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Digital Business IoT Maturity Patterns from EU-IoT Ecosystem

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Abstract

This paper presents the state-of-the-art novel and disruptive IoT business model practices, trends, and patterns in different industries studied under the EU-IoT project ecosystem. The patterns and best practices suggest an appropriate toolbox for stimulating a higher degree of innovation-driven thinking and exploitation. In addition, results from data collection, analysis, and architectural patterns, across 30 IoT use cases and surveys distributed over different domains, companies, and technologies, are presented. These results will act as guiding beacon and impact the future European IoT ecosystem. Beyond that, this will also exemplify best practices and technologies used to harness successful IoT solutions and relevant operation aspects in different domains. Essentially, this paper targets industry, innovators, IoT learners, and policy makers, offering inspiration and providing general guidelines on how novel technologies can be leveraged in the fast-changing landscape, thereby lowering the barriers for European stakeholders to adopt best practices that cover business-techno aspects for achieving success in the IoT area.

Keywords: IoT, business model evaluation, value network, EU-IoT, use cases, best practices, technology trends and patterns, DMAT.

18.1 Introduction

IoT is one of the most promising and revolutionary technology areas for future digital applications [1]. IoT is used for a wide range of domains such as industrial automation, healthcare, education, logistics, etc., and it spans from smart things [2], [3] to smart cities [1], [4] and smart industries [5–7]. IoT is predicted to change our lives as it comes with an enormous economic potential. The IoT architecture, which is applicable for all IoT solutions, generally consists of four layers: device, connectivity, cloud, and application [8]. The evolution of IoT is more than just technologies linked together as it involves entire ecosystems that consist of both technology and business constructs [8]. IoT ecosystems include many partners and stakeholders such as hardware makers, device manufactures, network service providers, cloud service providers, software vendors, standards bodies, regulators, industry groups, customers etc. [9]. This makes IoT domain a dynamic ecosystem, which is constantly improving, evolving, and bringing new business opportunities and challenges. Therefore, companies must develop and implement new business models that can help them to create, deliver, and capture the value produced by IoT [10], [11]. In addition, companies that succeed in developing and/or adapting their present BMs to the new technological potentials have extensive opportunities to innovate and to be highly competitive in market by generating values [12].

The success of businesses at present and in future relies heavily on the optimal utilization of technology [13]. Therefore, forces around the world, such as European Commission, are pushing hard for an evolution of the next-generation internet and relevant technologies. Key drivers of this evolution include IoT [14], [15], distributed edge computing, federated AI and analytics, augmented reality, tactile internet, data-centric services, blockchain [16], distributed architectures, scalability and interoperability [17], 5G and 6G networks, etc. However, to properly support and accelerate development of the evolution, there is a need of skills development in next-generation technologies and business models for optimal utilization of novel technologies. Therefore, it is necessary to create an understanding and alignment that enables industrial actors to adopt best practices for achieving success in the fast-changing IoT landscape. For this, EU embraces several initiatives that focus on the enhancement in the proliferation of new IoT solutions and creating ecosystem around them. EU-IoT project is one such initiative of EU that has vision to grow and consolidate the NG-IoT initiative and establish a competitive advantage by overcoming the current fragmentation of efforts to succeed in the IoT landscape.

18.2 Statement of Purpose

The purpose of this study is to explore and analyze different business models and technology patterns, values, trends, operational domains, and best practices that are enabled in IoT ecosystems in Europe by analyzing data based on 30 IoT use cases/success stories, for different industries. These use cases have been studied as part of the EU-IoT project, a coordination and support action under the H2020-EU program, grant agreement ID 956671. The EU-IoT project is also involved in the development of IoT business model innovation patterns and acceleration support oriented activities. These activities can help in accelerating the adoption of IoT-empowered solutions by lowering barriers in the IoT ecosystem and by supporting different stakeholders such as industry, innovators, learners, and policy makers. This will build and enhance required IoT skills and best practices ecosystem around different IoT business models. This is achieved by providing a toolbox that offers tools, templates, methods, and recommendations needed for practitioners to unlock successful IoT business model innovation. Hence, as illustrated in Figure 18.1, it all starts with the toolbox.

This toolbox offers (self-evaluation) tools, templates and methods that are combined with a set of recommendations on how to apply the toolbox, measure, and adopt best practices for IoT business model innovation. This targets industry stakeholders and addresses both innovators that are active users of IoT technologies already, but also the learners that are late bloomers in leveraging the innovation potential of digital technologies. The main objective of providing the toolbox is to effectively support industrial stakeholders and initiatives that foster the next-generation internet while stimulating innovation-driven thinking and exploitation. This will enable different stakeholders to leverage the best practices of IoT frontrunners to build the required skills and business models innovation in their domain of interest.

18.3 Methodology and Relevant Tools

The process of reporting on best practices and business model patterns for use cases has unfolded in three steps toward achieving the previously defined

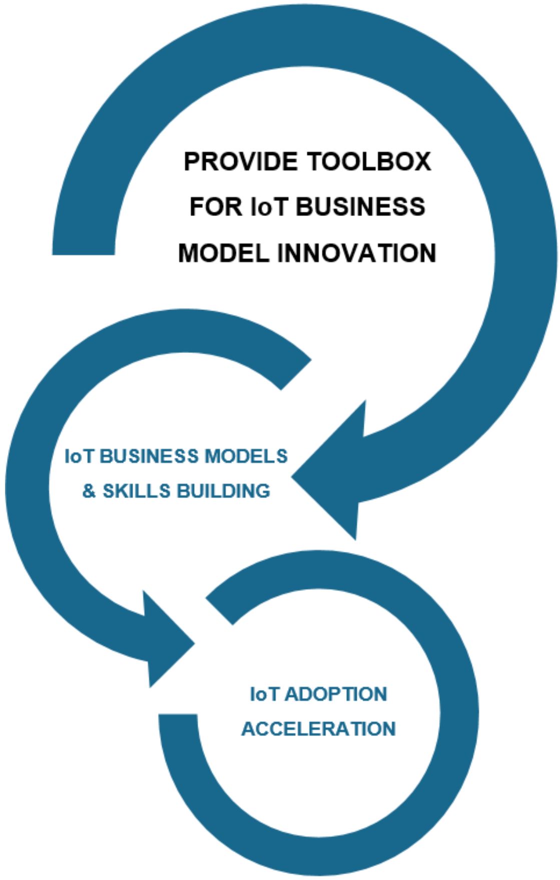


Figure 18.1 EU-IoT toolkit.

statement of purpose. The process that follows is composed of the steps that are illustrated in Figure 18.2.

Outcomes of the process include:

- Use case catalog of written success stories that introduce the explored IoT use cases. The catalog covers cases across 12 countries and 7 domains and in the scope of 18 different advanced technologies.
- Insights from analysis across all cases to identify and define archetypical factors for achieving success with IoT-empowered solutions (factors such as digital maturity levels on various dimensions, business model patterns (BMPs), and BM configurations for innovation).

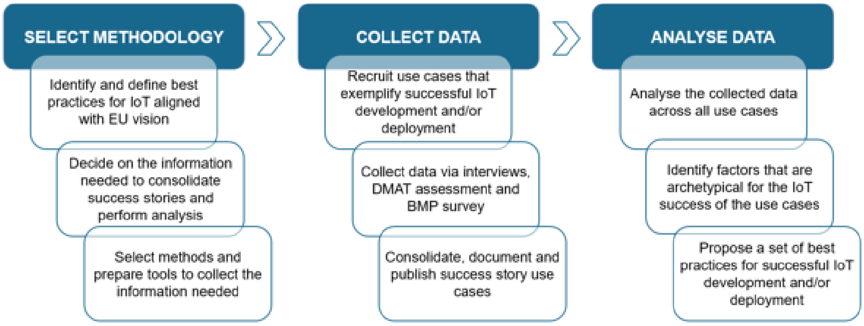


Figure 18.2 Process for reporting on best practices for IoT use cases.

