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H-CLOUD

Horizon Cloud – The Forum for Strategy Focused Cloud Stakeholders

Appendix 9:

Manufacturing

3 November 2020

Title	Cloud Computing in Europe. Appendix 9: Manufacturing
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1 CONTEXT

The European manufacturing industry is one of the most significant contributors to the European GDP. The manufacturing sector employed 28.5 million persons in 2017 and generated EUR 1 820 billion of value added. By these two measures, manufacturing was the second largest of the NACE sections within the EU-27's non-financial business economy in terms of its contribution to employment (22.8 %) and the largest contributor to non-financial business economy value added, accounting for more than one quarter of the total (29.3 %).

	Value
Main indicators	
Number of enterprises (number)	1 964 946
Number of persons employed (number)	28 531 905
Turnover (EUR million)	7 230 000
Purchases of goods and services (EUR million)	5 440 000
Personnel costs (EUR million)	1 110 000
Value added (EUR million)	1 820 000
Gross operating surplus (EUR million)	708 000
Share in non-financial business economy total (%)	
Number of enterprises	8.8
Number of persons employed	22.8
Value added	29.3
Derived indicators	
Apparent labour productivity (EUR thousand per head)	64.0
Average personnel costs (EUR thousand per head)	41.0
Wage-adjusted labour productivity (%)	154.0
Gross operating rate (%)	9.8

Figure 1. Key indicators, Manufacturing (NACE Section C), EU-27, 2017[1]

In the last 6-8 years, with digital transformation becoming a key priority both at the European level and worldwide, the focus has been on elevating European manufacturing industry's competitiveness by accelerating the speed of industrial transformation.

Manufacturing has a strong focus on pivoting to Industry 4.0 strategy which makes modern technologies aimed at improving speed, product and service-centric business model innovation and efficiency, a de facto choice. These innovative technologies include automation, robotics, IoT, analytics, 3D printing and artificial intelligence. Automation is a strong focus and will help companies to simplify complex tasks or processes and relieve human resources of heavy and time-consuming workloads. An important role is played by Robotics or collaborative robots (cobots) that help manufacturers achieve efficiency benefits and enable staff to save time. Efficiency gains are also enabled by Augmented Reality / Virtual Reality (ARVR) solutions that allow experts to provide remote support to on-site operators and guide them through step-by-step instructions. R&D and product innovation is another strong manufacturing priority driving experimentation with several emerging technologies. In this context, AI and Big Data/analytics are helping manufacturers to improve how they design, manufacture and deliver their products. 3D printing is also poised to grow as it will automate ways to create prototypes or new product parts, reducing production times and improving products. Product innovation is also driving adoption of advanced materials, micro and nano electronics, nanotechnologies and photonics with the aim to improve products and reduce costs.

The strong focus on advanced technologies is reflected also in the investment ensured compared with other sectors. With particular reference to AI, Big Data and Robotics, IDC forecasts manufacturing as #3 in future spending in AI and Big Data and #1 Robotics.

[1] Source: Eurostat https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Manufacturing_statistics_-_NACE_Rev._2#Structural_profile

