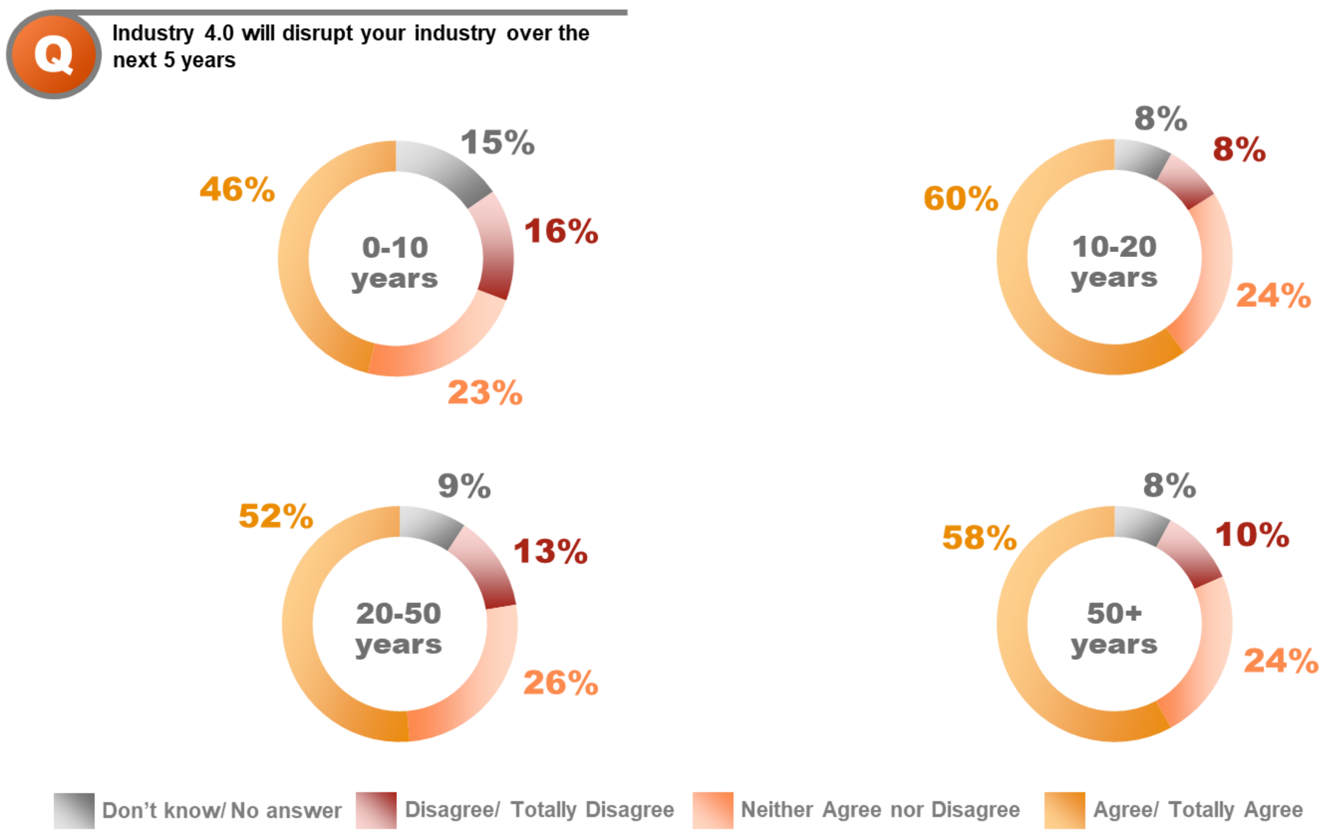


Figure 232: Greek executives' level of agreement regarding the disruption of their industry due to Industry 4.0, by Years of Operation, (%) – Source: Industry 4.0 survey

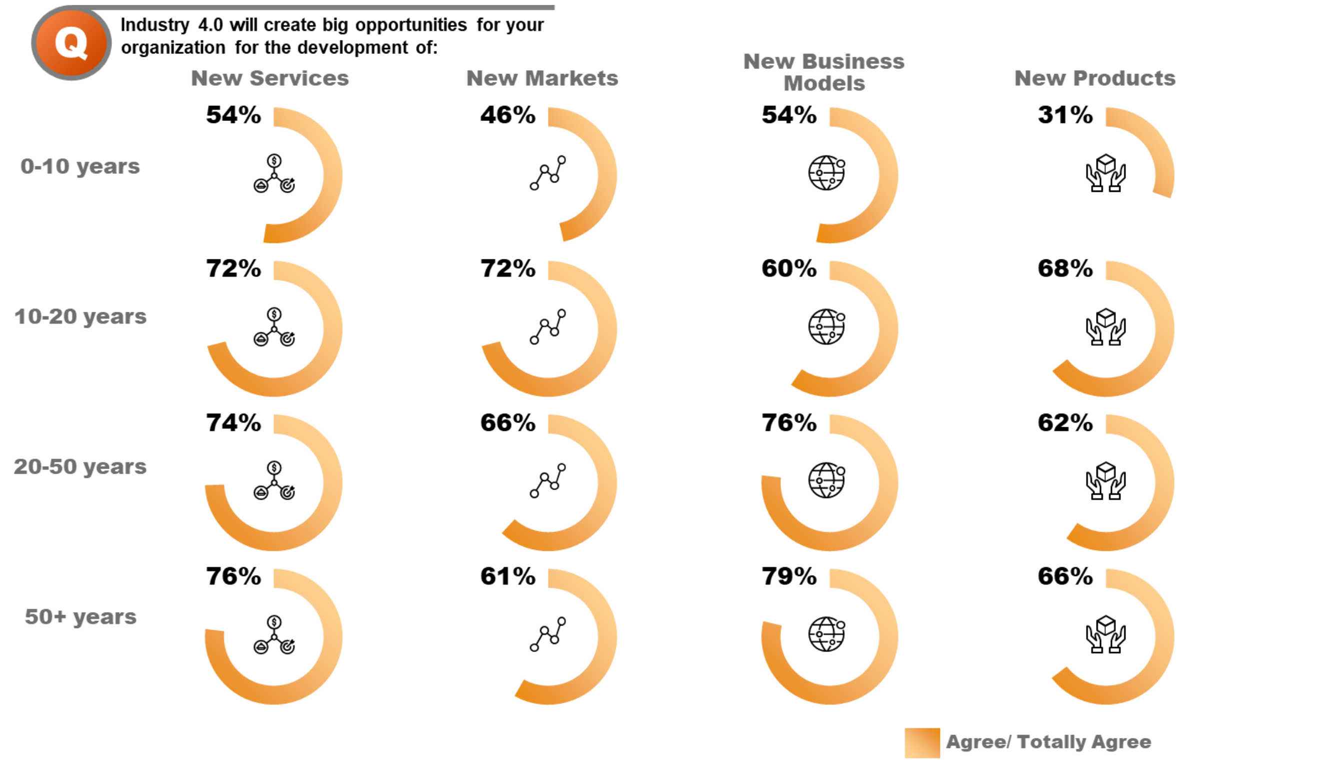


Figure 233: Greek executives' level of agreement regarding the opportunities that Industry 4.0 will open for their organisations, by Years of Operation, (%) – Source: Industry 4.0 survey

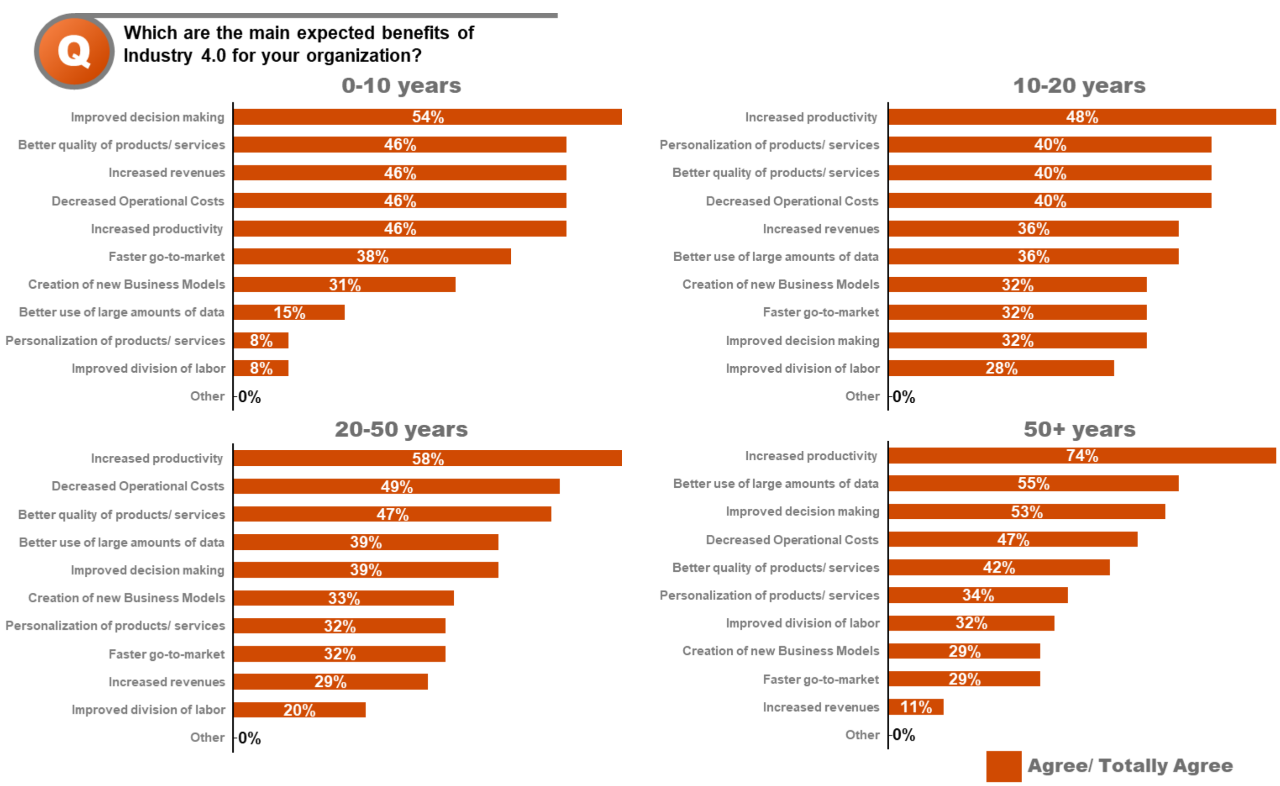


Figure 234: Greek executives' level of agreement regarding the benefits that Industry 4.0 will bring to their organisations, by Years of Operation, (%) – Source: Industry 4.0 survey