- Overview that concludes upon analytical insights and sums up the identified best practices for IoT use cases, serving as a guide for successful IoT development and deployment.

18.3.1 Data collection and analysis methodologies

As mentioned earlier, this is the study of data that is collected across 30 IoT use cases and also contains findings of different surveys conducted at industry level as part of EU-IoT project. The methodology used here for collection and analysis of data relies on a range of methodological tools and techniques:

For the collection data, our research has employed a range of methodological tools. These constitute the scientific frame of reference for establishing an appropriate mechanism to gather information on best practices for IoT use cases, which includes interviews (semi-structured), digital maturity assessment tool [18], and business model pattern survey [19].

It should be noted that data collection has relied on self-assessment methodology, and results are therefore influenced heavily by the case companies' own self-perception.

For the analysis of data, our research has further employed a range of methodological techniques. These constitute the theoretical frame of reference for establishing a common understanding of the concepts that are essential in exploring best practices for IoT use cases. These techniques include digital maturity, BM patterns [20], and the configuration of BMs for innovation. The methodological tools and techniques are employed in symbiosis to explore the IoT use cases and produce the results that will be presented in the next section. The methodology is presented in a simplified overview in Figure 18.3.

18.3.2 Interviews

Information and insights on IoT use cases are derived from dialogue with the people that are/or have been severely involved in the use case. Hence, the

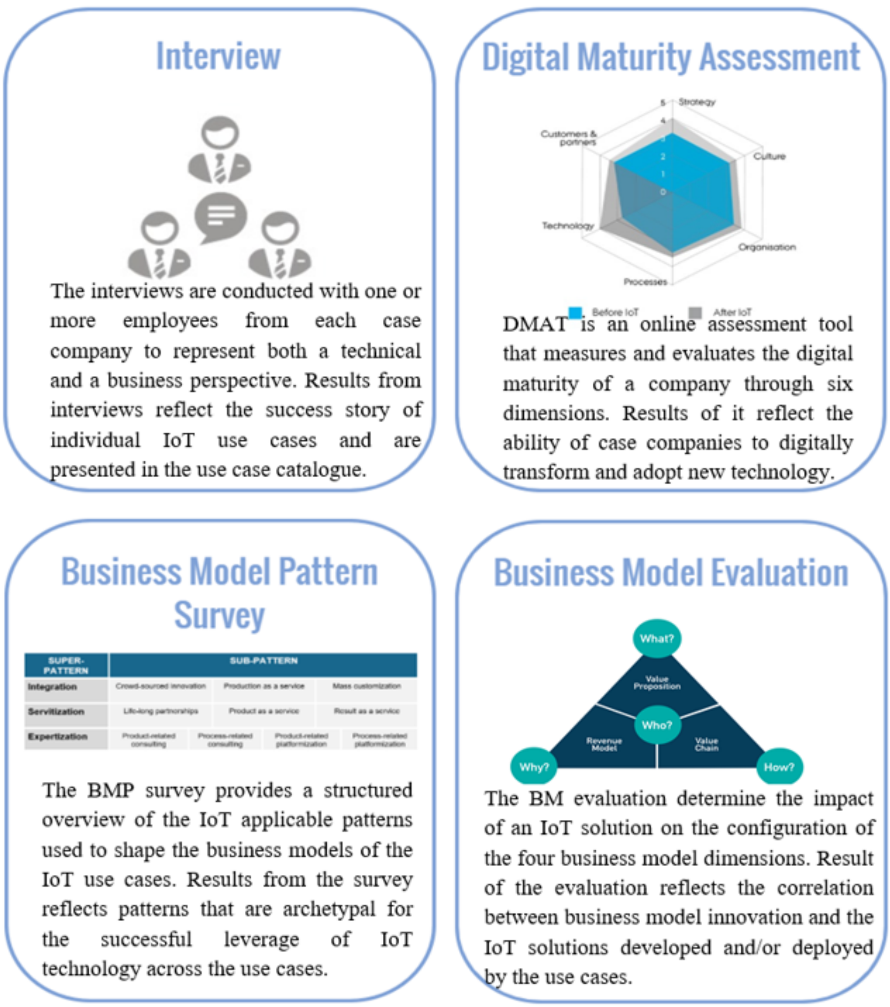


Figure 18.3 Methodological overview.

tool for data collection has been interviews based on a range of predefined questions to cover all relevant aspects and align the stories of the use cases. The methodology used for interviews was of semi-structured type. The interviews were conducted with one or more employees from each case company to ensure that their roles in developing and/or deploying the IoT solution represent both a technical and a business perspective.

18.3.3 Digital maturity assessment

The assessment of digital maturity is based on the research by Presser et al. [5], [18], and data collection was facilitated by the digital maturity assessment tool (DMAT). The term digital maturity refers to the measure of an organization's ability to create value through the implementation of digital solutions. Digital maturity is a key predictor of success for companies that initiate a digital transformation and high levels of digital maturity are often associated with having a competitive advantage. The DMAT assesses digital maturity along the dimensions of strategy, culture, organization, processes, technology, and/or customers and partners. The study takes an in-depth look at business dynamics and technological dynamics of relevance to IoT success in terms of digital maturity, BMPs, BM configuration for innovation, and technology trends. The quantitative results presented in Section 18.4 cannot be considered definitive but rather indicative for innovators and learners to achieve success in the IoT area.

Digital maturity self-assessment:

The use case cluster has been assessed for the digital maturity of their companies by scaling themselves (on a scale from 1 to 10) based on relevant questions as illustrated in Figure 18.4, and the relevant points are given below:

- **Best practice comparison:** On a scale from 1 to 10, the case companies assess themselves to an average score of 7.87. It indicates that the case companies generally consider themselves close to being **perfectly digitally mature** and close to the digital top performer(s) in their respective sector.
- **Digital maturity of organization:** On a scale from 1 to 10, the case companies assess themselves to an average score of 7.70. It indicates that the case companies generally consider themselves to be at a **high level of digital maturity**. This result is consistent with the total average digital maturity score of 7.82, which indicates that the case companies possess a great amount of self-knowledge.

Figure 18.4 Digital maturity self-assessment.

- **Digital maturity of BM:** On a scale from 1 to 10, the case companies assess themselves to an average score of 7.37. It indicates that the case companies generally consider themselves to have a **digitally mature BM**. This result, however, is lower than the self-defined digital maturity of the organization, indicating that the case companies acknowledge room for digital optimization in how value is created, delivered, and captured, in economic, social, cultural, or other contexts.

18.3.4 Business model patterns survey

The study of BMPs is based on the research by Weking et al. [19], and data collection was facilitated by a survey developed for the specific purpose of the EU-IoT project by the Interdisciplinary Centre for Digital Business Development, Aarhus University. The BMP survey is an online questionnaire that can be accessed via the online link. The patterns of a BM help us to understand the outline of the business. By using Weking et al.'s [19] taxonomy from 2020 to explore the BM patterns of our use case cluster, it is made very clear that they are all using the internet – or IT – as a fundamental source for building and innovating their BMs. The taxonomy depicts the super-patterns: **integration** that innovates its BM around new processes, **servitization** around new products, and **expertization** around a hybrid of products and processes.