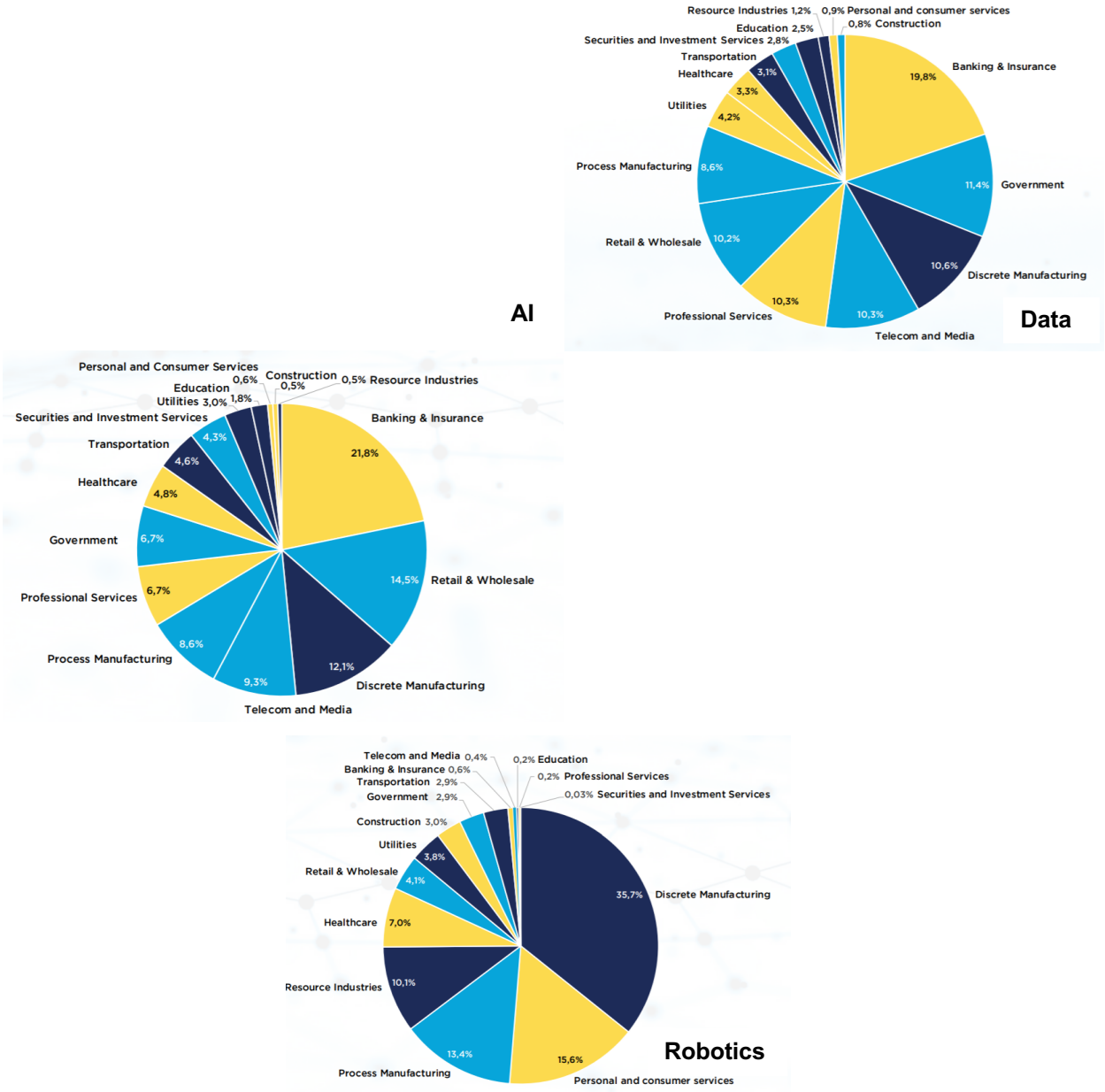

Figure 2. AI, Data and Robotics spending by Industry, by percentage of total investment, Western Europe, 2021[2]

European spending on manufacturing related technologies is expected to grow from €13.4 billion in 2020 to €19.4 billion in 2023[3].

Manufacturing is also leading in the generation and exploitation of industrial data, which is considered a key competitive advantage for Europe. On 19 February 2020, the European Commission presented two initiatives which are a part of its wider digital strategy to make "Europe fit for the digital age": a European data strategy and a white paper on artificial intelligence. The Commission plans to introduce a legislative framework for the governance of common European data spaces to facilitate the use of data for innovative business ideas in

[2] Source: IDC Worldwide AI Spending Guide, Forecast, August 2020, IDC Worldwide Robotics Spending Guide, Forecast, August 2020 and IDC Wo lrdwide Robotics Spending Guide, August 2020, Western Europe includes: AT, BE, DK, FI, FR, DE, EL, EI, IT, NL, PO, ES, SW, plus CH, NO, UK

[3] IDC Worldwide 3rd Platform Spending Guide: Manufacturing, August 2020

line with the European industrial strategy announced in March 2020 and in compliance with applicable personal data protection, consumer protection and competition laws. The Commission proposes to establish nine common European data spaces, one of them dedicated to the manufacturing sector. The creation of an Industrial manufacturing data space aims to support the competitiveness and performance of EU industry, to capture the potential value of use of non-personal data in manufacturing[4]. In such context, the Data strategy estimates that the potential value of the use of non-personal data in the sector could reach € 1,5 trillion by 2027.

