

In collaboration with
Boston Consulting Group



Data Excellence: Transforming manufacturing and supply systems

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Foreword

Data and analytics drive value through increased productivity, enhanced customer experience and a positive impact on society and the environment.



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Manufacturing industries are on the verge of a data-driven revolution. We will soon see companies collaborating in hyperconnected value networks in which data-and-analytics applications drive productivity, new customer experiences and societal and environmental impact. Nearly three-quarters (72%) of manufacturing executives consider advanced analytics to be more important now than they were three years ago.¹

The COVID-19-induced economic crisis has put an even stronger emphasis on the importance of data and analytics in manufacturing. Emerging from the crisis, companies will need more resilient supply systems to prepare for future shocks as well as higher productivity in their operations to free up liquidity for future investments. In fact, it is estimated that data-and-analytics-driven applications could potentially reduce conversion costs by up to 20%.²

While acknowledging the importance of data and analytics, many companies are becoming increasingly disillusioned with their efforts to capture value from it. Many companies lag behind in developing the important organizational and technological foundations required to successfully implement new data-and-analytics-driven applications and maximize the extraction of value.

In 2019, the World Economic Forum, in collaboration with Boston Consulting Group (BCG), launched a global initiative to help manufacturing

companies develop new capabilities, establish partnerships and accelerate value capture from data in manufacturing and across supply systems.³ Today, the initiative's community – which includes more than 40 leading manufacturers, innovative technology providers and experts from academia – is exchanging best practices, defining the foundations and piloting the development of new applications.

This report is a key milestone in the multi-year journey of our initiative. It describes the value pockets that manufacturers can unlock by leveraging the power of data; proposes a set of priorities for decision-makers; and highlights opportunities for cross-company collaboration. The value-driven applications and key priorities will be further defined in the Manufacturing Data Excellence Framework, which is being co-developed by this initiative's community. Manufacturers will be able to use the framework to assess their maturity with regard to the implementation level of applications, as well as the organizational and technological enablers required to extract value from data across their value networks.

We trust the report provides a meaningful contribution to efforts within and across manufacturing companies to use data and analytics to reach the next frontiers in productivity, customer experiences, and social and environmental sustainability.

Executive summary

Six priorities for decision-makers to capture value from data and analytics in manufacturing.

“ Many manufacturing companies lack the organizational and technological foundations to implement data-and-analytics applications both internally and at an ecosystem level.

In the near future, manufacturing companies will collaborate in hyperconnected value networks to increase productivity, develop new customer experiences and have a positive impact on society and the environment. To realize this vision, manufacturers will need to employ a large variety of data-and-analytics applications, such as predictive maintenance, advanced robotics,⁴ and tracking and tracing in supply networks. Data will be the lifeblood of these applications, becoming an imperative for the successful transformation of manufacturing and supply systems.

Value from data-and-analytics applications can be categorized into three main areas:

1. Productivity increase in manufacturing and supply systems
2. Enhanced customer experience through improved products and services
3. Positive impact on society and the environment

Depending on the type of application and enterprise, companies can unlock value from many applications themselves using only internal data. Such applications include tracking and tracing within a factory or navigation of automated guided vehicles used in logistics. More sophisticated applications often require the exchange of data beyond company boundaries to effectively train artificial intelligence (AI) algorithms and to support collaboration in complex networks that require full transparency. Consequently, data sharing is a key enabler of multiple advanced data-driven applications in manufacturing.⁵

However, many manufacturing companies lack the organizational and technological foundations to implement data-and-analytics applications both internally and at an ecosystem level.

To overcome these challenges and successfully implement data-driven applications, decision-makers should focus on six organizational and technological priorities.

Organizational priorities:

1. Define a data-to-value strategy and roadmap
2. Incentivize internal and external ecosystem partners
3. Build capabilities to capture and use data

Technological priorities:

4. Implement an open platform to unlock data silos
5. Enable connectivity for low-latency, high-bandwidth data flows
6. Ensure data security and privacy

To help accelerate the development of globally connected manufacturing data ecosystems, the World Economic Forum's Platform for Shaping the Future of Advanced Manufacturing and Production and community is developing a Manufacturing Data Excellence Framework. This framework comprises value-adding applications as well as technological and organizational success factors. Companies will be able to use this framework to assess their current maturity and define a path towards the development of successful data ecosystems. This community also encourages the incubation of new partnerships and the dissemination of learning through the exchange of best practices.

Introduction

“ This paper aims to help companies identify value opportunities and overcome roadblocks to maximize value from data and analytics.