18.3.5 Business model evaluation – innovation and configuration

The evaluation of BMs is based on the research by Gassmann et al. [21], and data collection was facilitated by the combination of the employed methodological tools. The concepts of BM innovation and BM configuration are explored with the theoretical framework of St. Gallen University [21], as shown in Figure 18.5, which depicts four dimensions that are the minimum requirements to define a BM. The four dimensions of a BM describe the rationale of how an organization creates, delivers, and captures value. This can be summarized as follows:

- WHO (customer) – Who are the target customers of the solution?
- WHAT (value proposition) – What does the company offer the customers? (Value design tool is the point of departure.)
- HOW (value chain) – How does the company, together with other partners, create this solution?
- WHY (revenue model) – How does the company create value in the form of revenue?

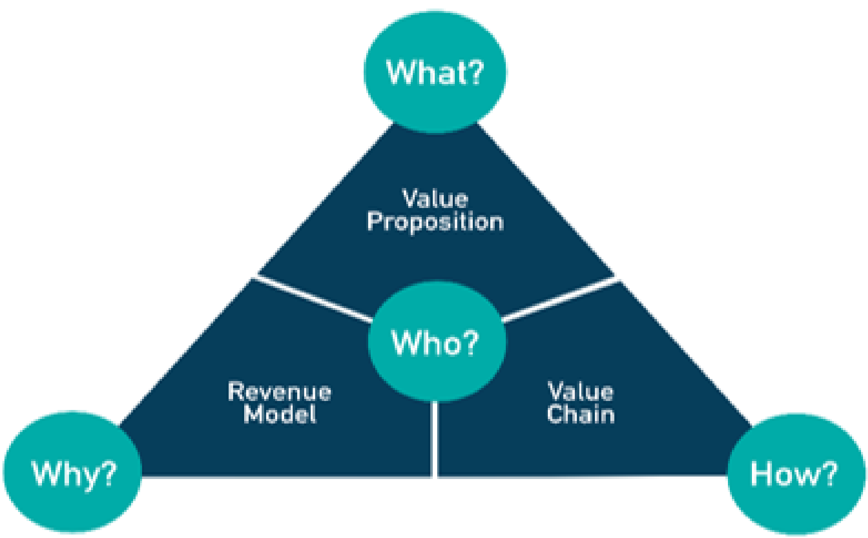


Figure 18.5 St. Gallen magic triangle.

Ultimately, the configuration of the dimensions is a plan for the successful operation of a business, and it provides the conceptual structure that supports the viability of the business. BM innovation is the process of reinventing or enhancing the BM by making simultaneous, and mutually supportive, changes to the dimensions.

18.4 Results and Analysis

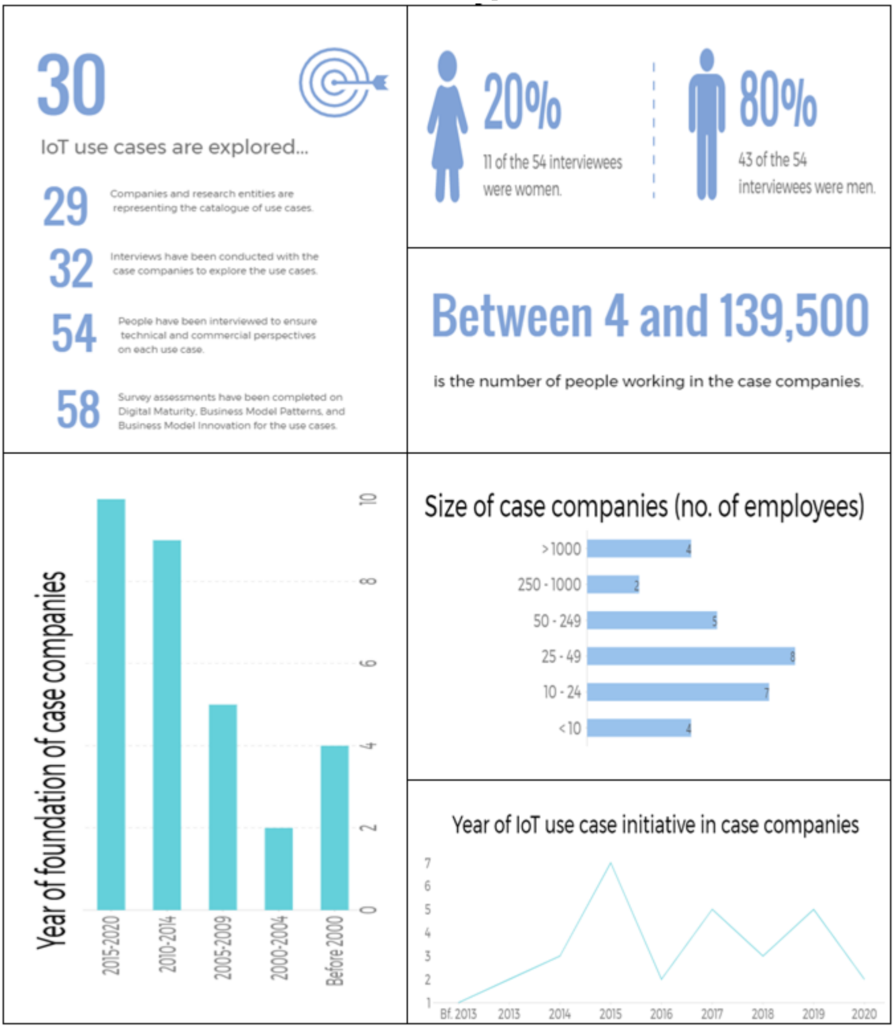
This section will provide the results from data collection across the cluster of IoT use cases explored under the EU-IoT. The findings presented are gathered from the interviews conducted following semi-structured approach, and assessments of digital maturity dimensions, technology trends, and BM patterns using methods explained in Section 18.3.

18.4.1 Use case companies overview

The results cover a broad overview of the 30 IoT use cases, and background information on the case companies that have been selected as suitable units of analysis. To establish a complete picture of best practices for IoT use cases, data has been collected both qualitatively and quantitatively to ensure that the exploration considers both the individual specifics of the cases and the collective totality of the cluster. To make the data sources visible for the exploration as the foundation of our findings on best practices for IoT use cases, the case company details have been presented in Table 18.1. The people who represent the case companies are varying in gender, age, and professional role in the organization. All are, or have been, severely involved in the IoT use case, and all were volunteered interviewees. The cluster of case companies represent varying sizes measured on personnel numbers wherein 80% of the case companies can be defined as SMEs (i.e., having less than 250 employees), and the cluster thereby represents the backbone of European economy well, where 99% of all businesses are in the defined group of SMEs.