[4] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy#a-single-market-for-data

2 CLOUD COMPUTING IN MANUFACTURING

2.1 Cloud computing adoption in manufacturing

Cloud computing is the underpinning infrastructure strategy that enables manufacturing to adopt and effectively implement the new wave of technology innovation. As shown in Figure 3 below, cloud and IoT platforms are enabling technologies of automated smart factories, producing smart products through smart materials and an augmented workforce, working with AR/VR (Augmented reality/ Virtual reality) tools and applications, wearables and collaborating with co-bots.

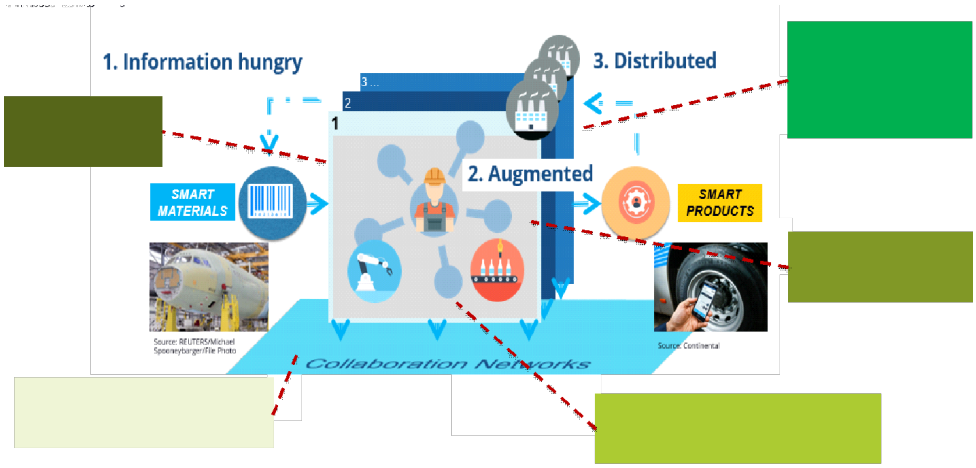

Figure 3. Smart Manufacturing vision

According to the ATI European enterprise survey, in 2019, 77% of discrete manufacturing enterprises and 65% of process manufacturing enterprises were cloud users.

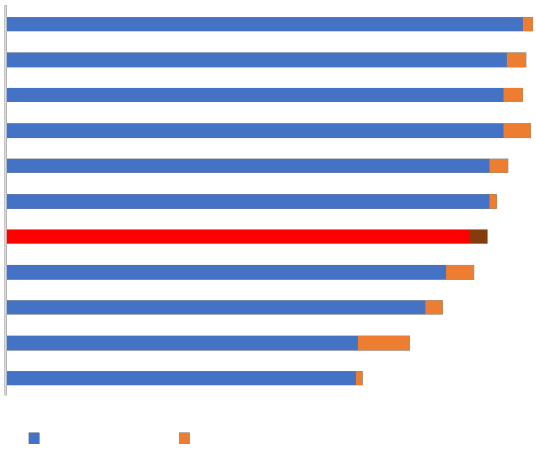

Figure 4. Public Cloud Uptake by Industry in the EU28, 2019[5]

[5] Source: IDC, ATI survey 2019, n=900, on behalf of DG GROWTH

According to a different survey carried out in a sample of Western European countries by IDC in 2020, the share of manufacturers managing IT services across multiple cloud locations and providers was already 69%, a high level of uptake showing the speed of diffusion of the trend towards more sophisticated and complex cloud management[6].