The future of manufacturing is digital and hyperconnected. In this environment, artificial intelligence (AI) will generate new insights from large amounts of data, and smart assets will operate autonomously. These applications will make complex networks more transparent for companies and enhance collaboration across corporate boundaries.⁶

Value creation will be driven by data-and-analytics applications – such as advanced optimization tools, machine learning algorithms and simulation software – across all company functions. Many companies recognize that these applications are rapidly changing the way they manufacture goods. A recent Boston Consulting Group (BCG) survey of more than 1,300 manufacturing executives found that nearly three-quarters (72%) of manufacturing companies consider advanced analytics to be more important now than they were three years ago.⁷

This step change in manufacturing yields significant benefits in three categories:

1. Increased productivity – for example, a higher degree of automation, better asset use and lower inventories
2. Enhanced customer experience – for example, improved service levels and increased personalization
3. Positive impact on society and the environment – for example, ethical production and a reduced carbon footprint

Depending on the application and company, many data-and-analytics applications can be implemented that rely solely on internal means. Cutting-edge applications, however, often require cross-company collaboration and data sharing. Data can be exchanged between peers, in supply networks or throughout the life cycle of an asset. In fact, 91% of surveyed manufacturing executives consider data sharing to be at least somewhat important, with 71% giving it significant importance.⁸

Yet many companies are struggling with the implementation of data-and-analytics applications both internally and at an ecosystem level. Only 39% of companies have managed to scale data-driven use cases beyond a single value stream (that is, the production process of a single product).⁹

This paper aims to help companies identify value opportunities and overcome roadblocks to maximize value from data and analytics. It describes:

- The areas in which value can be unlocked through data and analytics internally and via cross-company collaborations (section 2)
- Key priorities for decision-makers to capture value from data and analytics within their company and in data ecosystems (section 3)
- How a framework can help define a path forward to capture value more systematically from data and analytics in manufacturing and build new data ecosystems (section 4)

Data value in manufacturing

“ While many applications can be run by relying solely on a company's internal data, many sophisticated applications require the exchange of data across corporate boundaries.

Manufacturing companies capture value from data and analytics using different mechanisms, the most common being:

- Creating transparency in complex problems through, for example, pattern recognition and visualization
- Predicting future developments, such as by making projections based on historical data and machine learning
- Autonomous decision-making by, for example, controlling smart devices or implementing advanced optimization models

The extent to which a company needs to collaborate with other companies to share data depends on its size and the type of application. While many applications can be run by relying solely on a company's internal data, many sophisticated applications require the exchange of data across corporate boundaries.

As an example, consider equipment maintenance. Connecting an asset to a data platform allows for the real-time monitoring of an asset's condition. A company can fully implement this application using only internal data.

A more advanced application is the use of machine learning to predict and prevent failures. Such models need to be trained by a large amount of data. Companies can rarely provide this data alone, so they must share data with other asset operators.

Another reason to share data is the need for a single source of truth that provides full transparency of complex networks. This transparency enables, for example, the tracking of inventory or tracing of process conditions (such as the temperature of cooled drugs) along the supply chain, as well as verifying the provenance of goods (such as for ethical production).

Some leading manufacturing companies are already successfully implementing these cutting-edge data-and-analytics applications and have built effective data ecosystems around them. They are unlocking value across three areas, which we examine in the next sections:

1. Increased productivity
2. Enhanced customer experience
3. Positive impact on society and the environment

2.1 Increased productivity

Most data-and-analytics applications promote productivity. In fact, 80% of surveyed companies cited productivity-related objectives as their primary motivation for implementing advanced analytics in manufacturing. These objectives include process and shop-floor automation, output improvement, quality improvement and net working capital optimization.¹⁰ Overall, BCG estimates that data and analytics have the potential to reduce conversion costs by up to 20% (depending on the industrial sector).¹¹