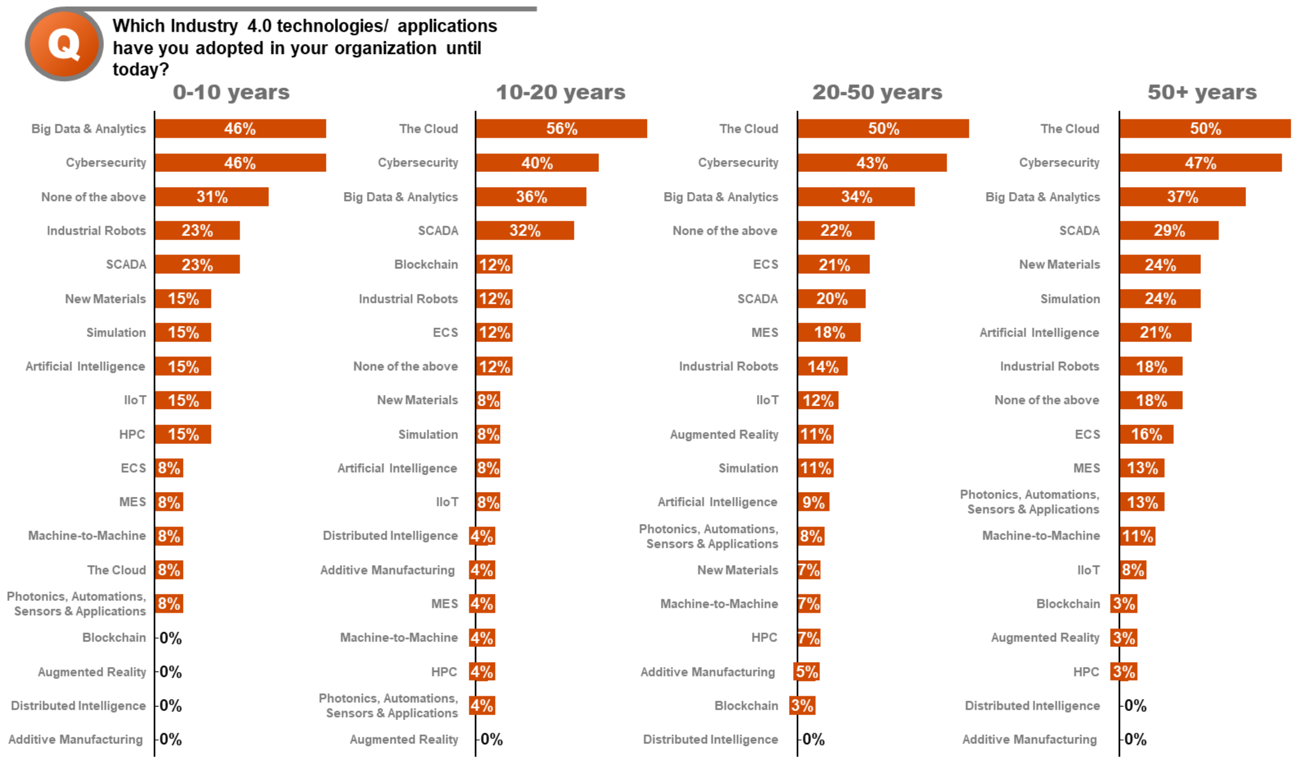


Figure 235: Key Industry 4.0 technologies/ applications that Greek executives have adopted in their organisations, by Years of Operation, (%) – Source: Industry 4.0 survey

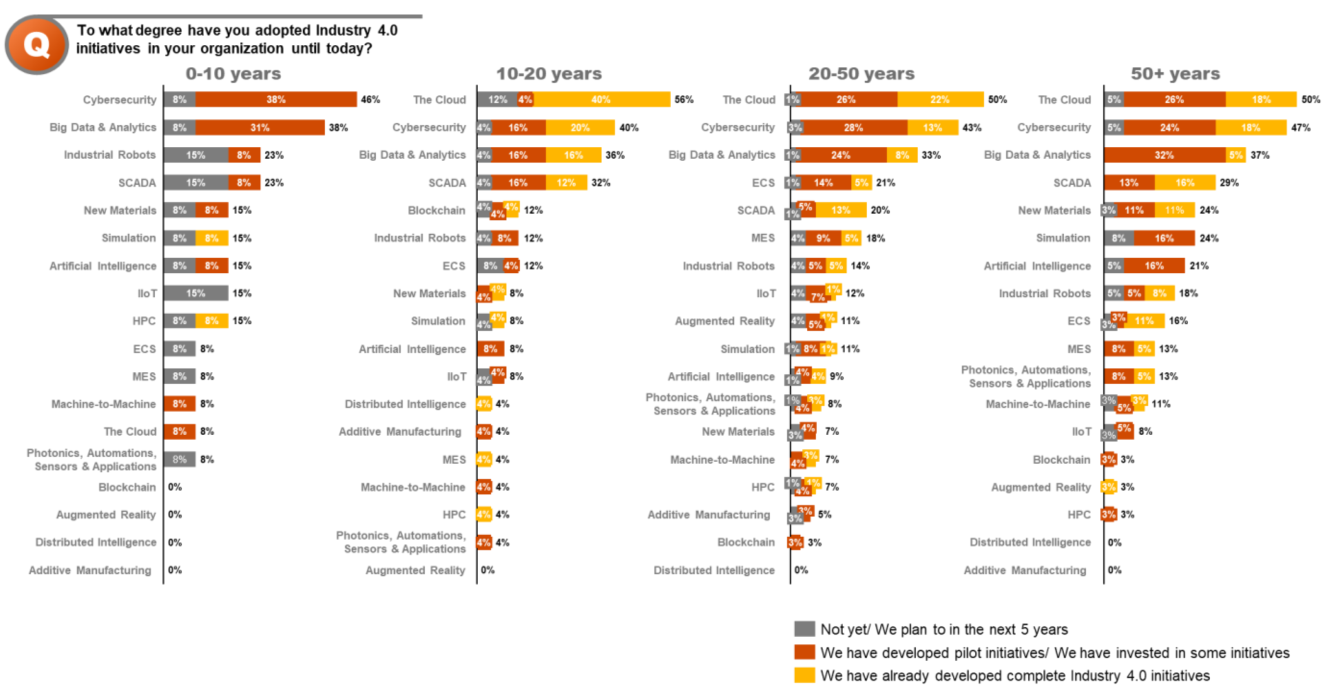


Figure 236: Organisation's degree of adoption of Industry 4.0 technologies/ applications, until today, by Years of Operation, (%) – Source: Industry 4.0 survey

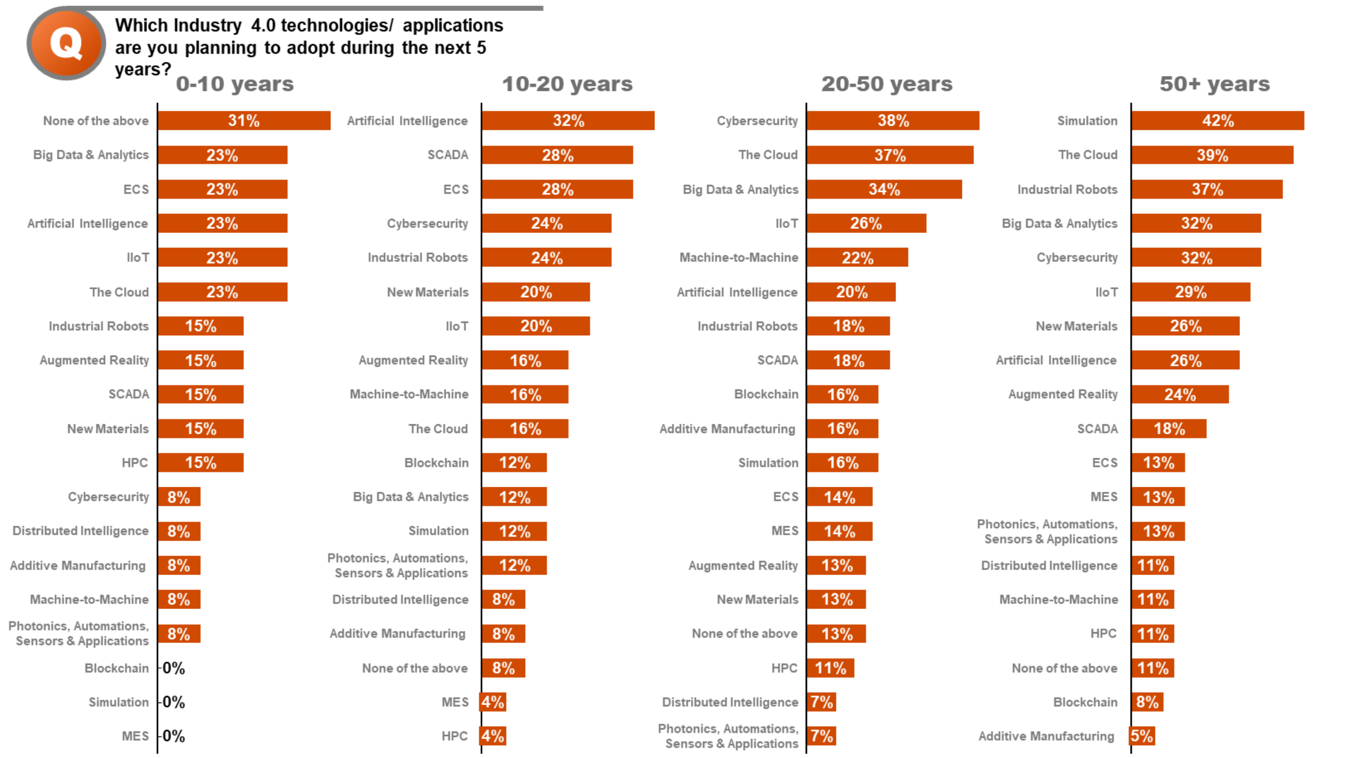


Figure 237: Key Industry 4.0 technologies/ applications that Greek executives plan to adopt in their organisations within the next 5 years, by Years of Operation, (%) -– Source: Industry 4.0 survey