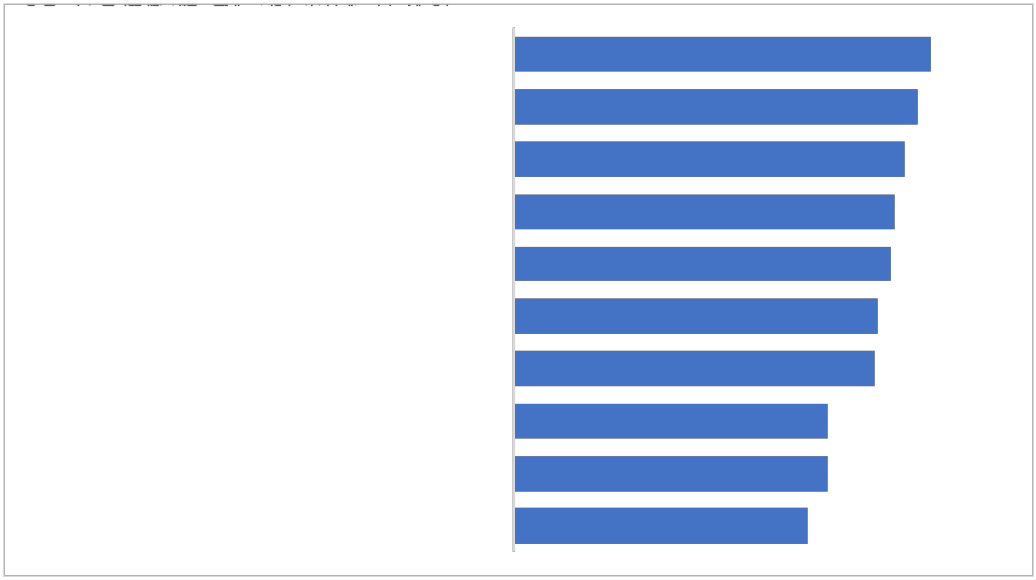

Figure 5. Technology adoption by Manufacturers Manufacturing in Europe (% of respondents)[7]

Moreover, IDC expects that by 2022, 70% of manufacturers will use cloud-based innovation platforms and marketplaces for cross-industry and customer co-development for the majority of new products and service ideas. In addition, product life-cycle management (PLM)-based cloud deployments will continue to rapidly evolve to become digital innovation platforms that support the service-centric approach of marketplaces[8].

Manufacturing enterprises are modernising their IT portfolio with a cloud focus to support industrial transformation, infrastructure and application modernization. Moving applications to a cloud infrastructure is the first step on an application modernization journey. Cloud helps manufacturers to reduce costs, adopt modern business models, provide new digital services, increase agility, optimize performance, and drive speed to market and revenue opportunities.

Cloud-based IT can enhance an organization's performance across the board – ranging from production, efficiency, through to operations. It brings in a flexible economic model to lower costs of business operations. Its role in modernizing traditional processes, such as inventory management, production capacity, and supply-demand management, brings efficiency. These systems and processes can leverage cloud-based innovation such as machine learning (ML) and analytics to identify the opportunity to shift inventory, reallocate manufacturing resources, and customize products.

It is not only used to facilitate factory transformation but also to store and manage the growing data production. To comply with EU requirements, organizations are also looking at energy efficiency and working on products that can help the EU meet its carbon footprint reduction goals. To do that, many manufacturers are deploying energy data management systems (EDMS), a tool used to collect, compress, and analyze data from various sources and output. Traditionally, EDMS is set up locally and embedded into existing infrastructures, however,

[6] IDC European Multicloud Survey - conducted in Q2 2020 and including 1,187 respondents, across Europe

[7] Source: IDC European MultiCloud survey, ibidem

[8] IDC FutureScape: Worldwide Manufacturing Product and Service Innovation 2020 Predictions

sometimes, EDMS is moved to the cloud to allow faster and cost-effective analysis of energy data.

With so much potential, it is likely that manufacturers will continue to consider cloud computing as a key enabler of their outcomes.

The convergence between operational technologies (OT) and information technologies (IT) in manufacturing represents the enabler of smart manufacturing, but also an additional factor of organizational complexity. The integration of enterprise and shop applications enable data-centric computing and smart manufacturing platforms. The main benefits of convergence include the improvement of operational performance (throughput/service reliability at same or lower costs), more efficient resource sharing, better and more comprehensive security, improved product and service quality, and of course greater agility and flexibility[9].

This convergence has been an ongoing process for several years but is now reaching the upper levels of the organization, through integrated IT/OT governance models, where investment decisions regarding control systems and execution systems are made through a shared services organization, a center of excellence (COE), or a corporate function. In addition, decision making about investment and priorities for operations is undertaken as a single unit. Within three years, 50% of European enterprises should have an integrated IT/OT governance model. In addition, IDC expects that 40% of manufacturers by 2022 will employ a cloud platform that crosses traditional IT boundaries and integrates operational technology.

2.2 Top cloud use cases

Not all use cases are equal for European manufacturing when it comes to cloud adoption as applications have different needs in terms of regulatory compliance, architecture, and organizational attributes. All these aspects have a huge impact on manufacturers' systems whether they run them in an on-premise cloud-style data centre or off-premise in hosted private cloud or public cloud services.