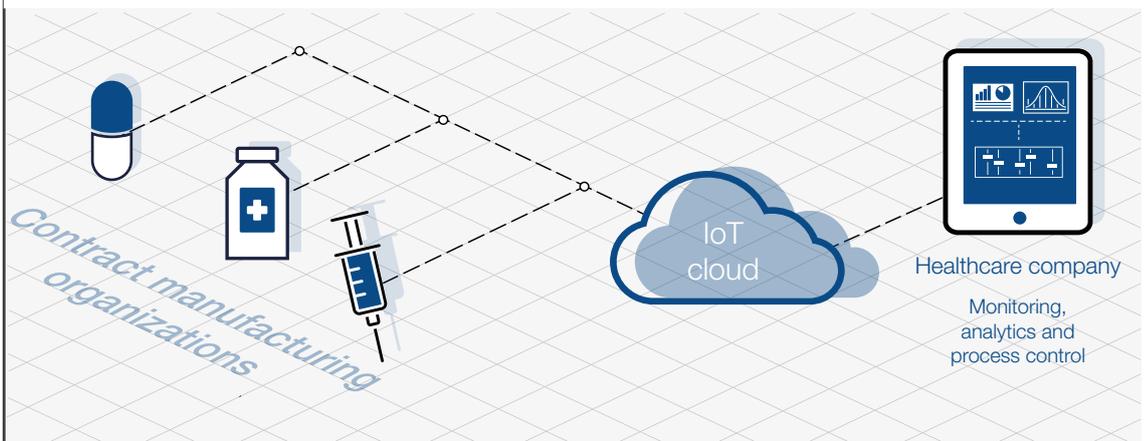
According to the survey, the most mature applications are found in:

- Quality management: machine learning models help determine the root causes of defects and predict and prevent future issues.
- Equipment maintenance: data transparency helps monitor the condition of an asset and machine learning models predict and prevent failures.

- Supply-chain management: end-to-end data flows enable the tracking and tracing of material throughout the supply chain and inventory reduction, as well as facilitating enhanced sales and operations planning. Moreover, this could entail data-driven supply chain risk management and the simulation of quick re-configuration scenarios.

As previously stated, many of these applications may be implemented solely within a company, but more sophisticated applications often require collaboration with external partners. One successful example of collaboration on data and analytics in supply-chain management can be observed at Johnson & Johnson (J&J) (Figure 1):

FIGURE 1 Example of data and analytics in supply-chain management



Source: Authors

Creating an end-to-end digital thread for healthcare will enable new ways to better serve customers and optimize supply chains. This requires connecting and integrating data beyond a company's four walls – with suppliers, customers, patients, hospitals and other external partners.

J&J has successfully established real-time data connectivity to its external manufacturers. Data relating to the external production process is frequently ingested by J&J's cloud data platform, which enables the monitoring and better control of process variations to ensure reliable, high-quality products for patients.

To connect with external manufacturers, J&J has been employing an internet of things (IoT)

technology stack built and deployed in internal facilities. The company has expanded the stack to external environments through an internet-facing IoT hub that meets all of the security, data privacy and compliance requirements. The hub allows J&J to onboard new contract manufacturing organizations more easily.

This capability can also be used to ingest broader datasets, such as enterprise resource planning (ERP) and other transactional data from external suppliers, for end-to-end smarter planning and supply-chain optimization. This will allow J&J to further integrate and orchestrate its external and internal ecosystems to transform customer experience and value.¹²

2.2 Enhanced customer experience

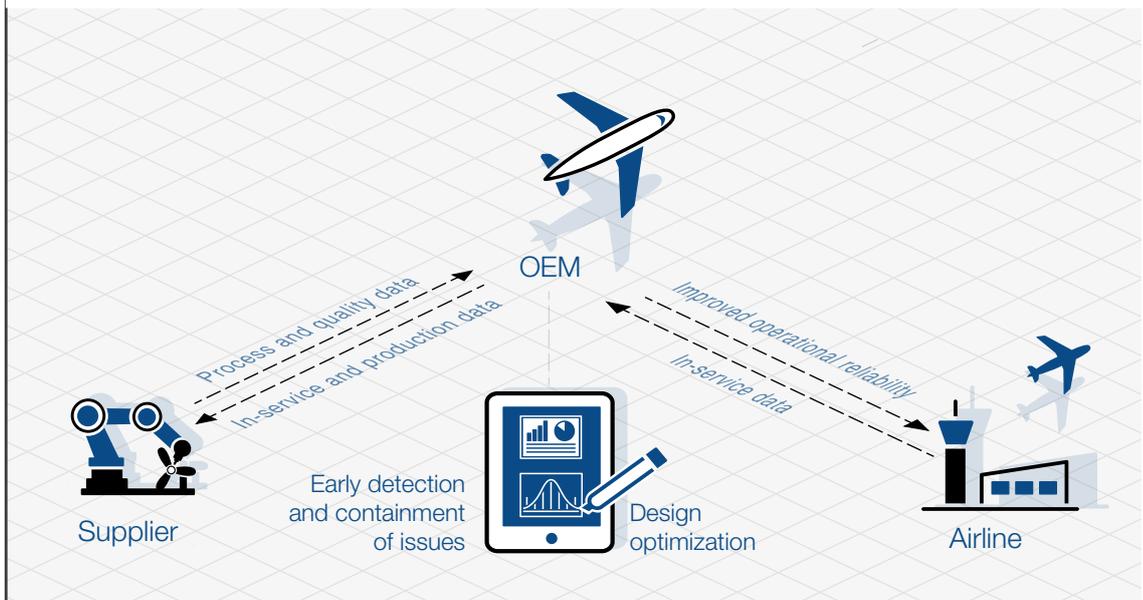
Beyond productivity improvements, data-and-analytics applications allow companies to enhance the customer experience in multiple ways, such as:

- Just-in-time delivery of critical goods: more accurate sales and operations planning as well as real-time tracking and tracing of critical materials (for example, medical goods or perishable food) prevent stock-outs and improve availability for customers.
- Improved product quality and reliability: better products and services are provided through design changes informed by in-service operational data.
- Transparency over provenance: the tagging of products enables real-time traceability back to their origin. This provides visibility in cases of recall and allows companies and customers to verify authenticity, preventing counterfeiting.

- Increased personalization: individual customer data is used in the engineering and manufacturing processes to tailor products to customer needs.

Some applications can be used with a company's internal data only (such as quality data analysis on a specific production process), while many other applications that improve the customer experience require data flows across company boundaries. Airbus provides an advanced example of how manufacturers can use in-service data shared by customers to improve the quality and operational reliability of their products (Figure 2).

FIGURE 2 Example of improved product quality and reliability based on in-service data



Source: Authors

Airbus has partnered with Palantir to build a data ecosystem around its platform Skywise that involves both suppliers and customers. The company applies analytics to aircraft flight data to improve the design and performance of its aircraft as well as its suppliers' components.

Moreover, Airbus leveraged the Skywise platform to accelerate and improve its production and supply-chain productivity. The company collaborates with suppliers to optimize industrial performance – for example, by exchanging quality data to reduce late and non-quality deliveries.

Airbus has successfully scaled the ecosystem to more than 100 airline customers and various suppliers.¹³

2.3 Positive impact on society and the environment

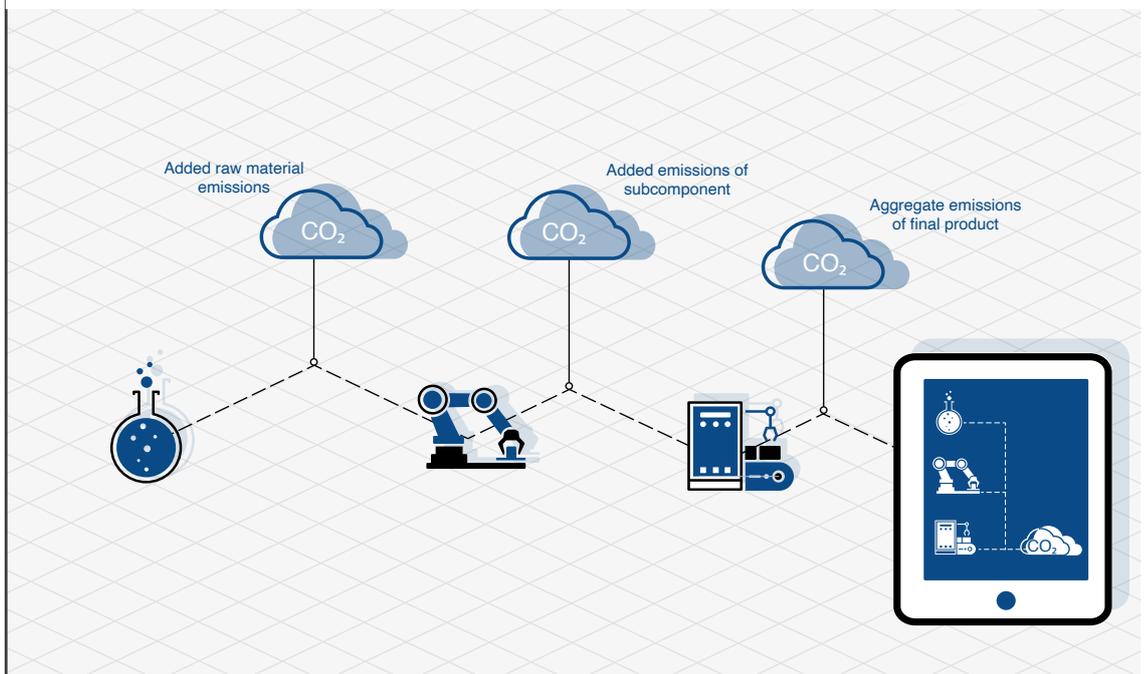
Manufacturers are increasingly applying data and analytics to have a positive impact on society and the environment. They rely on a range of data-and-analytics applications that can be categorized into three areas:

- Ethical production: end-to-end traceability enables the verification of a product's origin and the working conditions involved in its production.
- Increased resource efficiency: manufacturers apply machine learning algorithms to optimize process parameters in order to reduce the consumption of energy and other natural resources.¹⁴

- Environmental footprint transparency: the sharing of product characteristics along the supply chain creates visibility on its environmental footprint, such as its carbon dioxide (CO₂) emissions.

While some applications such as the monitoring of power consumption can be implemented within a company's four walls, much value is captured from collaboration and transparency along supply systems. For instance, supply-chain emissions are, on average, 5.5 times greater than internal operational emissions.¹⁵ Additionally, calculations of products' carbon footprints are usually manual and assumption-based, and thus not actionable.

FIGURE 3 Example of environmental footprint transparency



Source: Authors

To promote greater transparency and actionable insights, the World Economic Forum has incubated a pilot collaboration in which leading companies are simulating a hypothetical supply chain to ensure trust in tracing and aggregating a product's carbon footprint (Figure 3).

Dow, Siemens, Arçelik and others have simulated a flow from raw material to a subcomponent to a finished product. Employing blockchain technology, Siemens and GreenPlat are working on a blueprint for the industry that allows companies to exchange

data on CO₂ equivalents generated in every step of the product life cycle, from cradle to gate, using the same data structure.

The sharing of CO₂ equivalent data – demonstrated in this case along the hypothetical supply chain of a washing machine manufactured by Arçelik – allows manufacturers to obtain a complete and accurate supply-chain-wide carbon footprint. This ultimately helps supply-chain actors identify the major contributors to the CO₂ footprint and reduce this footprint for more sustainable value chains.

2.4 The challenges in capturing value

As the examples illustrate, data and analytics and, where needed, data ecosystems enable significant value creation. Yet many companies often do not capture the full value from their manufacturing data and struggle to implement such advanced applications. According to the survey, 62% of manufacturers have not scaled data-and-analytics-driven use cases beyond a single plant's value stream (that is, the manufacturing process for a specific product).¹⁶

Manufacturers participating in the survey cited various challenges that impeded their efforts to further scale and implement data-and-analytics solutions within their plants and across networks.¹⁷

The top five challenges are:

- Insufficient skills and capabilities (26% of executives surveyed)

- Data-security risks (24%)
- Lack of effective applications to process and make sense of data (22%)
- Complex internal governance and processes (22%)
- Roles and responsibilities not clearly defined (20%)

To overcome these challenges and implement data-and-analytics applications, companies need to establish both technological and organizational foundations. In the next section, we detail key priorities for capturing value.



How to unlock value in manufacturing: six key priorities

To successfully implement data-and-analytics applications, companies first need to prepare their organization and build the technological backbone. A company should tailor the specific improvements it makes to the envisioned applications, the amount of data available and the company's digital maturity.

Through our work with the community, we have discerned six key organizational and technological priorities for senior decision-makers in the manufacturing space.

Companies should focus on the following three organizational priorities:

1. Define a clear data-to-value strategy and roadmap

Having a clear target picture and roadmap on how to achieve the target helps a company select the value-driving applications that will allow it to optimize investment allocations and ensure value capture.

A clear target picture, with an easy-to-understand implementation roadmap, facilitates staff communication and supports change management. Moreover, articulating a shared objective and creating transparency in what the data is used for helps to convince partners to exchange data.

As an example, salmon producer Mowi and IoT software company EVERYTHING partnered to provide an end-to-end traceability platform to deliver full visibility into the provenance of salmon bought and consumed by customers worldwide. They identified clear value potential in achieving the level of transparency demanded by today's consumers, acknowledging that transparency is critical in a world where trust is a defining commodity.

The collection and harmonization of data from different production and supply systems ensures that every salmon in the system has one searchable source of truth.¹⁸

2. Incentivize internal and external ecosystem partners

Internal and external partners need clear incentives to collaborate in an ecosystem and share data – especially for more sophisticated applications requiring data from other business units, suppliers, customers or peers. Incentives can support partners in overcoming barriers. For instance, they may fear that they will lose their negotiation power and competitive advantage or unintentionally give away sensitive data. Incentives can be financial (such as a higher share of business) or in the form of insights that allow for better products and services. Partners could also be incentivized to work jointly on a common goal such as the greater good or compliance with regulations. Well-incentivized ecosystem partners often show a higher level of engagement and contribute to the identification and development of new applications.