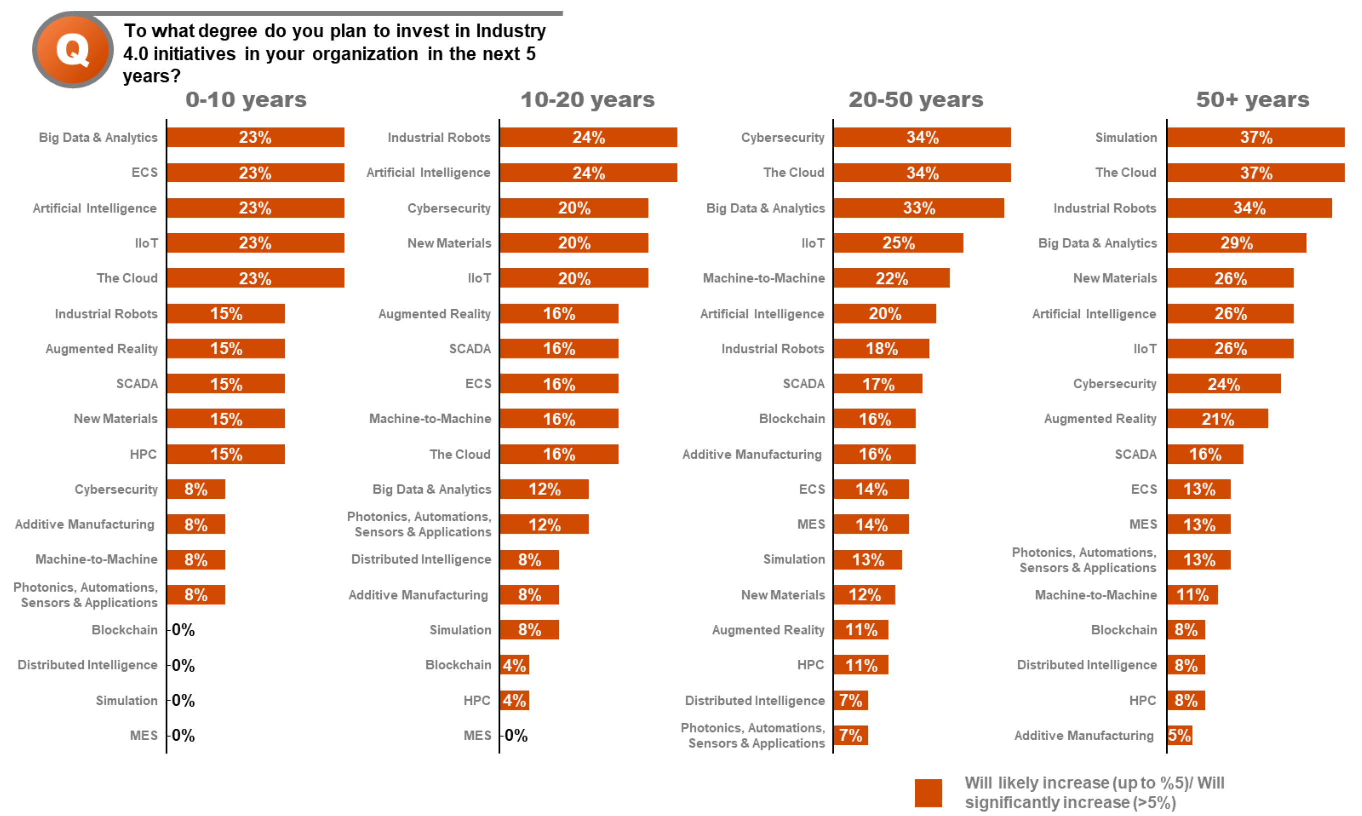


Figure 238: Organisation's planned degree of investment in Industry 4.0 initiatives, in the next 5 years, by Years of Operation, (%) – Source: Industry 4.0 survey

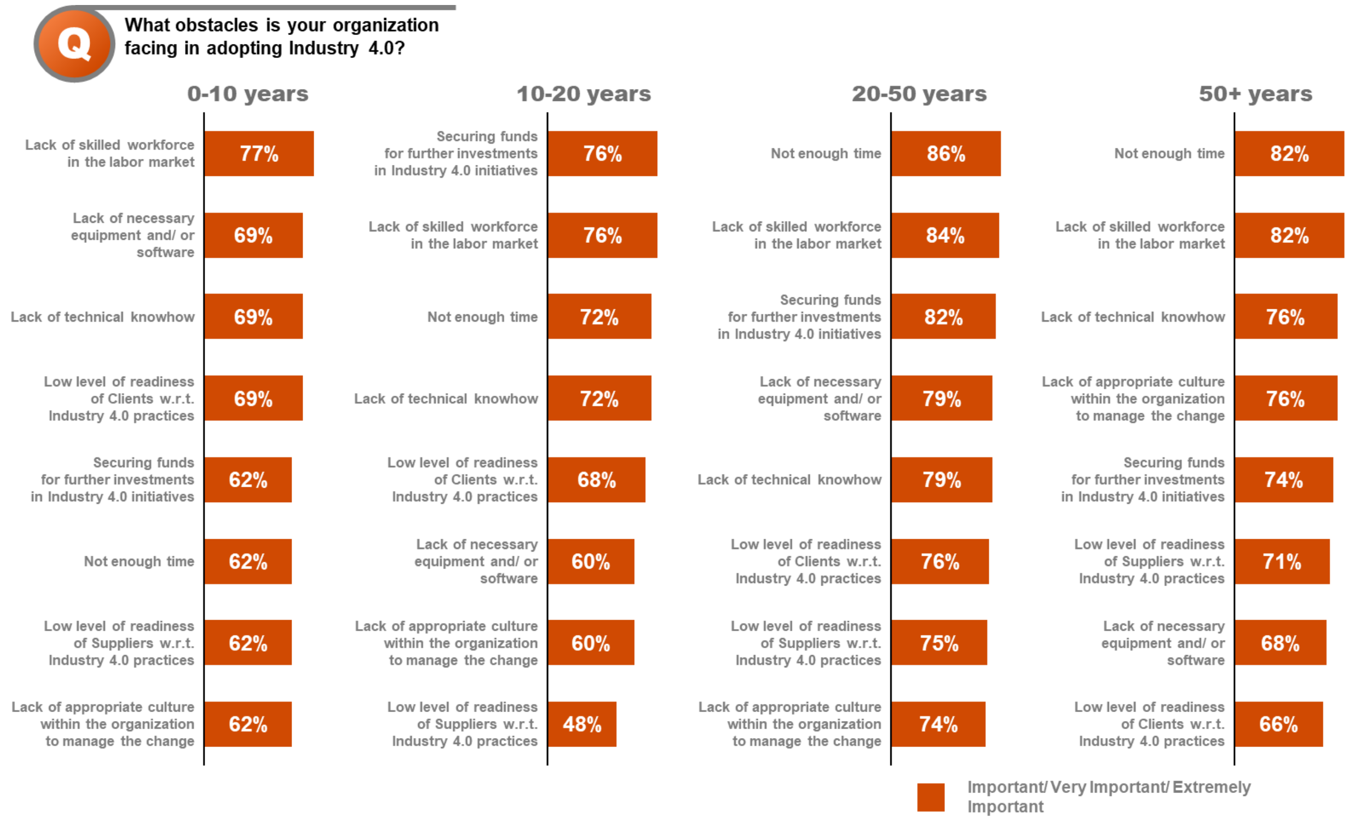


Figure 239: Key obstacles that Greek organisations face in adopting Industry 4.0, by Years of Operation, (%) – Source: Industry 4.0 survey

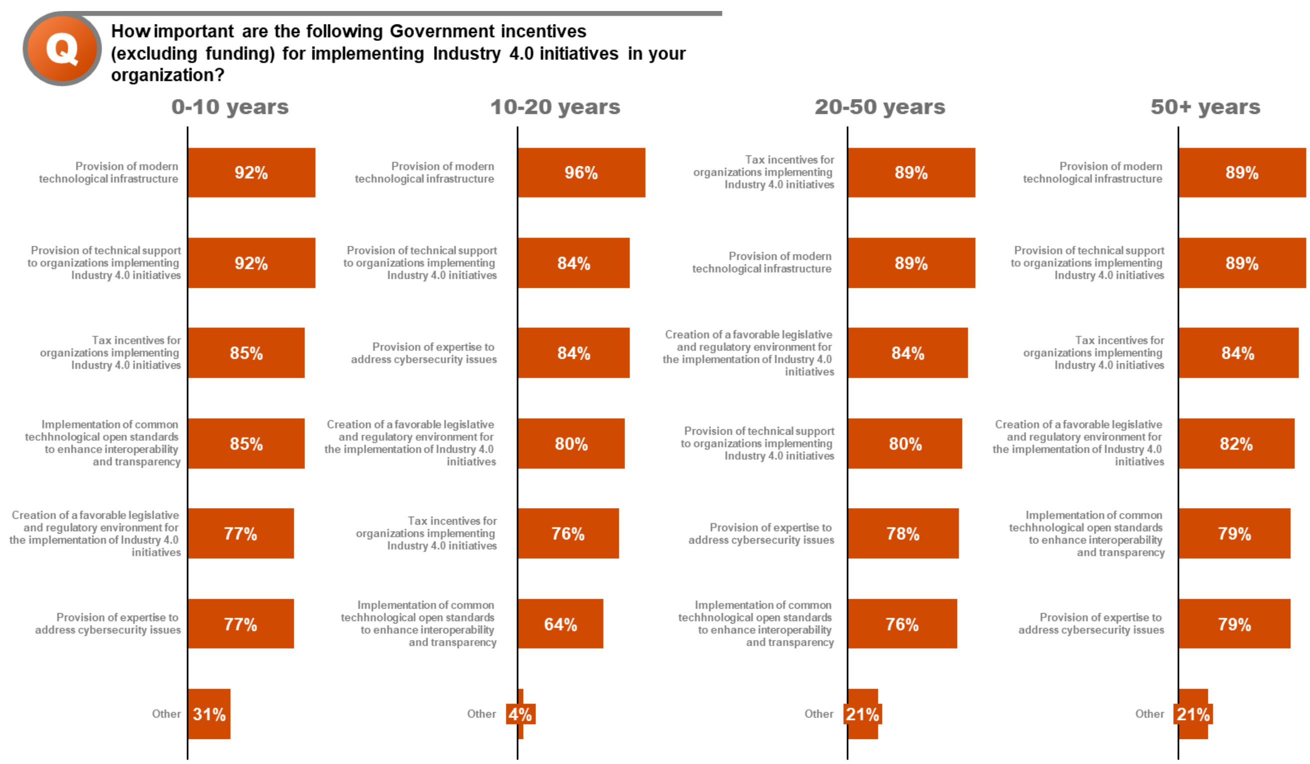


Figure 240: Important Government initiatives (excluding funding) that Greek executives wish to undertake in order to accelerate their organisations' digital transformation, by Years of Operation, (%) - Source: Industry 4.0 survey