The need for European organizations to manage, optimize, automate, and monitor their business applications and business services in different platforms and environments is constantly growing, and SaaS is becoming the preferred option in terms of costs and simplicity. Enterprise resource planning (ERP) and customer relationship management (CRM) use cases are critical for all enterprise business model and software implementation. Within this context, these use cases are well known in the manufacturing industry as more than 20% of European enterprises have already deployed them in the cloud while a consistent 14% and 16% are planning to do so within the next 12 months.

Emerging technologies, such as the Industrial Internet of Things (IIoT), artificial intelligence (AI), and machine learning (ML) are evolving rapidly, even though they are still at an early stage of adoption in the manufacturing industry. Companies need fast iterations to develop and test new solutions, before they can be scaled. These characteristics make IoT, AI, and ML use cases not only suitable for cloud computing, in many cases implementation of these emerging technologies almost requires the use of cloud computing, since “on premise” deployments are impractical.

[9] Big Data Challenges for Smart Manufacturing, BDVA WhitePaper 2020, https://www.bdva.eu/sites/default/files/BDVA_SMI_Whitepaper_2020.pdf

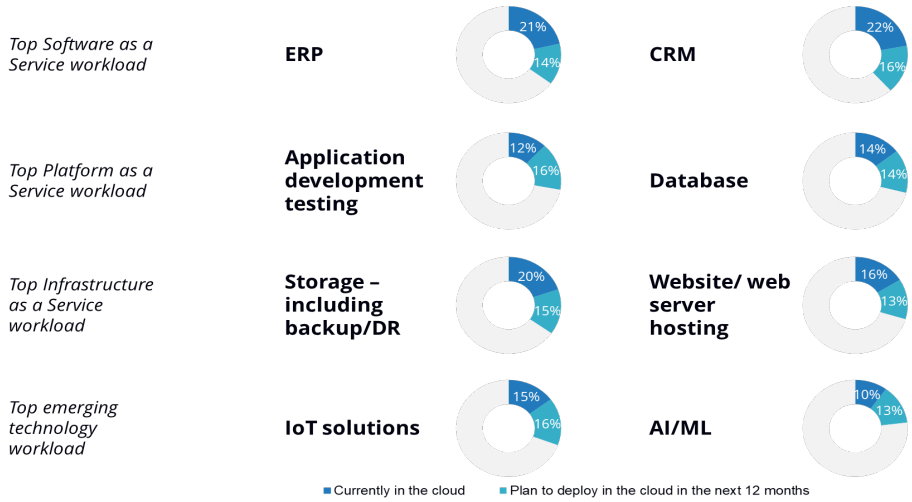

Figure 6. European Manufacturing Top PUBLIC Cloud Use Cases[10]

2.3 Industrial B2B platforms

According to IDC predictions in 2018, by 2022, 25% of manufacturers would be engaged in cross-industry collaboration, driven by rising customer expectations and competition from the platform economy, resulting in a 10% revenue increase. Among those collaborations, manufacturing companies are embracing new platform-enabled business opportunities through the creation of virtual buyer-and-seller communities, thus brokering interactions of makers and users with diverse but complementary interests[11]. Cloud-based B2B platforms, such as International Data Space, BMW's Open Manufacturing Platform, Siemens Addictive Manufacturing Network, Dassault Systèmes 3DEXPERIENCE Marketplace, fictiv, Krauss-Maffei Polymore, Volkwagen Automotive Cloud and Kloecner's XOM Materials marketplace, are flourishing across European industries (see figure x below) to[12]:

- Drive new data-driven business models.
- Share industry-specific industrial software applications on a common platform.
- Enable product and service innovations through commercial synergies in joint initiatives.
- Optimize B2B sell-side and buy-side processes.