Airbus, for example, had to incentivize both customers and suppliers to join its Skywise data ecosystem. The company assured customers that the insights generated by the platform would allow it to improve the aircraft design and boost operational reliability. For suppliers, participation in the platform offers the opportunity to gain insights about the operational behaviour of their components in service, which they can apply to improve their products.¹⁹

3. Build capabilities to capture and use data

To build and maintain data-and-analytics applications, companies need a new skill set that combines digital skills with sector-specific manufacturing know-how. As the technical infrastructure grows more complex and an increasing number of decisions are made by algorithms, it becomes more important for companies to have the data science skills to build applications and understand the insights generated by these algorithms.

The right combination of digital and manufacturing skills allows companies to translate insights into concrete actions in factories and supply systems.

For example, companies can apply insights arising from improved transparency in quality data to modify the production process.

As an alternative to building all of the required skills as internal competences, companies can either contract with external providers to gain access to certain specific capabilities or partner with technology firms to build full applications or machine learning models from scratch. For example, as part of their collaboration on Industry 4.0, Groupe Renault and Google Cloud are building a scalable programme to support Renault's process engineering, manufacturing and IT teams through co-working, training and enablement sessions. This will support Renault's efforts to develop a data-driven culture for operations and decision-making processes.²⁰

In addition, manufacturing companies should address these technological priorities:

4. Implement an open platform to unlock data silos

Many applications require bidirectional data flows from different companies or different systems within a company. This is hard to achieve, however, because data is often stuck in silos. A cloud-hosted platform helps companies overcome this barrier by facilitating the sharing of data both within the company and across company boundaries with suppliers, customers and other ecosystem partners.

The ease of accessing and combining data from different sources (such as databases, sensors or programmable logic controllers) supports the development of new use cases and the generation of additional insights. An open platform lets many different providers offer their applications, allowing companies to find the best application for their data-and-analytics needs (such as a machine learning or optimization model).

Large industry players have partnered with technology providers to develop open platforms. Volkswagen is partnering with Amazon Web Services (AWS) to build an Industrial Cloud – an IoT platform open to all plants and suppliers.²¹ Similarly, BMW and Microsoft have launched the Open Manufacturing Platform, which is now also used by other manufacturing companies.²² Both the Industrial Cloud and the Open Manufacturing Platform make it easier to share data within these platforms and offer a large variety of different applications and services.

In addition to these proprietary platforms, the European GAIA-X initiative is pursuing a European data infrastructure that serves as a blueprint for dataspace, with clear rules, policies and services that are agnostic to a specific technology provider.²³ Thus, unlike the Industrial Cloud and the Open Manufacturing Platform, GAIA-X does not provide a physical infrastructure. For more information on GAIA-X, see the box below.

BOX 1

GAIA-X supports a federated data infrastructure for Europe

The GAIA-X initiative, launched by the governments of France and Germany as well as other European partners, aims to support the adoption of data-driven applications and artificial intelligence in the public and private sectors. It provides a blueprint for a user-friendly and secure European dataspace, with a common set of rules, policies and federated services for different industry sectors.

The initiative supports organizations in sharing their data and gaining access to a multitude

of applications and services (such as artificial intelligence or machine learning models). Manufacturing-related applications under consideration include shared production, joint condition monitoring, predictive maintenance and supply-chain collaboration. To ensure transparency and interoperability, GAIA-X is promoting cooperation among network and interconnection providers, cloud solution providers and high-performance computing systems, as well as sector-specific clouds and edge systems.

5. Enable connectivity for low-latency, high-bandwidth data flows

Many applications require uninterrupted low-latency, high-bandwidth data transfers from assets throughout the factory and supply systems. Continuous wireless connectivity is particularly important when decisions are made autonomously – for example, to adjust process parameters. Most companies use either WiFi 6 or 5G networks to meet their wireless connectivity needs.

Wireless connectivity allows companies to have highly flexible factories within which they can easily adjust the layout. It also makes it possible to constantly

connect mobile assets and goods to a central platform, enabling an uninterrupted stream of data. In addition, wireless connectivity is a key enabler for the plug-and-play use of sensors and cameras, which can be used to upgrade older machines.