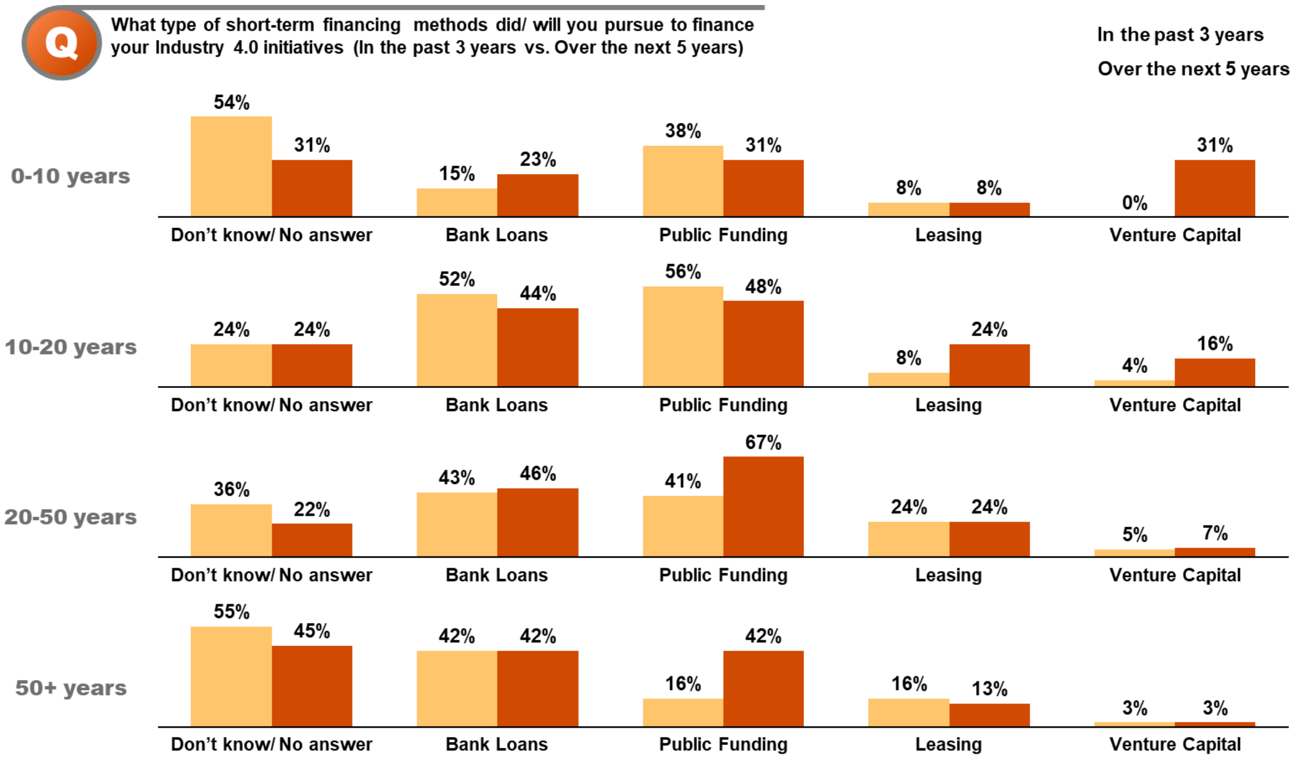


Figure 241: Short-term financing methods used/ to be used by Greek organisations during the last three years/ next five years, by Years of Operation, (%) – Source: Industry 4.0 survey

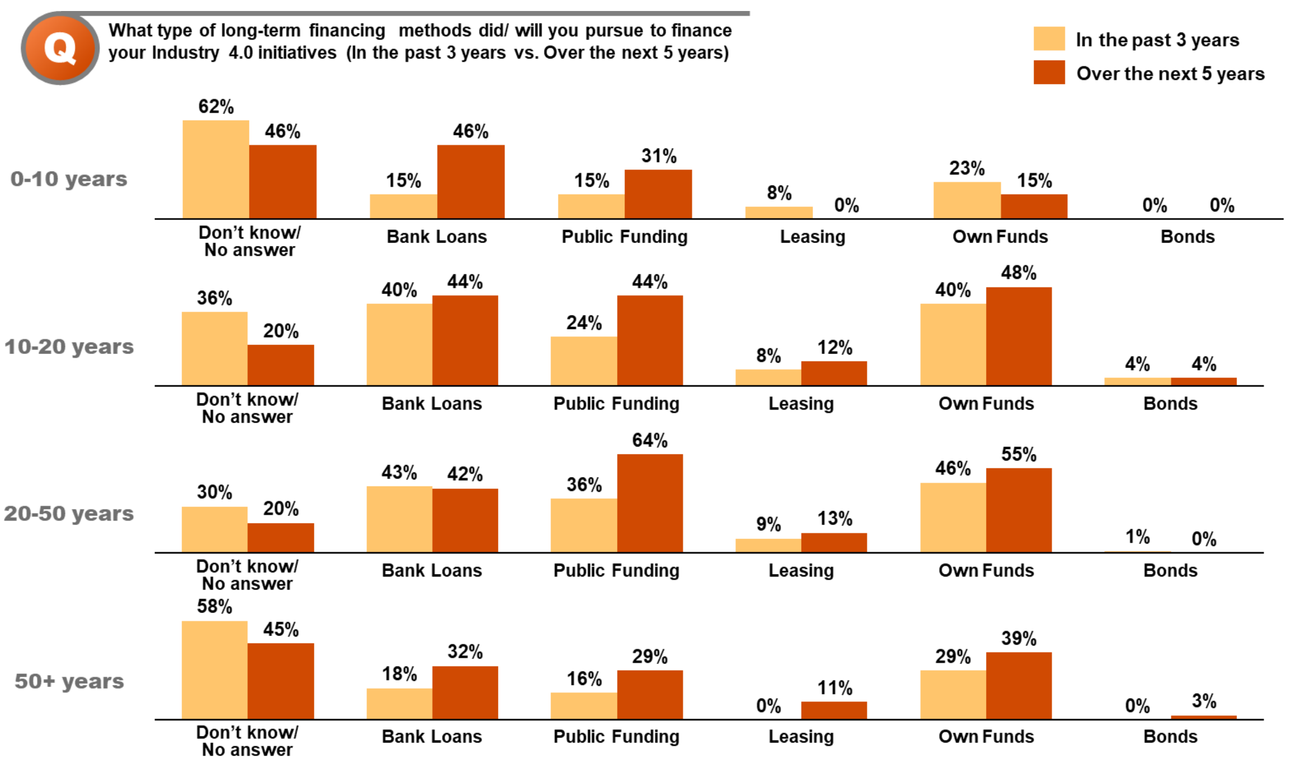


Figure 242: Long-term financing methods used/ to be used by Greek organisations during the last three years/ next five years, by Years of Operation, (%) – Source: Industry 4.0 survey

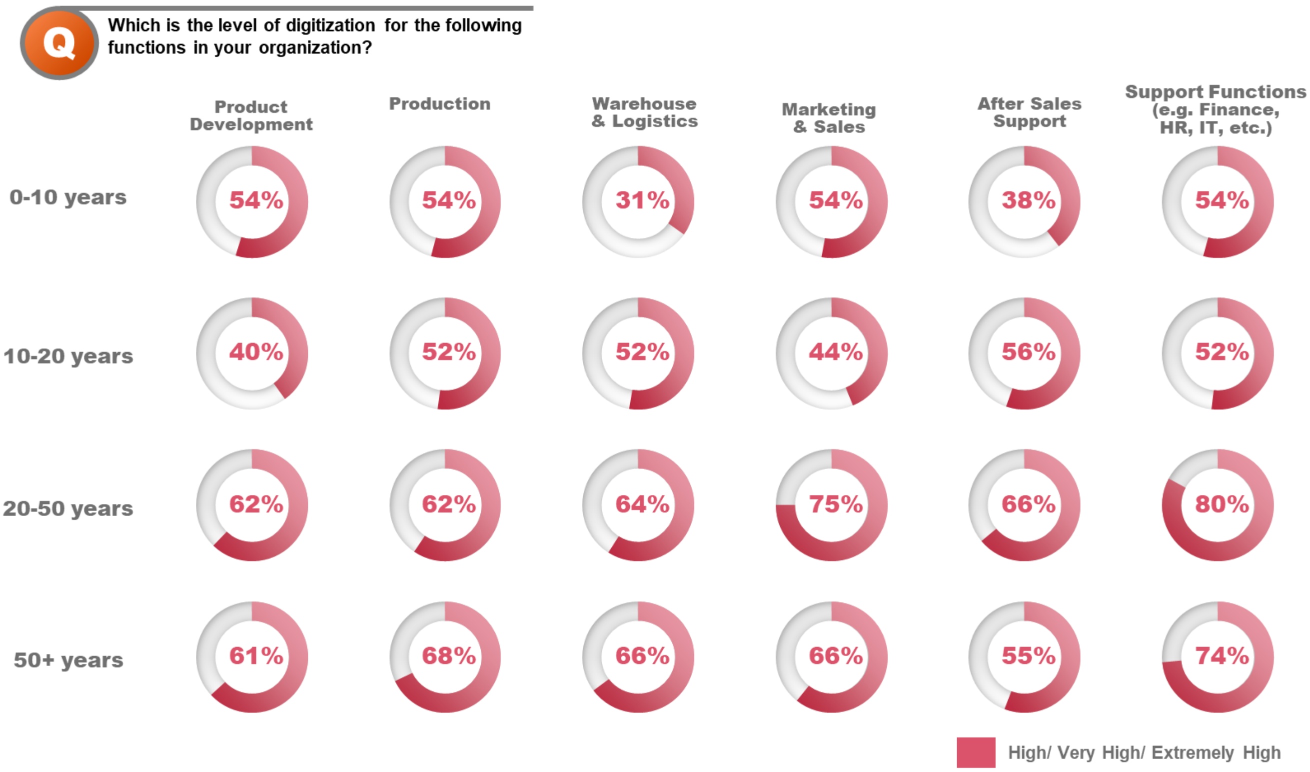


Figure 243: Greek executives' perception with regards to the level of digitisation of their organisation's functions, by Years of Operation, (%) – Source: Industry 4.0 survey

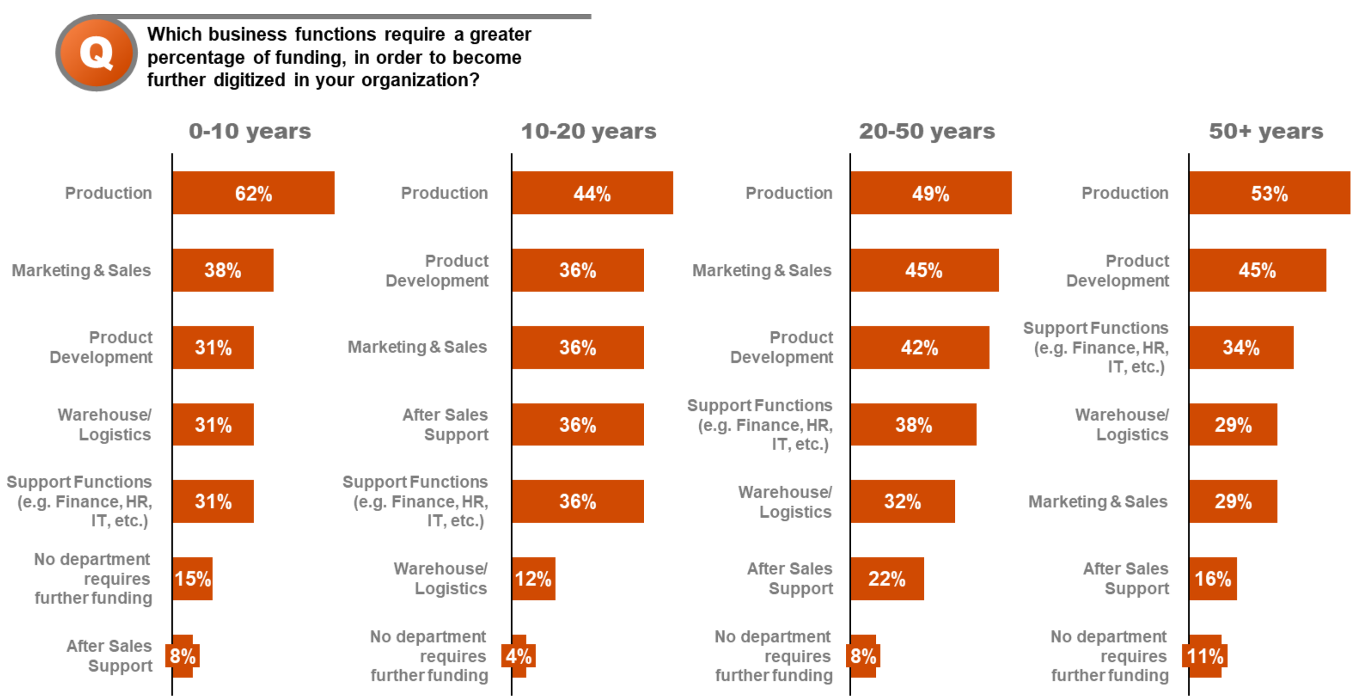


Figure 244: Funding required for further digitisation across different business functions of organisations, by Years of Operation, (%) – Source: Industry 4.0 survey