[10] Source: IDC European Tech and Industry Pulse Survey - conducted in Q3 2019 and including 291 central and local government IT and non-IT executives, across Europe

[11]

[12] IDC, "The Open Manufacturing Platform: A Collaborative Initiative to Accelerate Innovations in Industrial Production" – July 2020 https://www.idc.com/getdoc.jsp?containerId=EUR146713020

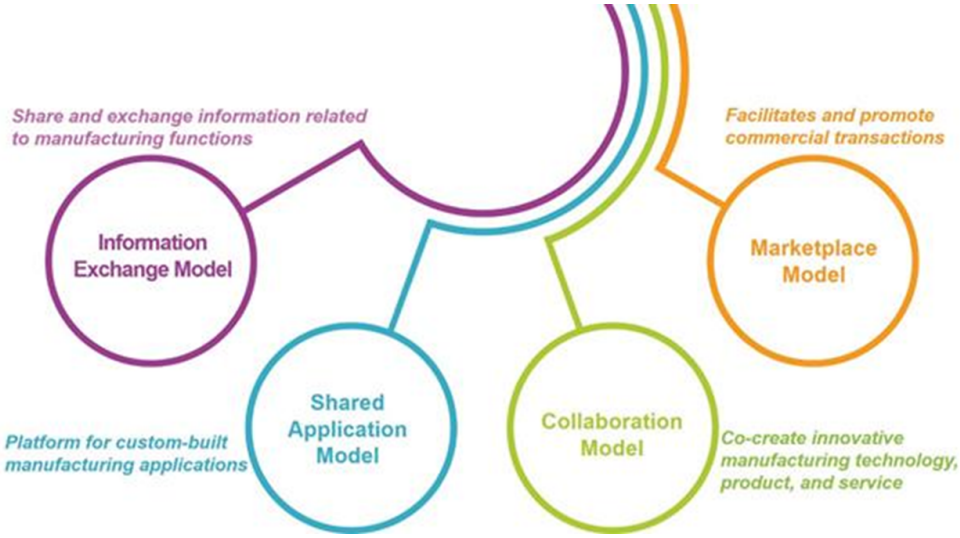

Figure 7. Four approaches for engaging in ecosystem collaboration[13]

B2B platforms have positively impacted manufacturing. For example, in industrial supply chains, digital platforms enable manufacturers to design and assemble more modular products through a co-innovation process, with their suppliers and customers. Such modularity empowers suppliers to combine short time-to-market with customisation of design and configurations that align with customer needs, even for very complex products, like airplanes[14].

[13] Source: IDC, "The Open Manufacturing Platform: A Collaborative Initiative to Accelerate Innovations in Industrial Production", ibidem

[14] TNO – Industrial B2B platforms: the race Europe cannot afford to lose, October 2019

3 CLOUD, EDGE AND AI IN MANUFACTURING

The 'edge' is one of the most talked about topics in the IT industry today, as well as a top area of strategic IT investment due to the rising number of organisations undertaking digital transformation initiatives. As a result, infrastructure functions such as data processing are expanding beyond centralised data centres. The development of edge computing is strongly influencing the cloud market.
The move to edge computing in manufacturing is gaining steam, driven by the diffusion of IoT networks and AI applications leveraging data in real-time, where edge processing is more efficient, for applications such as intelligent shop floor monitoring and predictive maintenance of smart products. Distributed datacentre and remote office and branch offices (ROBO) are currently the most frequently deployed applications across the board for manufacturing companies. Applications such as low-power computing and basic analytics and integrated/converged platforms that specifically enable key industry-specific use cases have an adoption rate that is in line with more generalist applications such as ROBO.

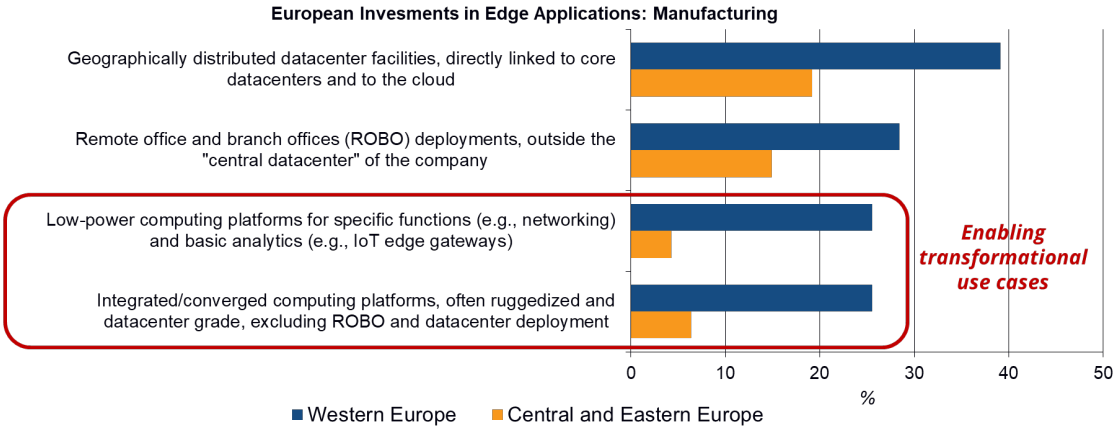

Figure 8. European Investment in Edge Applications: Manufacturing[15]