Some relevant information to consider in the exploration of best practices for IoT includes the timing of significant milestones achieved by the case company with regard to the use case. All the case companies covered in the cluster were founded between 1935 and 2019, with the average year of founding being 2006. Hence, majority of the case companies are founded in the most recent decade, with precisely 63% in the period 2010–2020. All the use cases covered in the cluster were initiated between 2007 and 2020,

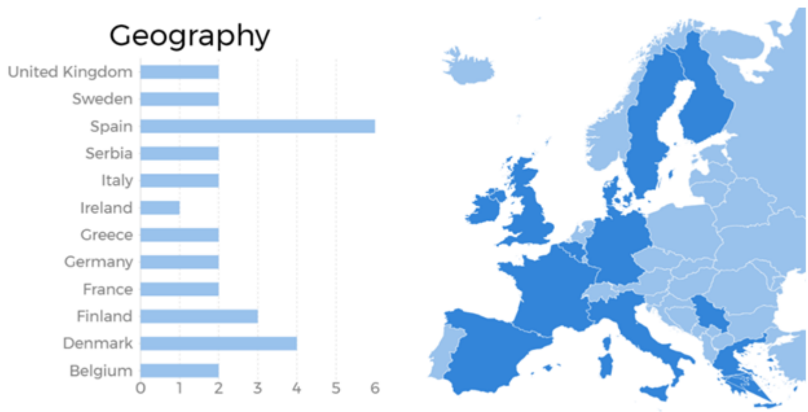
Table 18.1 Data overview of case companies and related information.



with the average year of founding being 2016. 80% of the IoT use cases were initiated in the period from 2015 and onwards. Only one of the 30 use cases was initiated before 2013.

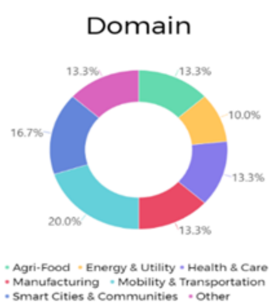
Data insights:

Table 18.1 (Continued.)



Use case geographical distribution

Note: In a business use case, the case company generates valuable impact by leveraging IoT technology in a solution, and in a technology use case, the case company generates valuable impact by offering IoT technology as a solution. Hence, Business use cases focus on IoT as value creation, and Technology use cases focus on IoT as value proposition.



The use cases are distributed across the six key domains. The seventh domain 'Other' covers cases in the areas of telecommunications, cyber security and cross-domain application.

- The data indicates that the corporate world has started to realize the value of developing and/or deploying IoT technology during the recent decade.

This reflects the increasing trend and overall growth in IoT solutions in the European landscape.

- None of the explored IoT use cases were initiated after 2020, which may indicate that a period of some years must occur after the initiation of an IoT initiative to mature it into a successful use case.
- Majority of best practice companies seems to be born digital and are founded on the basis of an IoT initiative, or adopts an IoT initiative within a short period of time after foundation.

18.4.2 Digital maturity

Digital maturity has been assessed to explore how successful IoT development and deployment interlinks with the digital maturity of a company. Based on an assessment of 30 use cases, the digital maturity patterns, studied for different companies, have been described in this section. It is found that the overall digital maturity score is 7.82 as highlighted in Figure 18.6 and the domain specific score is shown in Figure 18.8. The digital maturity (on a scale from 1 to 5) is mapped out on the six dimensions defined by the DMAT methodology, and the average distribution across the dimensions is illustrated in Figure 18.7. Across all case companies, **culture** is the most digitally mature dimension, and therefore likely to be a driver of digital competitive advantages.

Processes is the least digitally mature dimension and therefore likely to contain digital development areas. It has been observed that companies in the **manufacturing domain demonstrates the highest level of digital maturity**, whereas case companies in the energy & utility domain along with case companies in the **mobility & transportation domain demonstrates the lowest level of digital maturity**. In case of digital maturity across domains, the average distribution across the dimensions is illustrated in Figure 18.9. All domains are least digitally mature on the **processes** dimension.

Data insights:

- All domains are most digitally mature (DMAT score $>$ 7) on the strategy, technology, and customers & partners dimensions. This means they are more digitally mature than the average for their respective sector and have exceptional abilities to digitally transform and to adopt new technology.

Figure 18.6 Digital maturity score across use case companies.

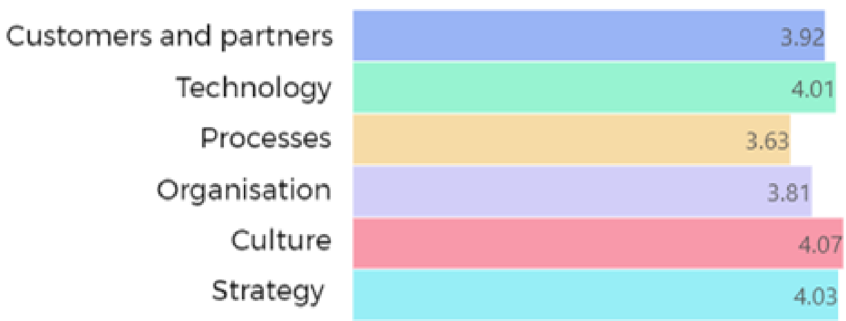


Figure 18.7 Digital maturity dimensions distribution.

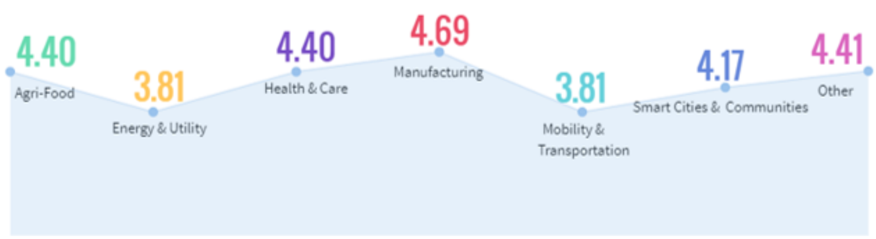


Figure 18.8 Digital maturity across domains.

- **Strategy** is likely to be the driver of digital competitive advantages for case companies in agri-food, mobility & transportation, and other, as this is the most digitally mature dimension of these domains.
- **Technology** is likely to be the driver of digital competitive advantages for case companies in health & care and smart cities & communities, as this is the most digitally mature dimension of these domains.

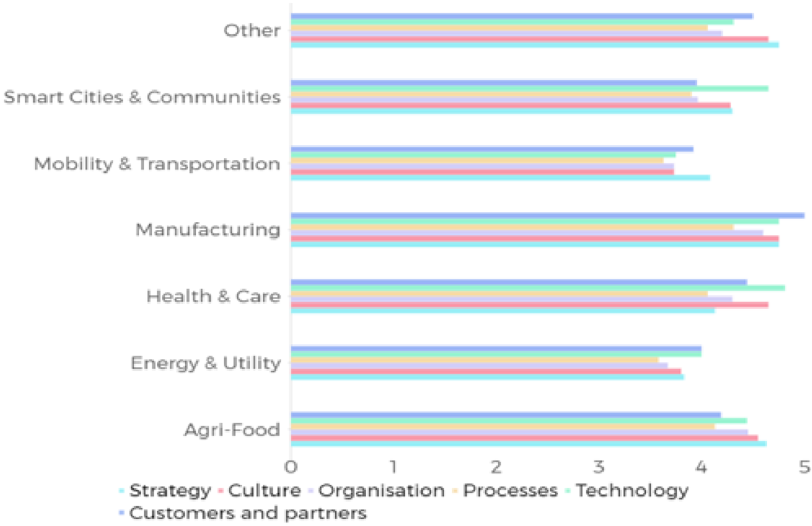


Figure 18.9 Digital maturity dimensions distribution across domains.