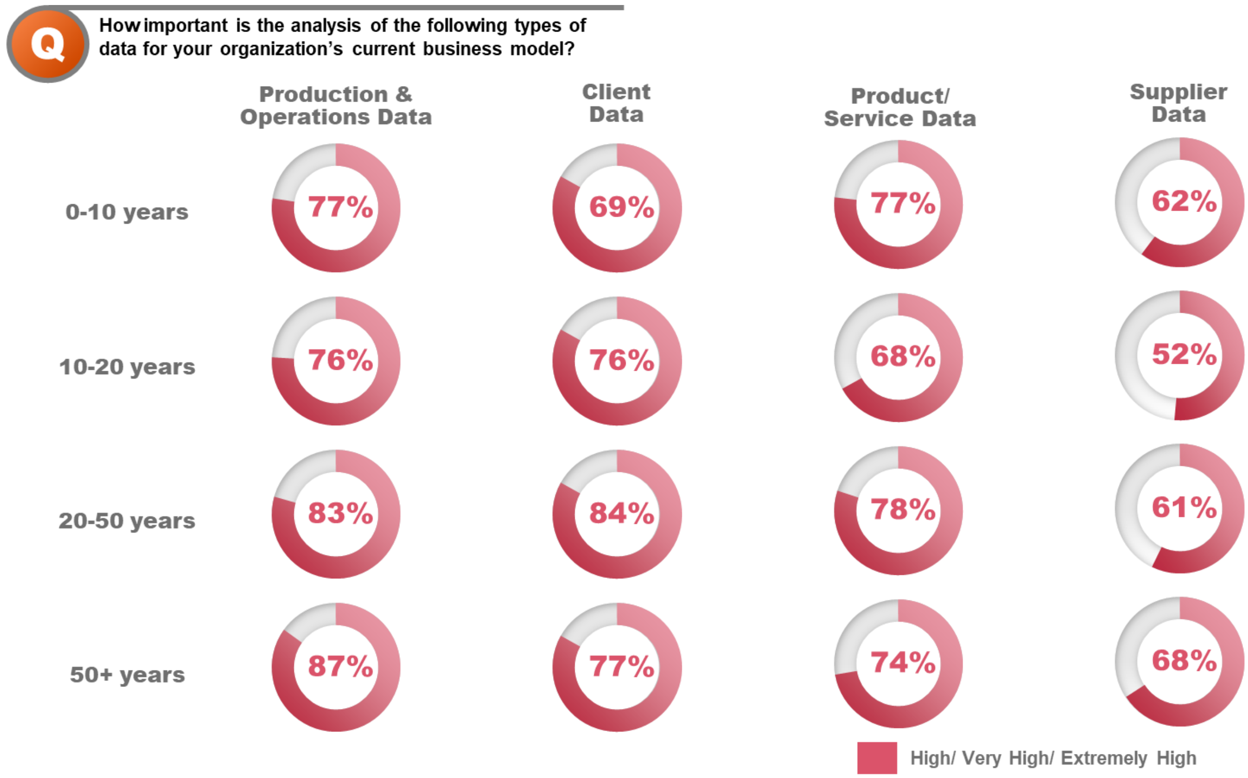


Figure 245: Level of importance of the analysis of different types of data, for the organisation's current business model, by Years of Operation, (%) – Source: Industry 4.0 survey

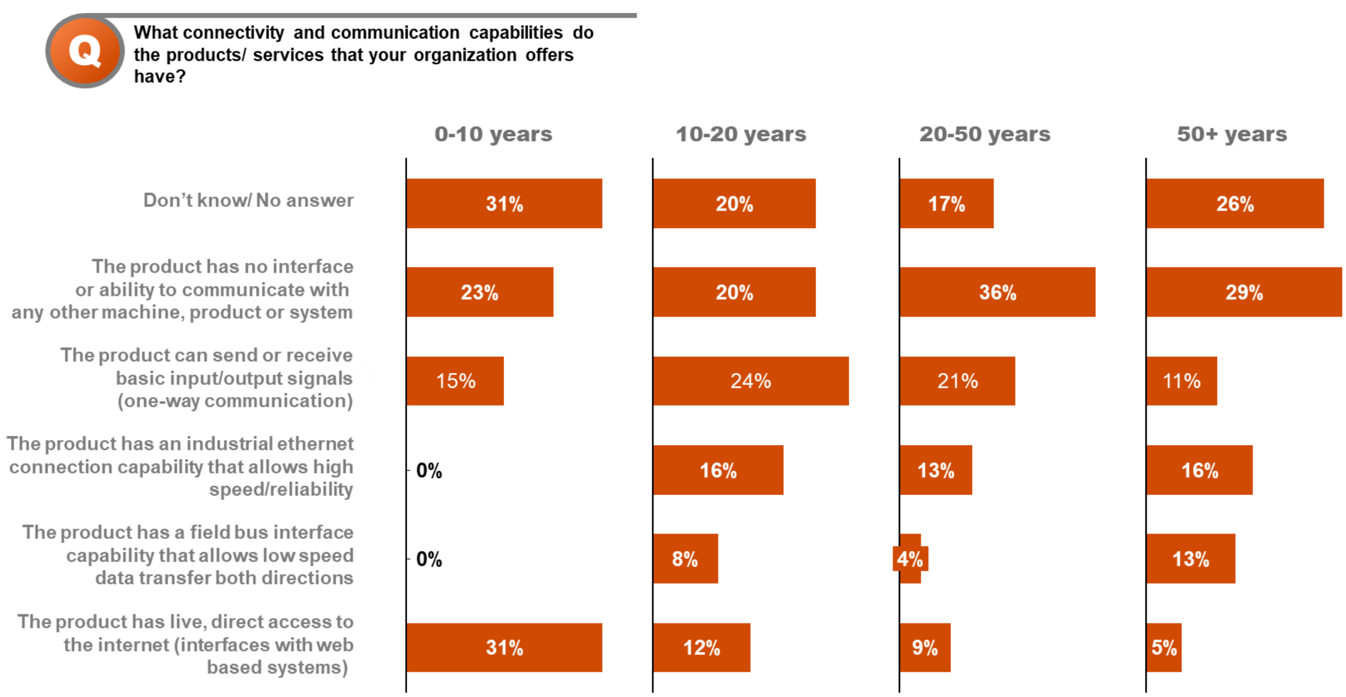


Figure 246: Degree of interconnectivity capabilities of products/ services that organisations offer, by Years of Operation, (%) – Source: Industry 4.0 survey

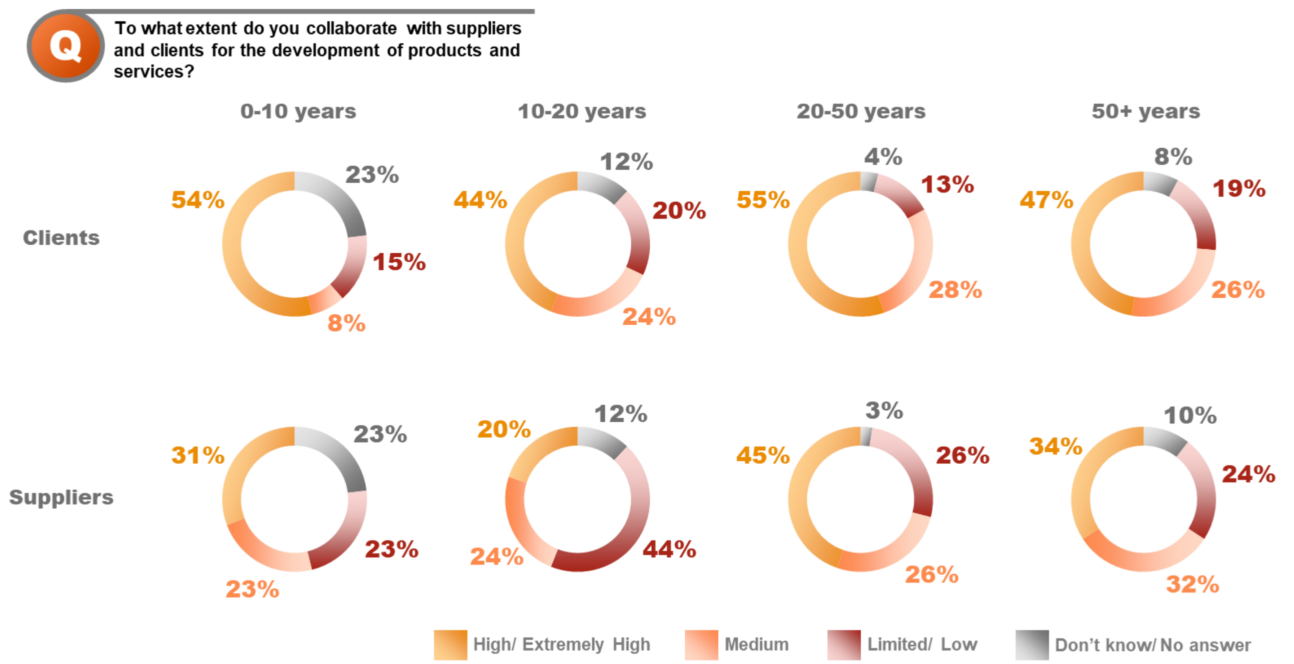


Figure 247: Degree of collaboration with partners/ suppliers for product/service development, by Years of Operation, (%) – Source: Industry 4.0 survey