However, edge computing is not displacing cloud but becoming another component of the flexible computing infrastructure required by the extreme dynamism of the manufacturing context, which spans from edge to cloud and back. The choice to balance centralized cloud platforms and edge platforms varies depending on the type of industry and the use cases.
In this distributed environment AI is needed for resolving key challenges, such as:

- how to take into account what, where and when data is collected and analysed
- how to design services to respond to changes in application behaviour or data variability
- how to react to changes and trigger rules associated with the content of the data and models[16].

This mix of technologies is paving the way for transformational use cases emerging in manufacturing, such as real-time production control, from visibility up to "zero touch" factories, advanced quality tracking and reporting based on autonomous visual inspection, outcome-based business models, based on data streams gathered for service execution and predictive maintenance. Nevertheless, this requires considerable investments for digital technologies on the shop floor. Enterprises must have increased computing power and sensors use, as AI solutions place extensive demand on IT infrastructure. The reliable use of adaptive algorithms to implement in their shop-floor operation requires constant optimization to enhance quality

[15] Source: IDC's European Tech and Industry Pulse Survey, 2019–2020 (n = 290 respondents from manufacturing)

[16] Big Data Challenges for Smart Manufacturing, ibidem

and process efficiency. Manufacturers need to search for different approaches in which the production lines are monitored, and machines are integrated with real-time sensors, thereby gathering real-time data and checking for any defects.

In the next few years we are set to observe an even greater explosion of data being generated in the manufacturing domain and a remarkable change in the proportion of computing tasks that are performed across smart connected assets, edge and cloud. Challenges related to cloud management, data privacy and security, standardisation, interoperability and data portability, skills and organisational change need to be addressed.

- **Cloud Management Challenges:** Cloud computing is evolving fast towards an integrated approach to the development of value-added services, reflecting organisations' increasing need to seamlessly leverage edge and cloud resources from multiple cloud providers[17]. This requires new approaches, processes, and tools that link different platforms via a common methodological foundation that addresses all infrastructural layers. Over two-thirds of enterprises have created cloud centres of excellence to serve as focal points for defining business KPIs and operational processes, which are in turn used for decisions about where to deploy applications. End-user experience, cloud cost tracking, transaction health, compliance, and security policies all need to be consistent across multiple clouds and applications.
- **Cloud Data Privacy and Security:** Requirements regarding security, privacy, and traceability in cloud environments are increasing with the number of organisations involved in data-driven services, as well as with the growing complexity of distributed networks. Organisations along the value chain require more than just to connect; they must also meet all data security, protection, and governance policy requirements. When data is transferred across company boundaries, new data security and privacy challenges arise around protecting stakeholders' interests. New technologies – such as those used for distributed ledgers, homomorphic encryption, multiparty computation, and federation – can enhance security-framework traceability and privacy during cross-company data exchange and acquisition. The trade-off is that storing data (hashes and signatures) in a blockchain or distributed ledger and performing operations using homomorphic encrypted data leads to the additional consumption of computing and storage resources. These challenges must be met by suppliers and users at the industry-value-chain level, not simply at the individual-enterprise level.
- **Standardisation, Interoperability, and Data Portability:** European organisations want data and workload portability across providers and the ability to integrate cloud with legacy systems. They expect application data architectures, application logic, and user interfaces to adapt to their business processes. And they demand fine-grained elasticity at low or marginal cost, including the ability to create new workloads in emerging technology areas, such as training machine-learning algorithms and managing IoT devices at the edge, such as video cameras and environmental sensors. European suppliers must rise to these challenges and develop their offerings to respond to the outlined industry needs. Investments are needed in the development of standards and interoperability in a multi-cloud environment.
- **Skills and Organisational Challenges:** Many European entities, particularly small and medium-sized enterprises, cannot afford the technical and supplier management skills necessary to develop, deploy, and manage cloud services. Their budgeting and procurement policies and processes are geared towards a strict distinction between capital expenditure to acquire systems and operating expenditure to run them. IT operating models often rely on a centralised function that manages IT assets and services. Cloud services require a shift towards operating expenditure, which opens

[17] Cost-Efficient Request Scheduling and Resource Provisioning in Multiclouds for Internet of Things, Xin Chen, Yongchau Zhang, and Ying Chen, IEEE Internet of Things Journal, 2020

the door to shadow IT purchases from line-of-business executives and managers who do not have a comprehensive view of how their choices impact overall costs, interoperability, or system security.