- **Customers & partners** is likely to be the driver of digital competitive advantages for case companies in manufacturing as this is the most digitally mature dimension of these domains. The same is true for energy & utility, although in combination with the technology dimension.
- **Culture** is the most digitally mature dimension on average across all domains. However, it does not apply to any isolated domain.
- The most digitally mature dimension differs across domains and includes strategy, technology, and customers & partners, indicating that these are the main drivers of digital competitive advantages.
- The data indicates that the digital capabilities of the use case cluster are vastly mature, which may be explicated by the origin of many of the case companies being born digital.
- The data indicates that **manufacturing** is the most digitally mature domain whereas **energy & utility** and the **mobility & transportation** are the least digitally maturity domains.
- **Processes** is the least digitally mature dimension across all domains, indicating that it is a digital development area for all companies regardless of domain.

18.4.3 Business model patterns

BMPs have been surveyed to explore how the BMs of use cases that successfully leverage IoT technology are shaped by IoT applicable patterns.

Figures 18.10 and 18.11 illustrate a distribution of the BM super and sub-patterns that have been archetypal for the IoT use case cluster. Majority of the use cases are characterized by the BM super patterns **servitization** and **expertization**. Only one of the 30 cases is characterized by the super pattern **integration**, and two cases cannot be characterized by any of the patterns suggested by the taxonomy.

- **Integration** implies that innovation initiatives made by the case company typically devote to new processes. This company strives to cover more activities in the value chain rather than specializing on a single step and/or selling directly to customers via online channels.
- **Servitization** implies that innovation initiatives made by the case company typically devote to new products or services. These companies strive to become a solution provider by offering new product support services instead of selling solely tangible products and/or integrating sensors into products.
- **Expertization** implies that innovation initiatives made by the case company typically devote to a combination of processes **and** products or services.

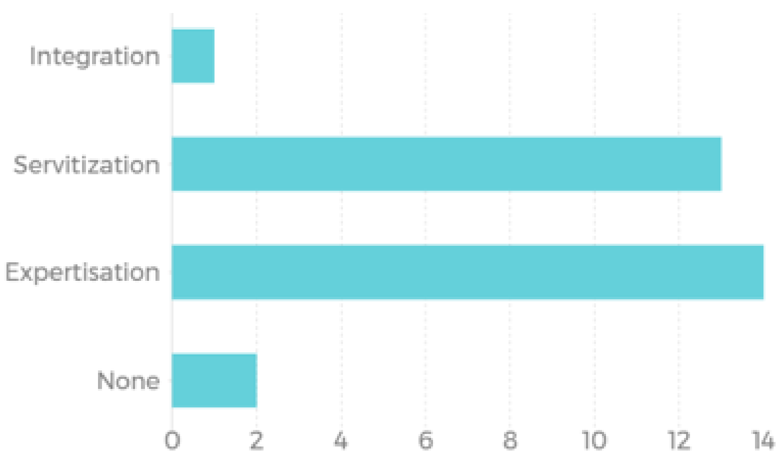


Figure 18.10 BM super patterns.

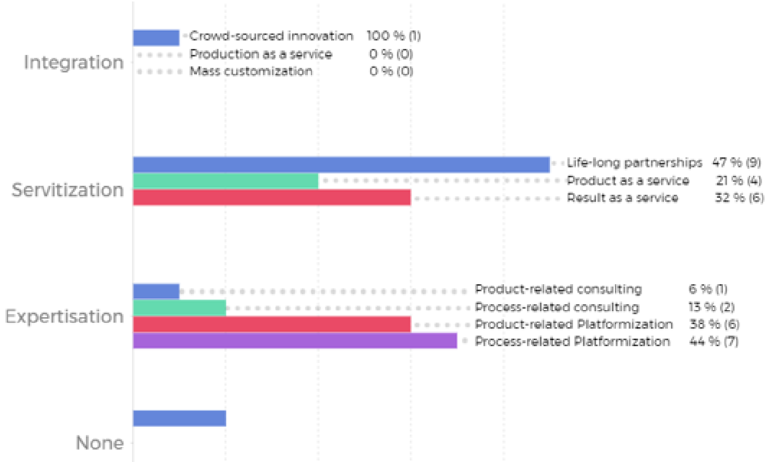


Figure 18.11 BM sub-patterns.

Table 18.2 Total distribution of business model patterns.

SUPER-PATTERN	SUB-PATTERN			
Integration *3 % (1)*	Crowd-sourced innovation *4 % (1)*	Production as a service	Mass customization	
Servitization *43 % (13)*	Life-long partnerships *32 % (9)*	Product as a service *14 % (4)*	Result as a service *21 % (6)*	
Expertization *47 % (14)*	Product-related consulting *4 % (1)*	Process-related consulting *7 % (2)*	Product-related Platformization *21 % (6)*	Process-relate Platformizatio *25 % (7)*

**Note that two of the 30 use cases cannot be characterized by the patterns suggested by the taxonomy, and percentages are therefore calculated based on the remaining 28 cases.*

These companies strive to apply internally built expertise and know-how in products, processes, or as a service. Table 18.2 is showing the BMP distribution in terms of super and sub-pattern classification. The results are showing that the **servitization** and **expertization** super patterns are trending in the industry. Under sub-patterns, **life-long** partnership is the highest choice of demand that the customer looks from the service provider of related product under servitization.

18.4.4 Business model innovation and configuration

BMs have been evaluated to explore how successful development and deployment of IoT solutions correlate with the configuration of the four BM dimensions and BM innovation. Figure 18.12 illustrates the total distribution of BM dimensions that have been subject to significant change, i.e., which specific dimension(s) in the case company BMs that were impacted by the development and/or deployment of the IoT solution.

Figure 18.13 shows the distribution of BM dimensions impacted per domain by the development and/or deployment of the IoT solution.

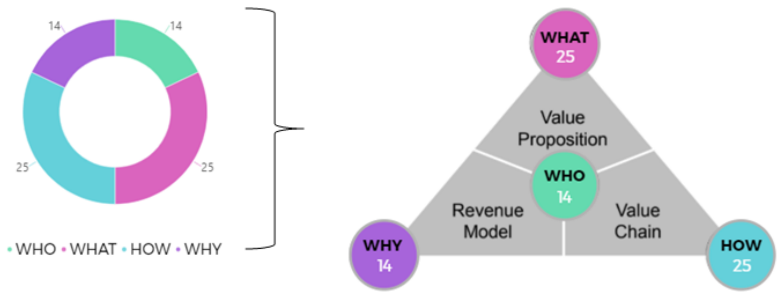


Figure 18.12 BM dimension distribution.

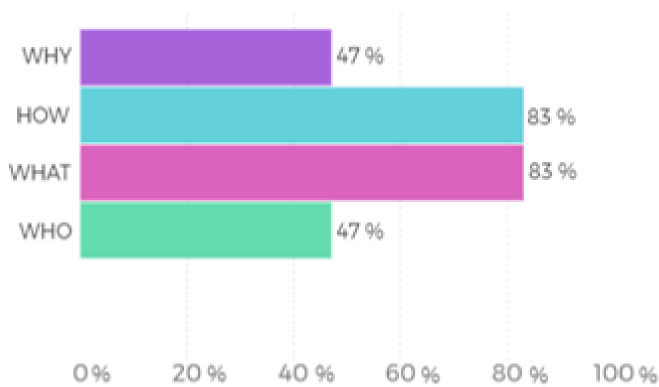


Figure 18.13 BM dimension impact.

Data insights:

- The **target customer** was impacted in 47% of the cases by the IoT development and/or deployment. Hence, the WHO of the BM has changed significantly for 14 of the 30 case companies.
- The **value proposition** was impacted in 83% of the cases by the IoT development and/or deployment. Hence, the WHAT of the BM has changed significantly for 25 of the 30 case companies. This means

the value proposition is typically the dominating subject of significant change in the domains agri-food, health & care, and smart cities & communities.