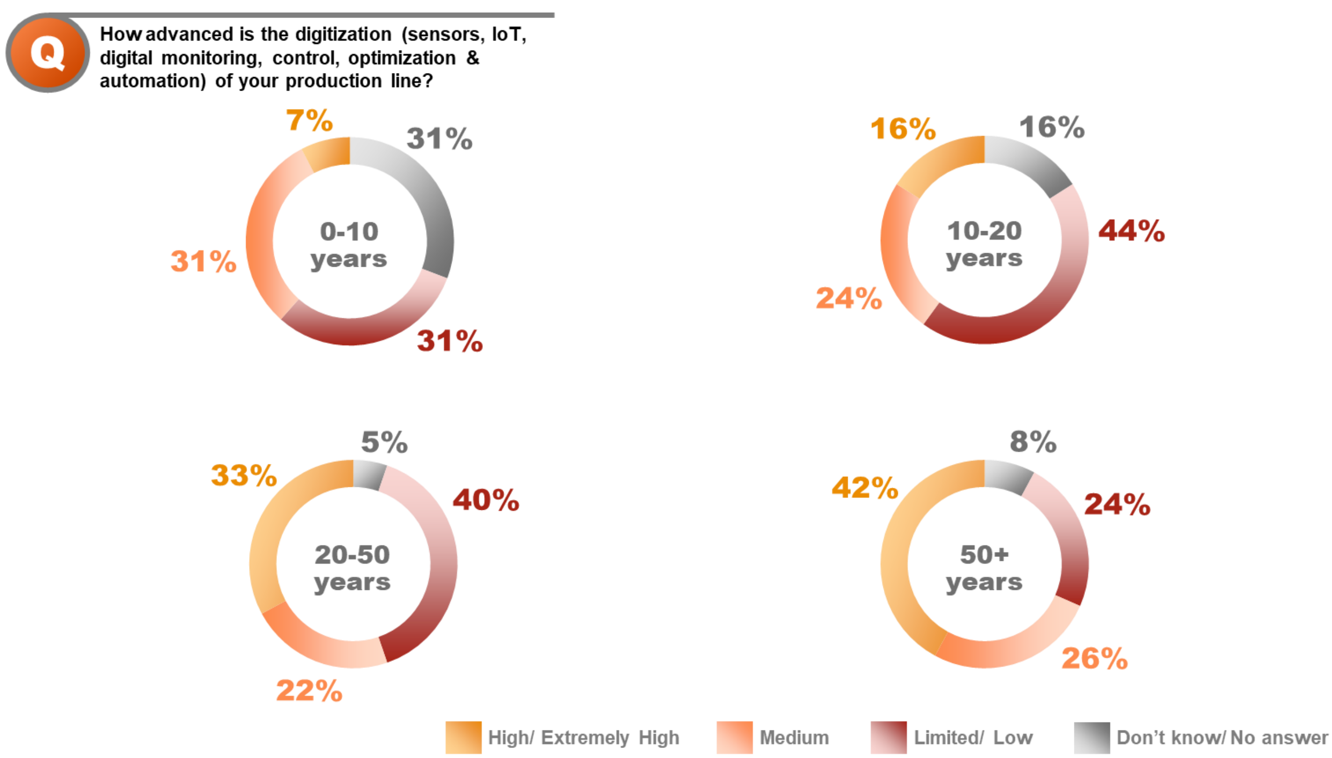


Figure 248: Degree of digitisation of the production line of organisations, by Years of Operation, (%) – Source: Industry 4.0 survey

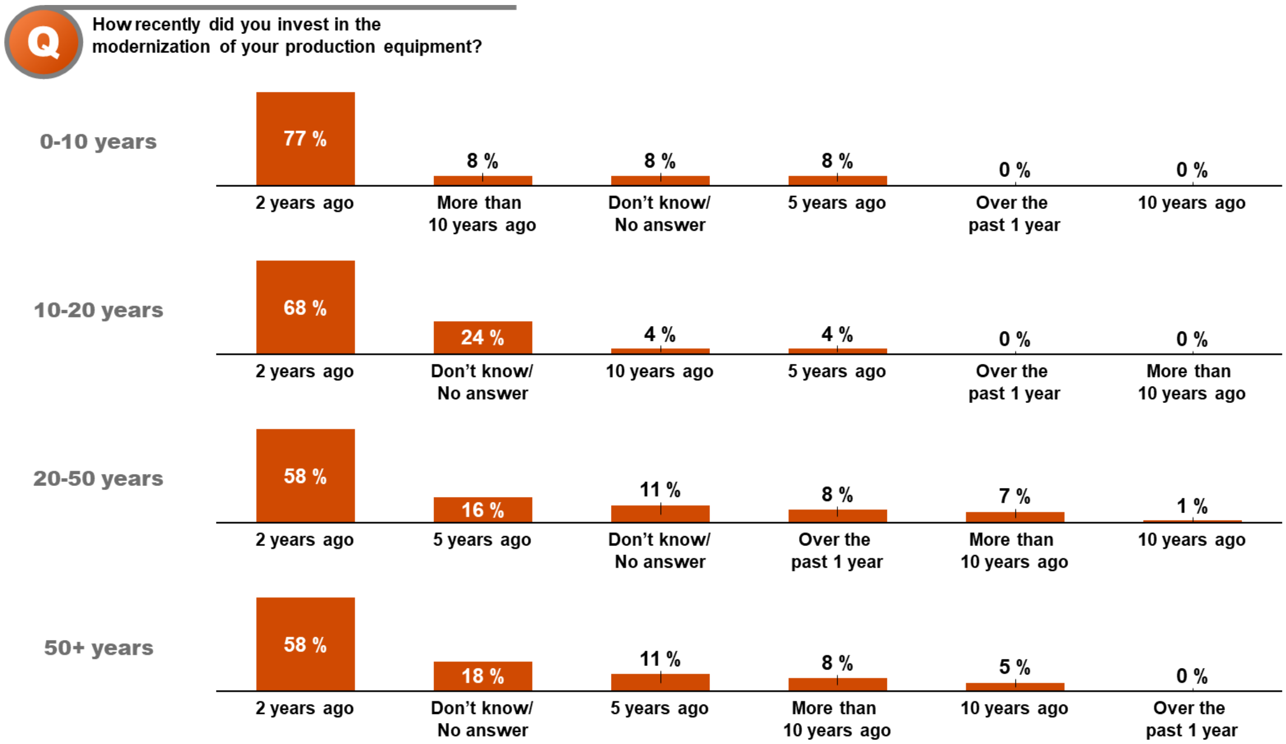


Figure 249: Last time organisations invested in the modernisation of their production equipment, by Years of Operation, (%) – Source: Industry 4.0 survey

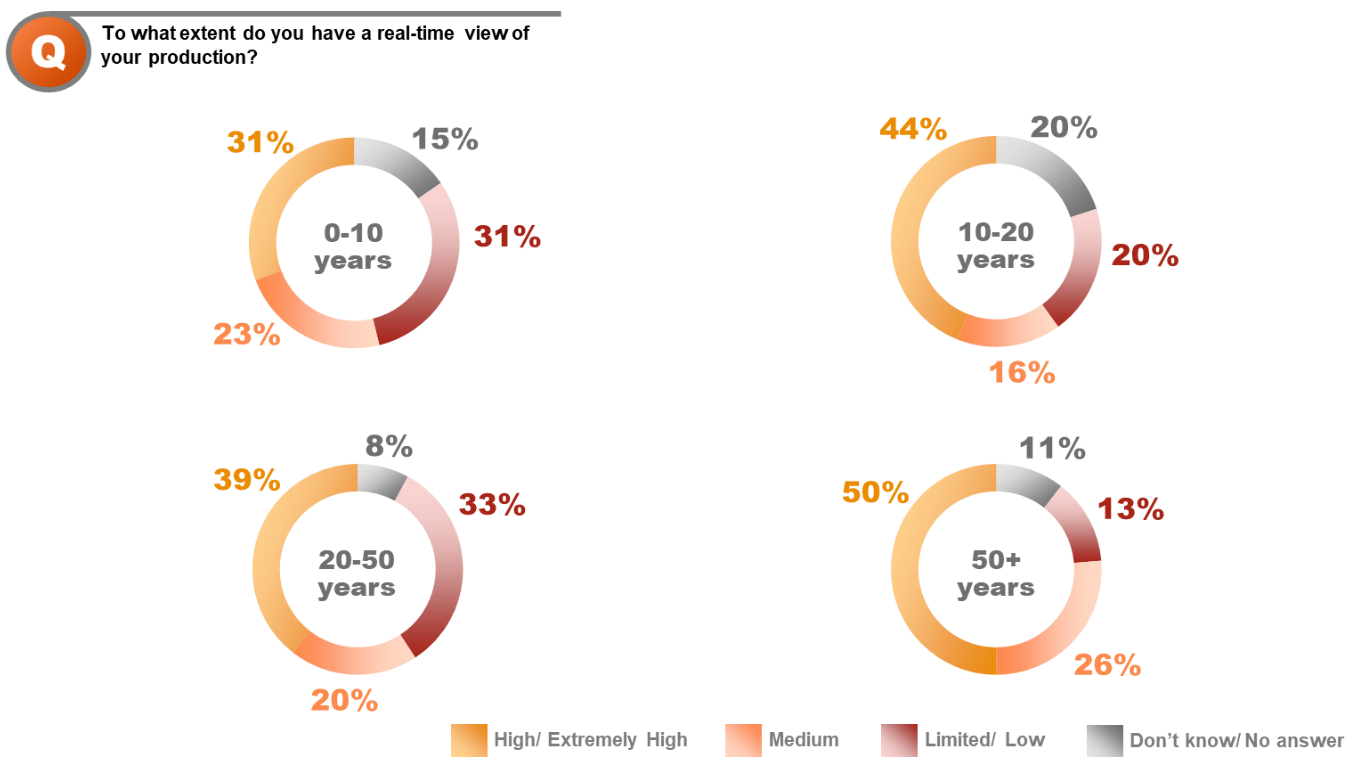


Figure 250: Degree of real-time view of production capacity, by Years of Operation, (%) – Source: Industry 4.0 survey

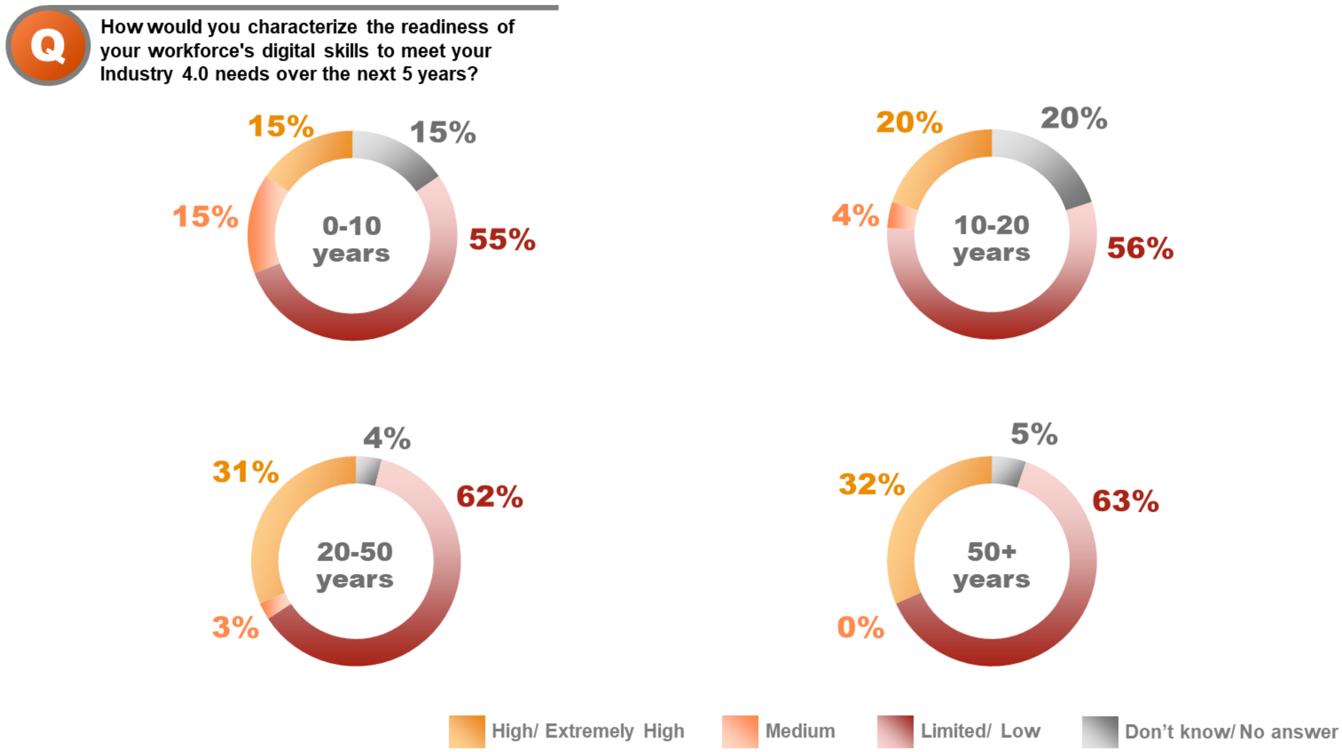


Figure 251: Degree of organisation's confidence in the current level of digital skills of their workforce, to meet Industry 4.0 challenges, by Years of Operation, (%) – Source: Industry 4.0 survey