4 CLOUD COMPUTING FOR SUSTAINABILITY IN MANUFACTURING

One of the key goals for future industrial production is guaranteeing the triple sustainability objective (e.g. environmental, economic and social). European manufacturers are developing circular economy strategies in order to minimize waste and reduce their carbon footprint and optimize their energy consumption by moving towards renewable energy sources. All these processes are heavily data-centric, and cloud infrastructures are often required to manage these challenges. For example, both for sustainability goals and to respond to market demands, manufacturers are investing in intelligent PLM (product life-cycle management) and SLM (Service life-cycle management) which are based on cloud platforms. The promise of AI-infused PLM and SLM is that, in concert with human analysis, the best decisions will be made during product development and service delivery, resulting in optimal customer, or consumer, experiences[18].

However, this transition is opening new challenges. According to the BDVA Whitepaper on smart manufacturing, in order to ride the *servitisation* wave, an overall interoperability between Product, Data and Services is needed as well as the development of new standards which extends the Product Lifecycle to a Service Lifecycle (and a Data Lifecycle). Then, of course, new privacy preserving and data confidentiality/sovereignty Secure Product Data Processing Architectures are needed, alongside lifecycle Product Models which are able to integrate the different stakeholders of complex long living products (such as ships, aircrafts, machinery, but also cars and smart appliances) into interoperable Product Lifecycle Data Models and for the industrial assets in standard Asset Administration Shells.

As a technology, cloud computing is potentially environmentally friendly because it minimises energy consumption through virtualisation, multicore architectures, and the efficient scheduling of resources. Concerning energy efficiency, many manufacturers are deploying energy data management systems (EDMS), a tool used to collect, compress, and analyse data from various sources and output. Traditionally, EDMS is set up locally and embedded into existing infrastructures, however, sometimes, EDMS is moved to the cloud to allow faster and cost-effective analysis of energy data.

However, the energy savings resulting from efficiency improvements are more than offset by the second order of effects of increased demand and use of cloud, with the risk of a final net increase of energy consumption driven by data centres. However, cloud service providers are constantly investing to optimize energy consumption and their carbon footprint, and to support their customers in their energy efficiency and sustainability efforts.

[18] IDC FutureScape: Worldwide Manufacturing Product and Service Innovation 2020 Predictions

5 CONCLUSIONS

The manufacturing sector plays a particularly important role in the European digital economy. European manufacturers are at the forefront of digital transformation, increasing their investment in multiple advanced technologies, playing a critical role in the emergence of the European digital economy.

The Factory of the Future is information intensive: from data-hungry factories to smart and connected products, information is created, used and distributed everywhere. In the next few years we expect an even greater explosion of data being generated in the manufacturing domain. Cloud computing is the underpinning infrastructure strategy that enables manufacturing to adopt and effectively implement the new wave of data-driven technology innovation.

According to IDC, in 2020 the share of manufacturers managing IT services across multiple cloud locations and providers was already 69%, a high level of uptake showing the speed of diffusion of the trend towards more sophisticated and complex cloud management. Furthermore, it is expected that by 2022, 70% of manufacturers will use cloud-based innovation platforms and marketplaces for cross-industry and customer co-development across the majority of new products and service ideas.

Due to extreme dynamism of the manufacturing context, use cases require flexible and efficient computing infrastructure, which spans from edge to cloud and back, creating a computing continuum, where AI is needed for resolving key challenges. Deploying and adopting seamless and interoperable cloud infrastructures to respond to demand and needs from (not exclusively) the manufacturing sector and to ensure greater data-infrastructure sovereignty in Europe is critical. However, technical and organisational challenges related to cloud management, data privacy and security, standardisation, interoperability and data portability, skills and organisational change must be solved to achieve this goal. Policy support is needed at the EU and national levels to promote the standardisation, interoperability, and sustainability of cloud offerings.