- The **value chain** was impacted in 83% of the cases by the IoT development and/or deployment. Hence, the HOW of the BM has changed significantly for 25 of the 30 case companies. The value chain is typically the dominating subject of significant change in the domains **manufacturing** and **other**.
- The **revenue model** was impacted in 47% of the cases by the IoT development and/or deployment. Hence, the WHY of the BM has changed significantly for 14 of the 30 case companies.
- The **four dimensions** are never equally impacted by the development and/or deployment of the IoT empowered solution. Only one or two dimensions can be simultaneously dominating subjects of significant change.
- The **WHO and WHY** dimension are rarely dominating subjects of significant change. These are either equally or less impacted than the **WHAT and WHY** dimensions.

To determine the correlation between BM innovation and the development and/or deployment of an IoT solution, we have explored the concept in alignment with the theory proposed by the University of St. Gallen [21], defining the occurrence of BM innovation with the occurrence of significant change in at least two of the four BM dimensions. The outcome of BMI is shown in Figure 18.14. Figure 18.15 illustrates the number of dimensions in the BM of the case companies that are impacted in specific domain by the development and/or deployment of the IoT solution. Figure 18.16 illustrates the number of dimensions in the BM of the case companies that are impacted

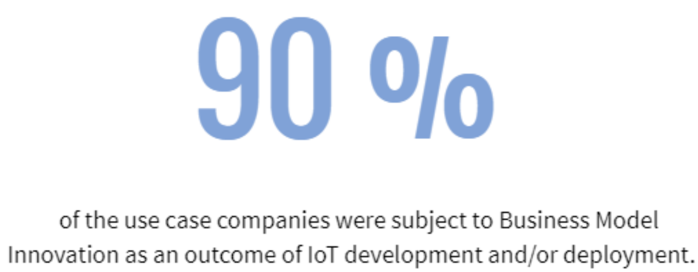


Figure 18.14 BMI outcome.

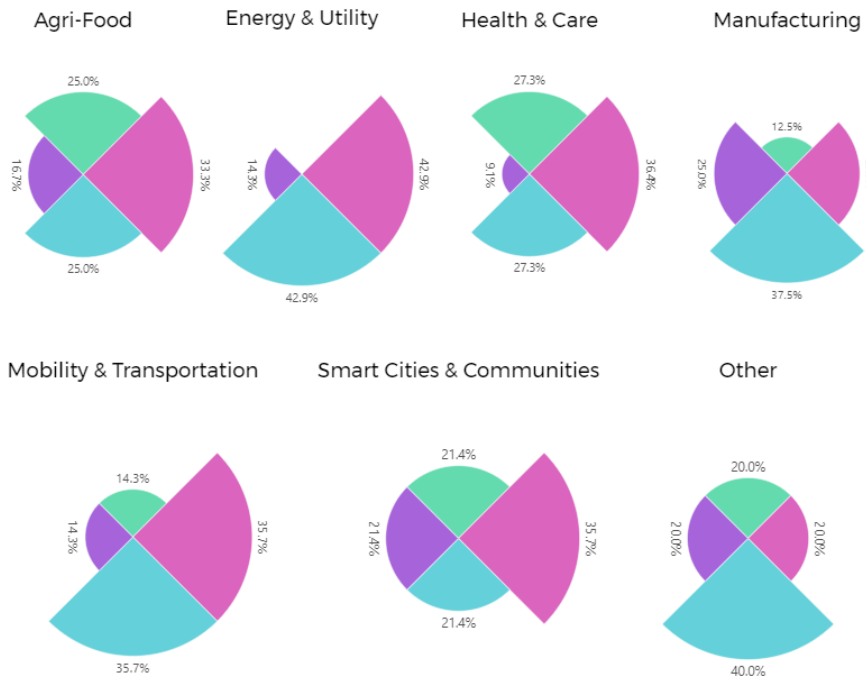


Figure 18.15 BM dimension impact across domains.

by the development and/or deployment of the IoT solution – distributed across domains. Figure 18.17 illustrates all the BM configurations of the case companies, i.e., the combination of BM dimensions that are impacted by the development and/or deployment of the IoT solution. The BM dimension combinations WHO-WHAT-HOW-WHY, WHAT-HOW-WHY, and WHAT-HOW are the most popular configurations that are subjected to significant change, as an outcome of the case companies' IoT development and deployment.

Data insights:

- Almost half (43.4%) of the case companies were impacted on two BM dimensions, and almost a fourth (23.4 %) were impacted on three BM dimensions and equivalent (23.4 %) on all four BM dimensions.
- All case companies were impacted on at least one BM dimension.
- The case companies were, on average, impacted on 2.65 dimensions. This indicates that the best practices for IoT typically include significant change in two or three BM dimensions.

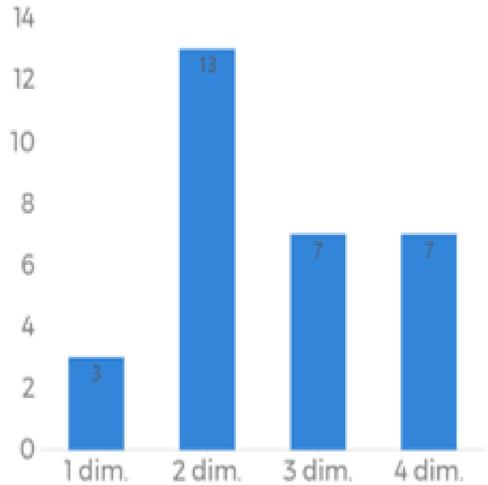


Figure 18.16 BMI-BM dimensions impacted per case.

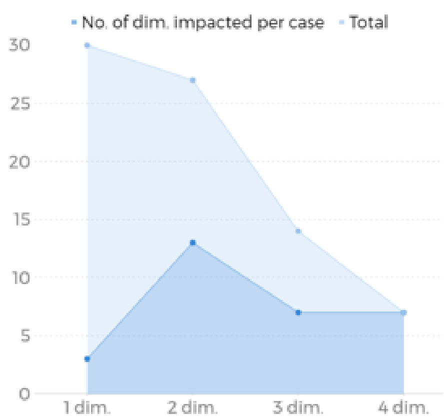


Figure 18.17 BMI – number of BM dimensions accumulated impact.

- **90% of the case companies** were impacted on more than one BM dimension and are therefore cases of BM innovation.
- The case companies across all domains were on average impacted on 2.25–3.00 dimensions. This indicates that the **best practices for IoT**

– no matter what domain the company operates in – typically include significant change in two or three BM dimensions.

- As an outcome of development and/or deployment of the IoT empowered solution, companies in the domains **manufacturing** and **mobility & transportation** are more likely to see impact on two BM dimensions, whereas companies in the domains agri-food and health & care are more likely to see impact on three BM dimensions.
- The data indicates that successful BMs in the IoT area are impacted on their **value proposition** and/or value chain by the development and deployment of IoT solutions. Hence, the single BM dimensions that are most often subject to significant change are WHAT and WHO.
- The data indicates that the combinations of BM dimensions that are most often subjected to significant change include: WHAT-HOW, WHAT-HOW-WHY, and WHAT-HOW-WHY-WHO. These configurations seem archetypical for achieving success in the IoT area.
- The data indicates that **BM innovation** – with 90% probability – is an outcome of best practice of IoT development and/or deployment.