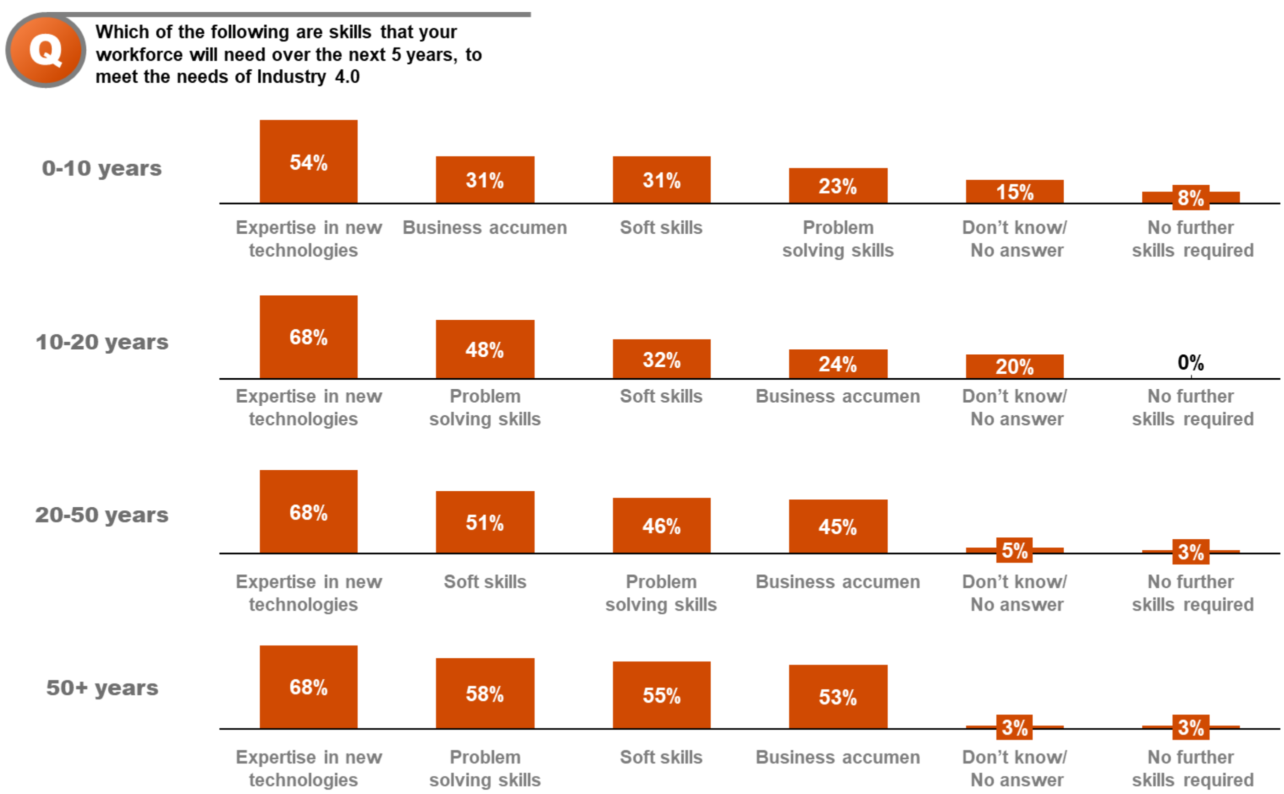


Figure 252: Level of importance that different types of skills will have with regards to Industry 4.0, in the next 5 years, by Years of Operation, (%) – Source: Industry 4.0 survey

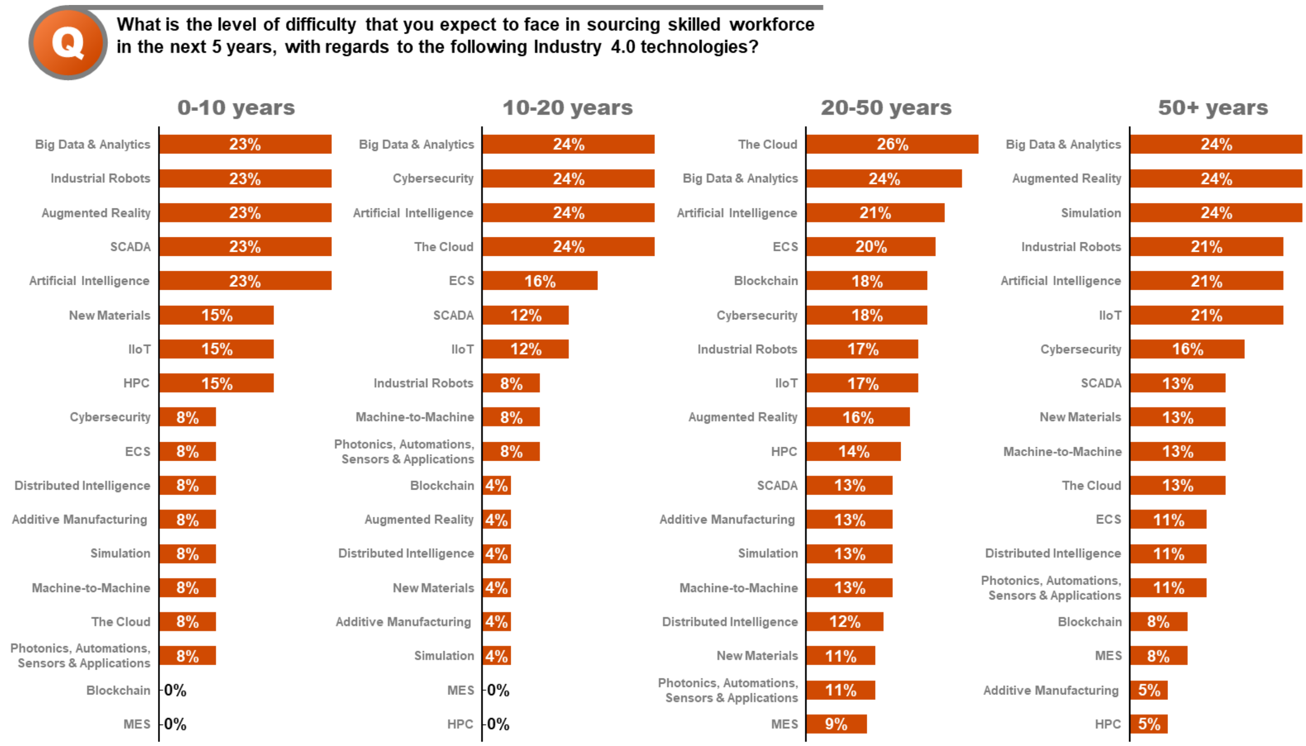


Figure 253: Level of difficulty that organisations expect to face in sourcing skilled workforce for adopting Industry 4.0 initiatives, in the next 5 years, by Years of Operation, (%) – Source: Industry 4.0 survey