Ericsson was able to fully connect assets in one of its own factories in the US even before the factory was completed. Using 5G technology allowed the company to employ a flexible and safe network to remotely set up, monitor and maintain key assets as well as track material and inventory. The flexibility of the 5G standard let Ericsson connect easily with its suppliers and the low-latency, high bandwidth data flow enabled remote support by suppliers.²⁴

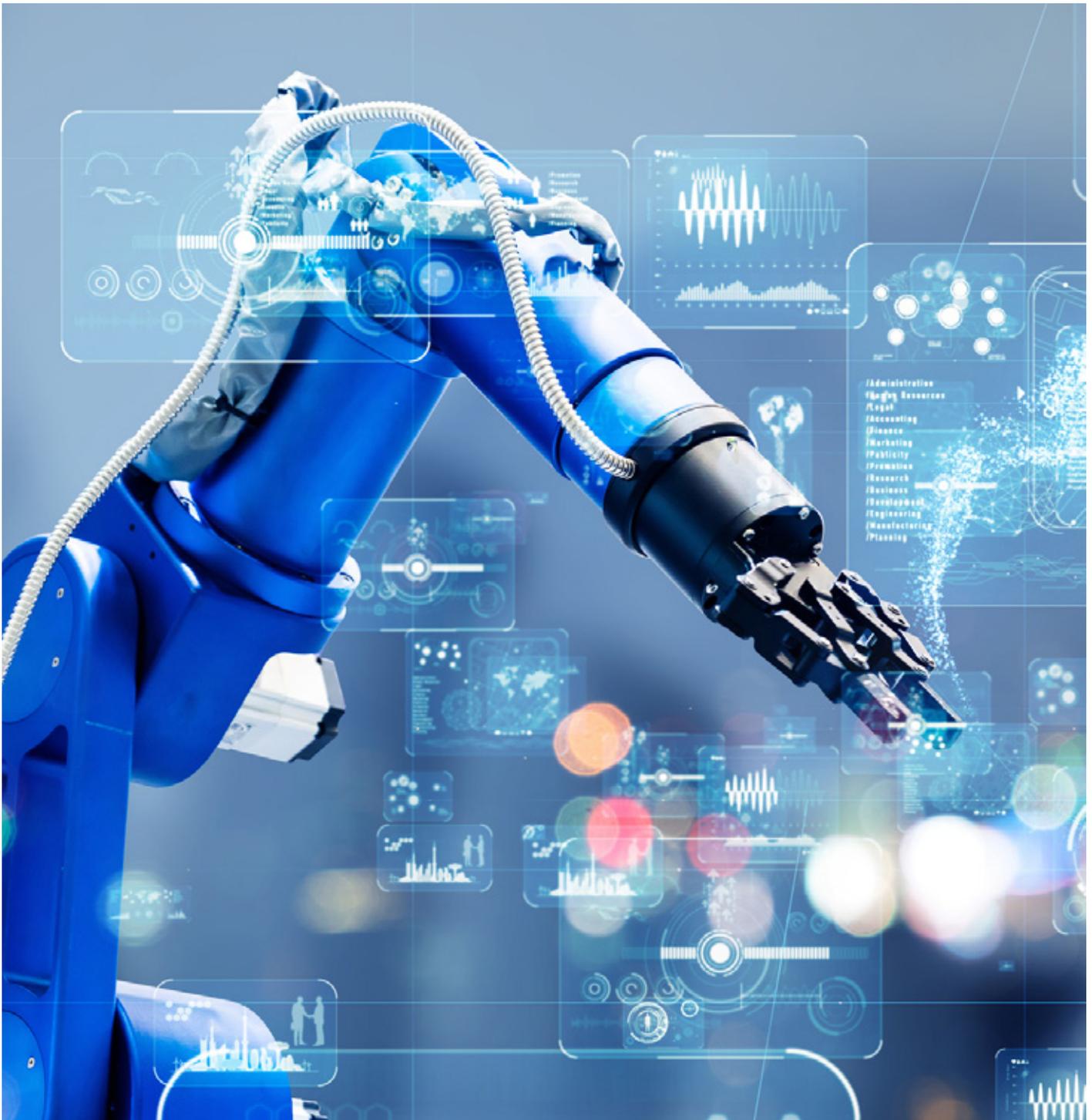
6. Ensure data security and privacy

Data security is a must-have requirement. Company data needs to be secure and protected from breaches and other cybersecurity risks. Security includes providing redundant structures and/or shared ledgers, so that data is available for running data-and-analytics applications even if the company is under cyberattack.

Data privacy is also essential for manufacturers to share sensitive data (such as design data or production volumes) and ensure that it is used only for the intended purpose. For instance, operational machine data and parameters may be used to train a prediction algorithm but must not reveal actual production volumes or product mix.