Figures 18.18–18.20 have illustrated all the BM configurations of the case companies – both per case, the actual accumulated total of the cluster, and the potential accumulated total of the cluster, which are summarized as follows:

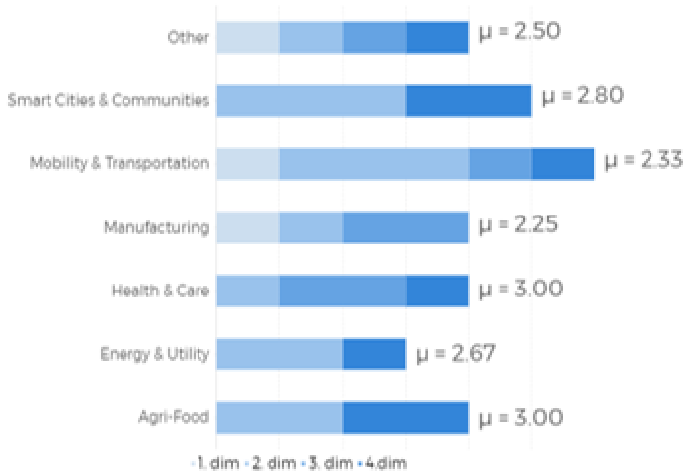


Figure 18.18 BMI across domains.

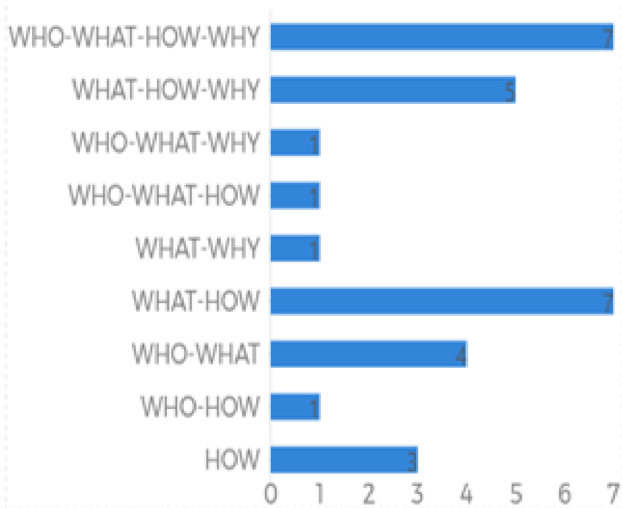


Figure 18.19 BM Config-Dimension combination per case.

- All illustrated two-dimensional BM configurations are applied in 37% or more of all the potential BMI cases.
- All illustrated three-dimensional BM configurations are applied in 30% or more of all the potential BMI cases.
- The four-dimensional BM configurations are applied in 26% of all the potential BMI cases.
- The BM dimension combination **WHAT-HOW** was among the most popular configurations for significant change (applied in 26% of all the potential BMI cases).
- This specific combination was applied in 54% of the potential two-dimensional BMI cases, and it is part of the **BM configuration in 74 %** of all the potential BMI cases.
- The BM dimension combination WHAT-WHY was not among the most popular configurations for significant change (applied in 4% of all the potential BMI cases).
- This specific combination was applied only in 8% of the potential two-dimensional BMI cases, but it is, however, part of the BM configuration in 48% of all the potential BMI cases.

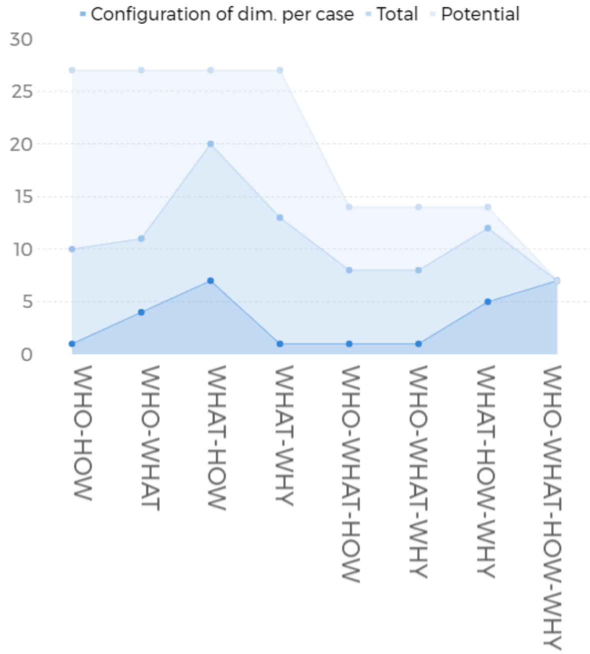


Figure 18.20 BM configuration – BM dimensions combination accumulated.
**Note that three of the use case cluster's 30 BMs are not subjected to BMI. Potential calculations are therefore based on the remaining 27 BMI cases.*

- The BM dimension combination **WHAT-HOW-WHY** was among the most popular configurations for significant change (applied in 19% of all the potential BMI cases).
- This specific combination was applied in 36% of the potential three-dimensional BMI cases, and it is part of the BM configuration in 44% of all the potential BMI cases.

**Note that configurations not mentioned constitute less than 40% of the total accumulated BMI cases.*

18.4.5 Technology trends

Technology trends that characterize IoT use cases have been explored to conclude whether the application of specific technologies is repetitive for achieving success in the IoT area. In the setting of digital business, both IT and IoT can play a role, as highlighted in Figure 18.21, which is constitutive,

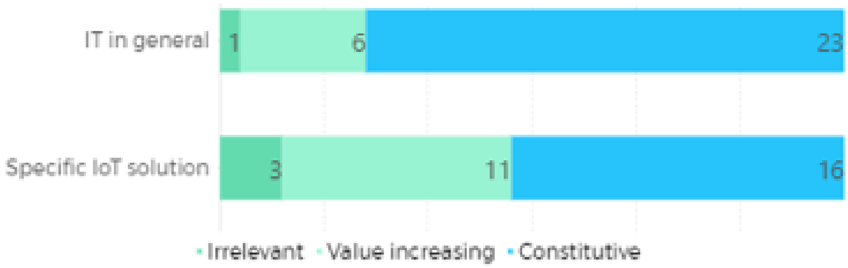


Figure 18.21 Role of IT and IoT.

value increasing via IoT solution development or deployment or irrelevant for the general BM of the organization. Figure 18.22 shows technology trends applied in the context of case companies.

Data insights:

- To 90% of the case companies, the **specific IoT solution** developed and/or deployed adds value to the overall BM of the company. To more than half (53.3%), the IoT solution even matures into having a constitutive role, causing IoT to drive the selection of patterns that depict the overall BM of the company.
- **IT as a general phenomenon** is value increasing for the business of almost all the case companies explored and constitutive to 76.7% of them. This indicates that the value potential of business directly relies on the integration of IT-driven BM patterns for three-fourth of the companies.
- The data indicates that IT as a general phenomenon often plays a constitutive role in the BM of companies that successfully develop and/or deploy IoT solutions. Hence, the best practice seems to rest upon the **digital underpinning**.
- The data further indicates that the specific IoT solution being developed and/or deployed should at least assume a value-increasing role for the overall BM of the company to foster future success.
- The data indicates that key technological trends include **sensors and/or cameras**, **artificial intelligence**, **digital twins**, **machine learning**, and **open software and/or hardware**. These constitute the archetypical technologies that presently seem repetitive for achieving success in the IoT area.