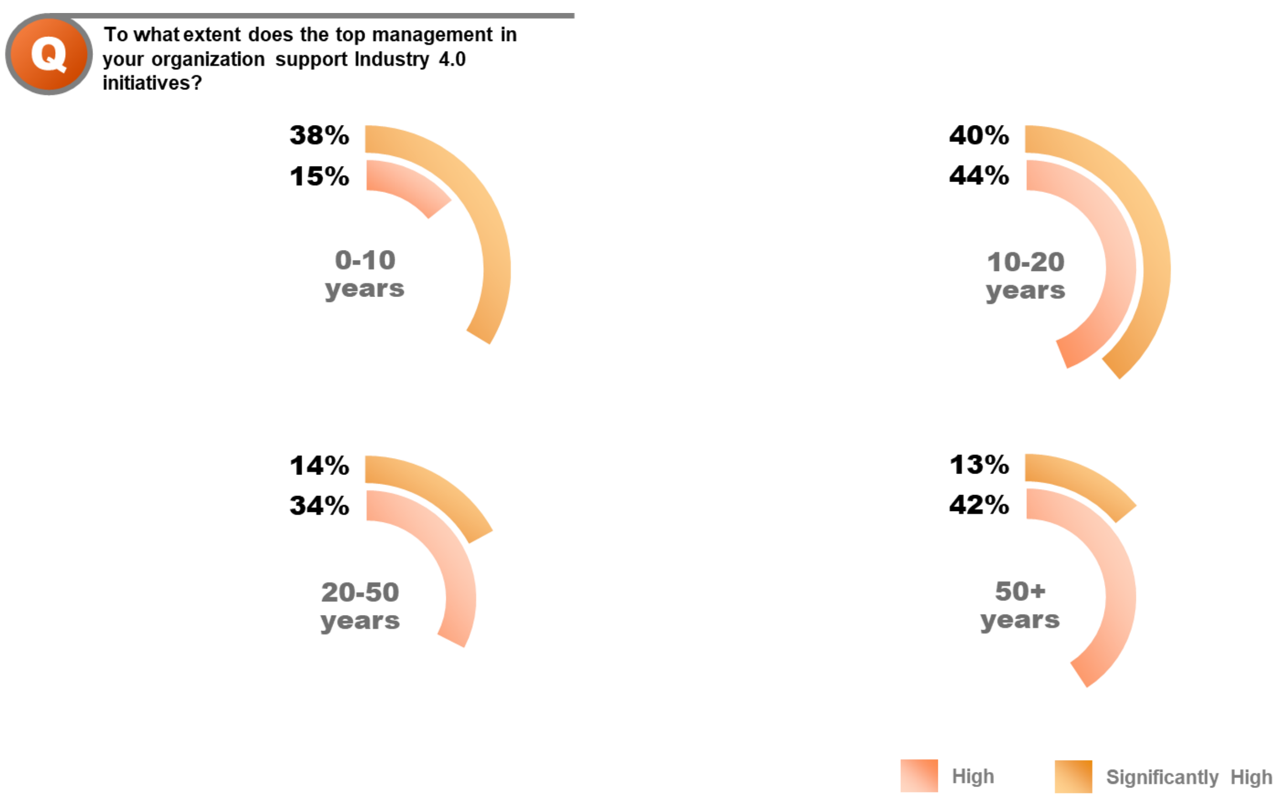
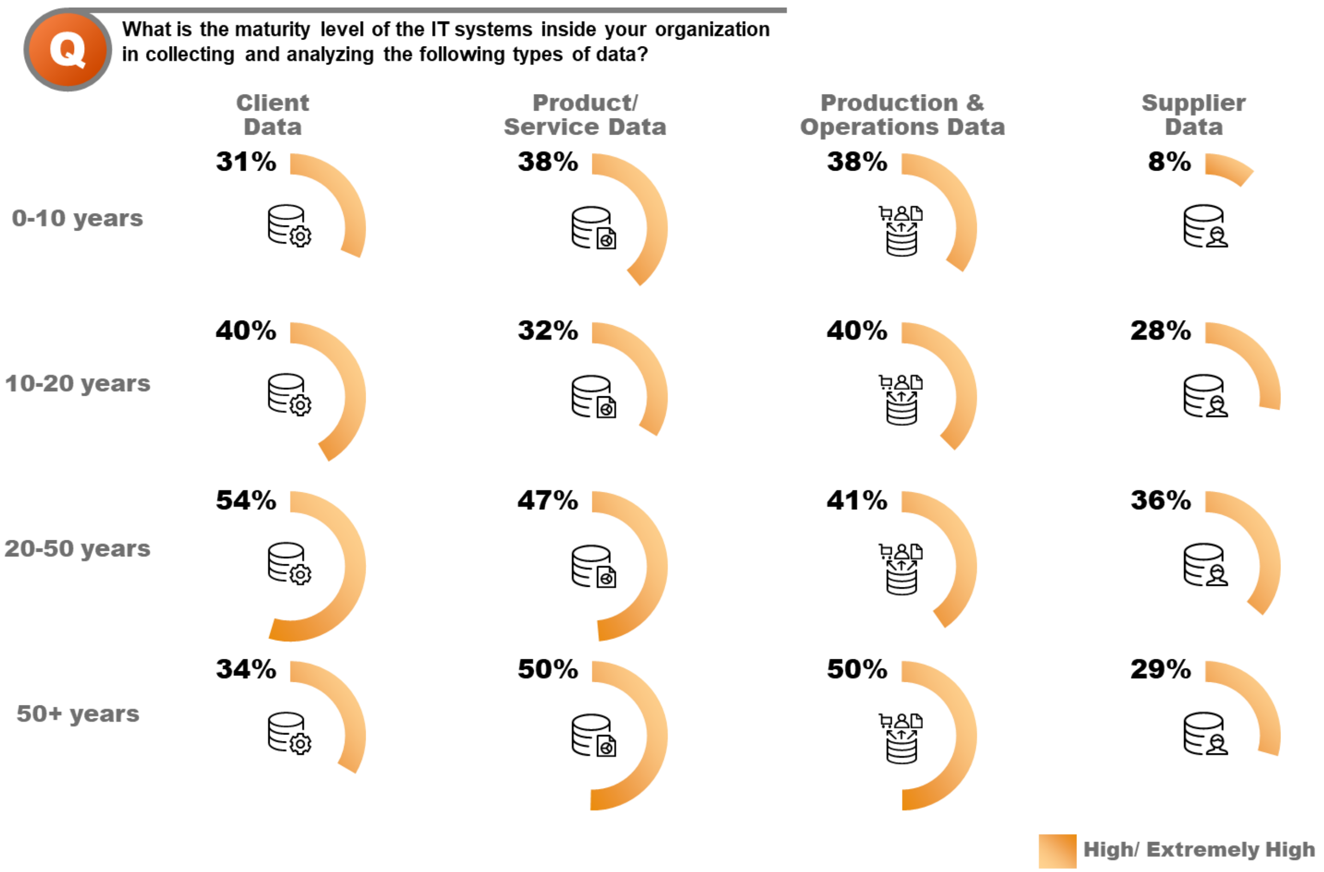


Figure 254: Degree of top management support for ongoing Industry 4.0 initiatives, by Years of Operation, (%) - Source: Industry 4.0 survey



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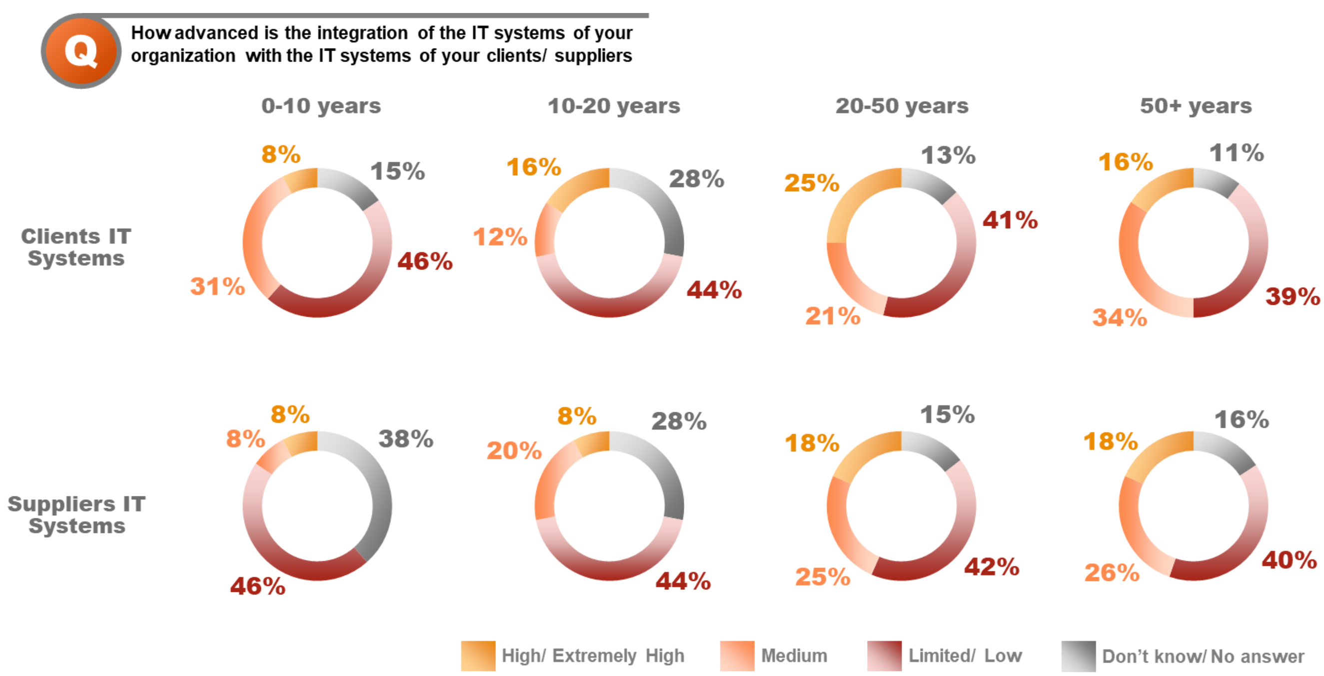

Figure 256: Degree of organisation's IT systems integration with IT systems of Clients/ Suppliers, by Years of Operation, (%) – Source: Industry 4.0 survey

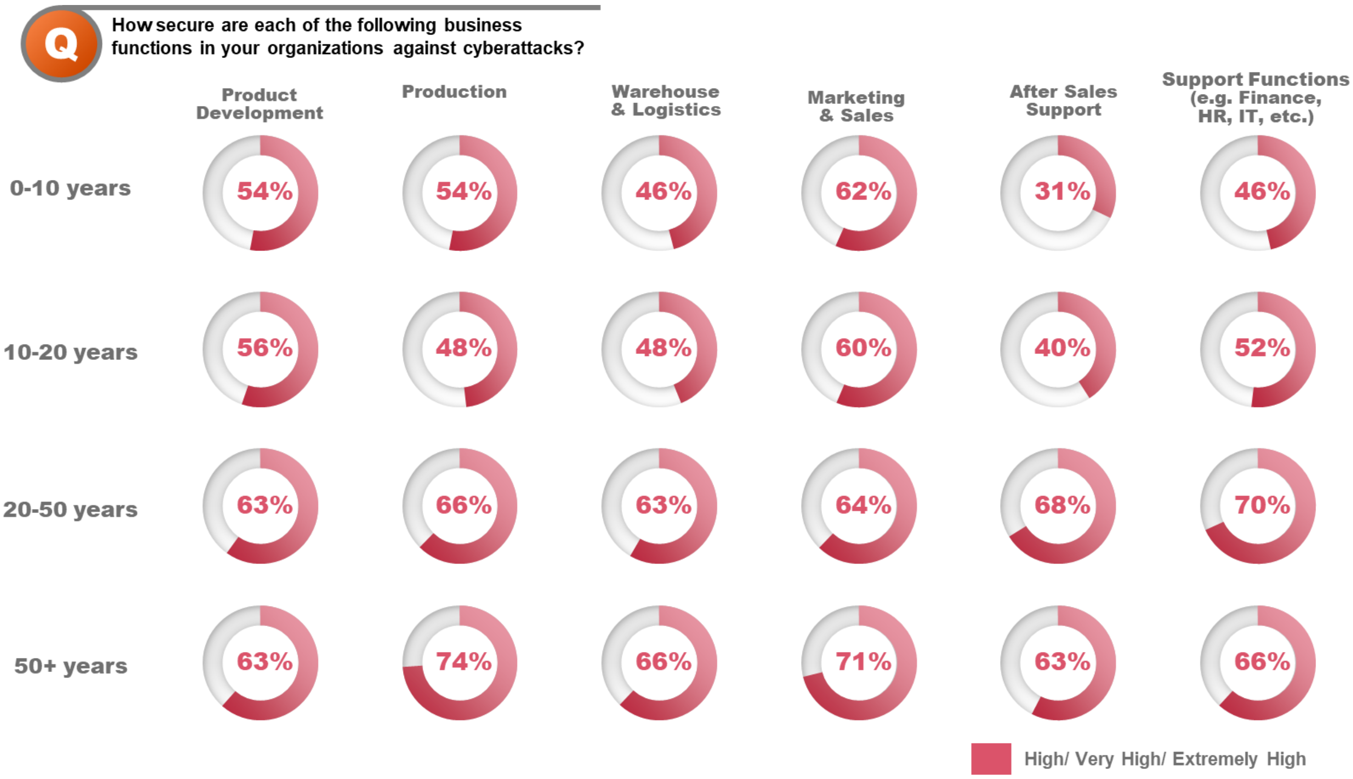

Figure 257: Degree of security against cyberattacks across different business functions, by Years of Operation, (%) – Source: Industry 4.0 survey

The current version of the document represents the 2nd Draft of Deliverable 1. This has been prepared in the context of the project "Digital transformation of the Greek Industry", for the purposes of the Deliverable 1 in accordance with the signed contract.