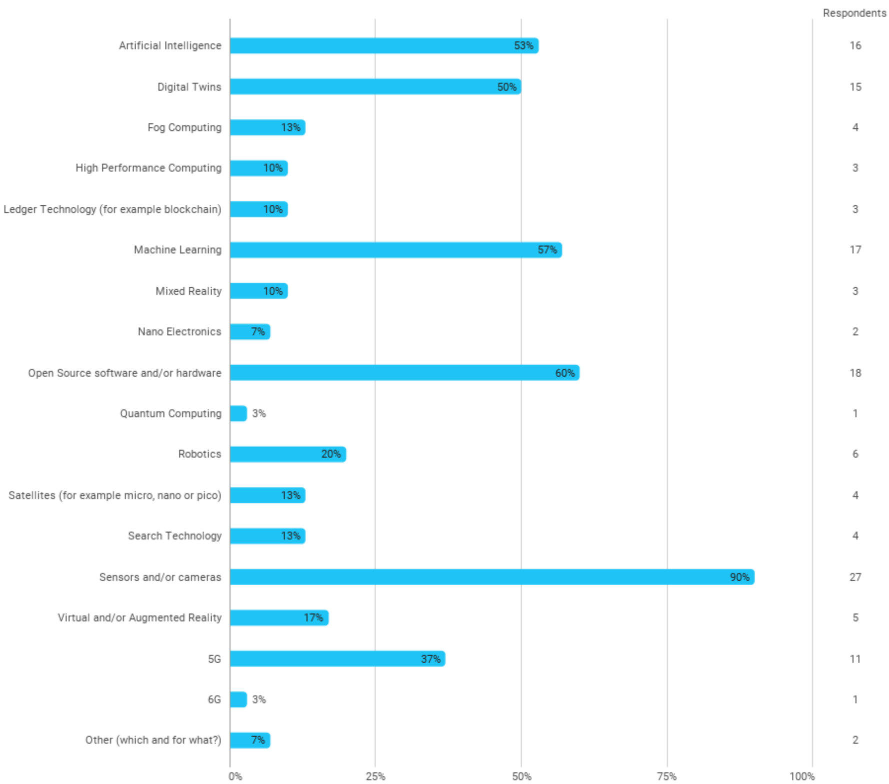


Figure 18.22 Technologies applied base case companies.

- Other technologies applied include **addictive manufacturing**, **LoRa**, and **software-defined networking (SDN)** technology.
- **Sensors and/or cameras** is the utmost adopted and widespread technology, with 90% of the IoT use case cluster applying it in their case companies.
- **Artificial intelligence**, **digital twins**, **machine learning**, and **open software and/or hardware** are also common technologies that are applied in half or more of the case companies.
- **6G**, **quantum computing**, and **nano electronics** are the technologies that are least applied in the case companies.

18.4.6 Relevant skill areas and patterns

This section highlights the trends of skills in the IoT area (Figures 18.23, 18.24) based on relevant survey conducted with various random professionals across industries as part of the EU-IoT project study.

Data insights:

- **All IoT skill areas are important**. However, **IoT data and related data analytics** skills and modern computing (cloud/edge/mobile) seem to be the most important in modern times.
- **IT sector is the most prevalent** area where these skills are used and known.
- At resource level, **engineers are the most interested and expected to be skilled** in these areas.

18.5 Conclusion

This study has presented the analysis for 30 IoT use cases carried out as part of the EU-IoT project with an objective to explore and analyze different business models and technology patterns, values, trends, operational domains, and best practices that are enabled in the IoT ecosystem. The data has been collected across Europe from different domain companies that varied in size and scale of operations. In order to fulfill the objective, various business modeling tools have been used, which includes interviews, surveys, DMAT, St. Gallen's magic triangle, and BMP survey. This study also presented the background of

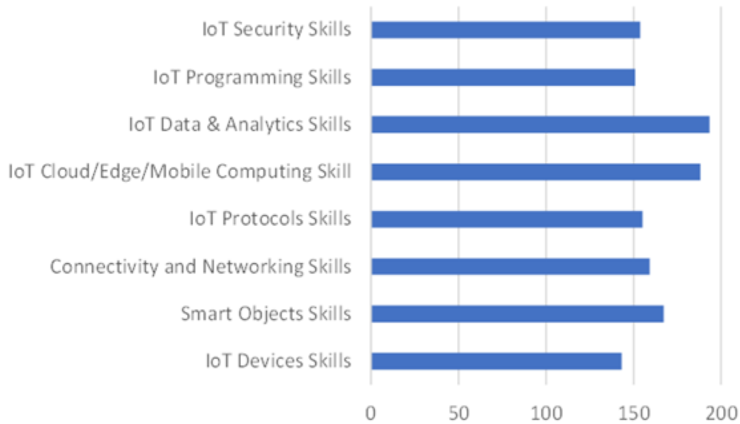


Figure 18.23 IoT skill areas importance.

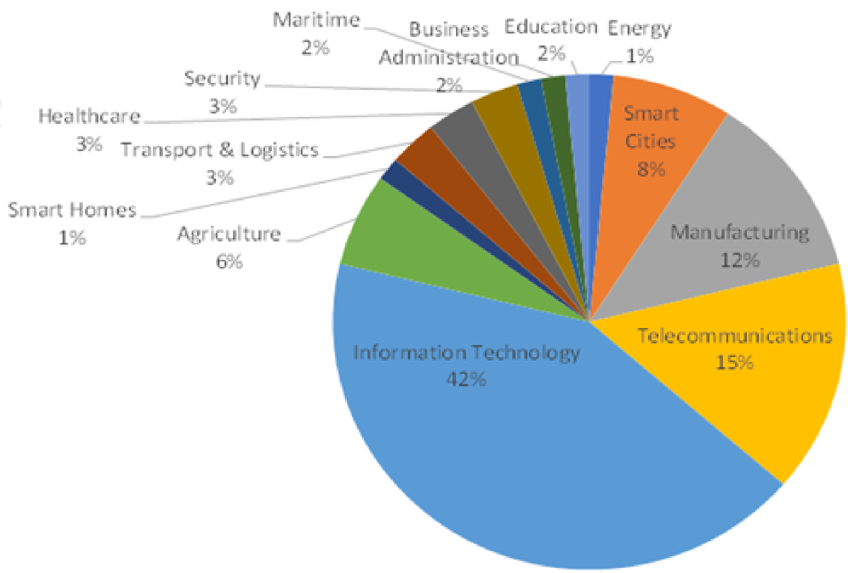


Figure 18.24 Skills survey sector distribution.

those tools and how they have been used in relevant context. There are a lot of data collected for 30 use cases and each use case is then analyzed individually and in an aggregate manner to derive the impact in terms of digital maturity, business model patterns, business model innovation, and configuration aspects. In addition, the applied technology trend in all the cases has also been presented. Finally, for practitioners/recruiters, the required skill patterns are also presented, which are mapped to relevant IoT skill areas based on the surveys conducted with various professionals across industry. Beyond that, it tells what kind of business models patterns (integration, expertization, and servitization) are used in IoT ecosystems and what the role of the underlying ecosystem is. The data indicates that **IT as a general phenomenon often plays a constitutive role** in the BM of companies that successfully develop and/or deploy IoT solutions. Hence, the best practice seems to rest upon digital underpinning. The data further indicates that the **specific IoT solution** being developed and/or deployed should at least assume a **value-increasing role for the overall BM** of the company to foster future success. The data also indicates that **key technological trends** include sensors and/or cameras, Artificial intelligence, digital twins, machine learning, and open software and/or hardware. These constitute the archetypical technologies that presently seem **repetitive for achieving success in the IoT area**.

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