Additionally, maintaining data integrity through the prevention of unrequested manipulations is a key enabler of autonomous decision-making by algorithms. Correct data inputs are essential for effective algorithmic decisions.

Many use cases rely on blockchain technology to secure data privacy and integrity.²⁵ When Dow Chemical, for example, built an automated early-warning system for a vast supply chain, it worked with SIMBA Chain to track and monitor all data on a blockchain. The blockchain's shared-ledger architecture enables the exchange of data between separate systems and companies. The data records are immutable and the blockchain provides an audit trail that cannot be repudiated.²⁶



4

Manufacturing Data Excellence: a path forward

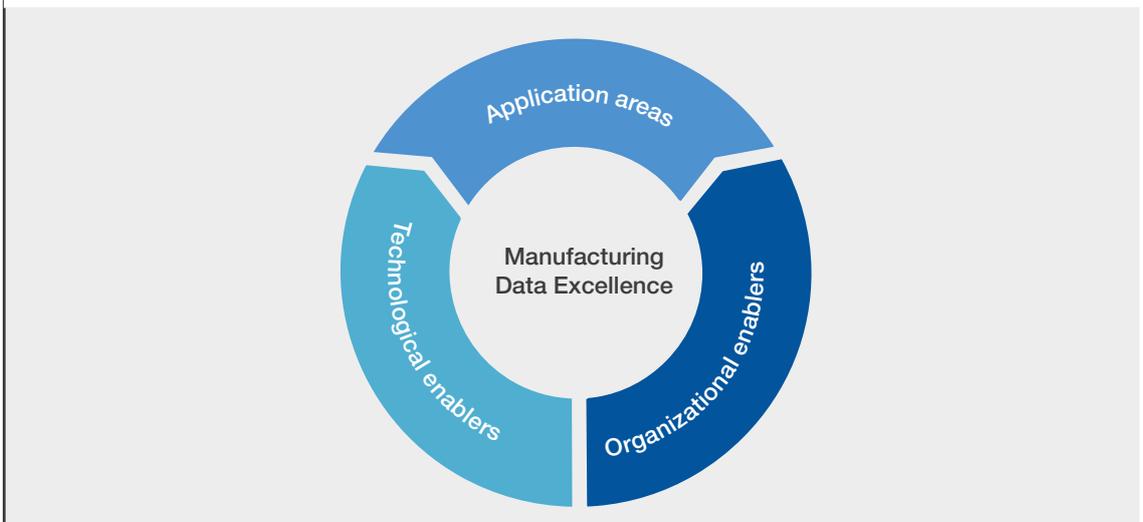
Addressing these six priorities will help manufacturers capture value through data-and-analytics applications both internally and within larger data ecosystems. Companies will be able to unlock new levels of productivity, offer improved products and services, and create a positive impact on society and the environment.

To drive value creation, companies need to understand their current level of maturity in terms of capturing value from data and analytics both within their company and across data ecosystems.

The World Economic Forum’s Platform for Shaping the Future of Advanced Manufacturing and Production and its global community are developing a **Manufacturing Data Excellence Framework** comprising three main pillars (Figure 4):

- The implementation status of value-adding applications
- The maturity of the organizational set-up
- The maturity of the technological backbone

FIGURE 4 Manufacturing Data Excellence Framework



Source: Authors

The framework will allow companies to assess their maturity in terms of implementing value-adding applications and enablers along approximately 20 different dimensions (for more information, see the box below). This will allow them to determine their strengths and development areas and devise a path forward to close any gaps and increase their maturity. Increased maturity in the enabling dimensions will allow companies to implement more sophisticated data-and-analytics applications and build data ecosystems where needed.

With its unique positioning in the World Economic Forum’s Platform for Shaping the Future of

Advanced Manufacturing and Production, our global community is also incubating new partnerships – with the objective, for example, of investigating specific applications such as transparency in CO₂ emission levels of industrial goods. Companies can collaborate not only on specific applications but can also address technological and organizational enablers together through co-development, training or sharing of lessons learned. Ultimately, the community plans to disseminate insights and exchange best practices to support a journey towards globally connected manufacturing data ecosystems.

BOX 2 | The Manufacturing Data Excellence Framework supports value creation

The framework disaggregates the challenges to capturing value from data by highlighting prerequisites and key success factors. It helps manufacturers identify new opportunities to promote productivity, customer value and societal and environmental impact through data and analytics, and supports cross-company collaboration.

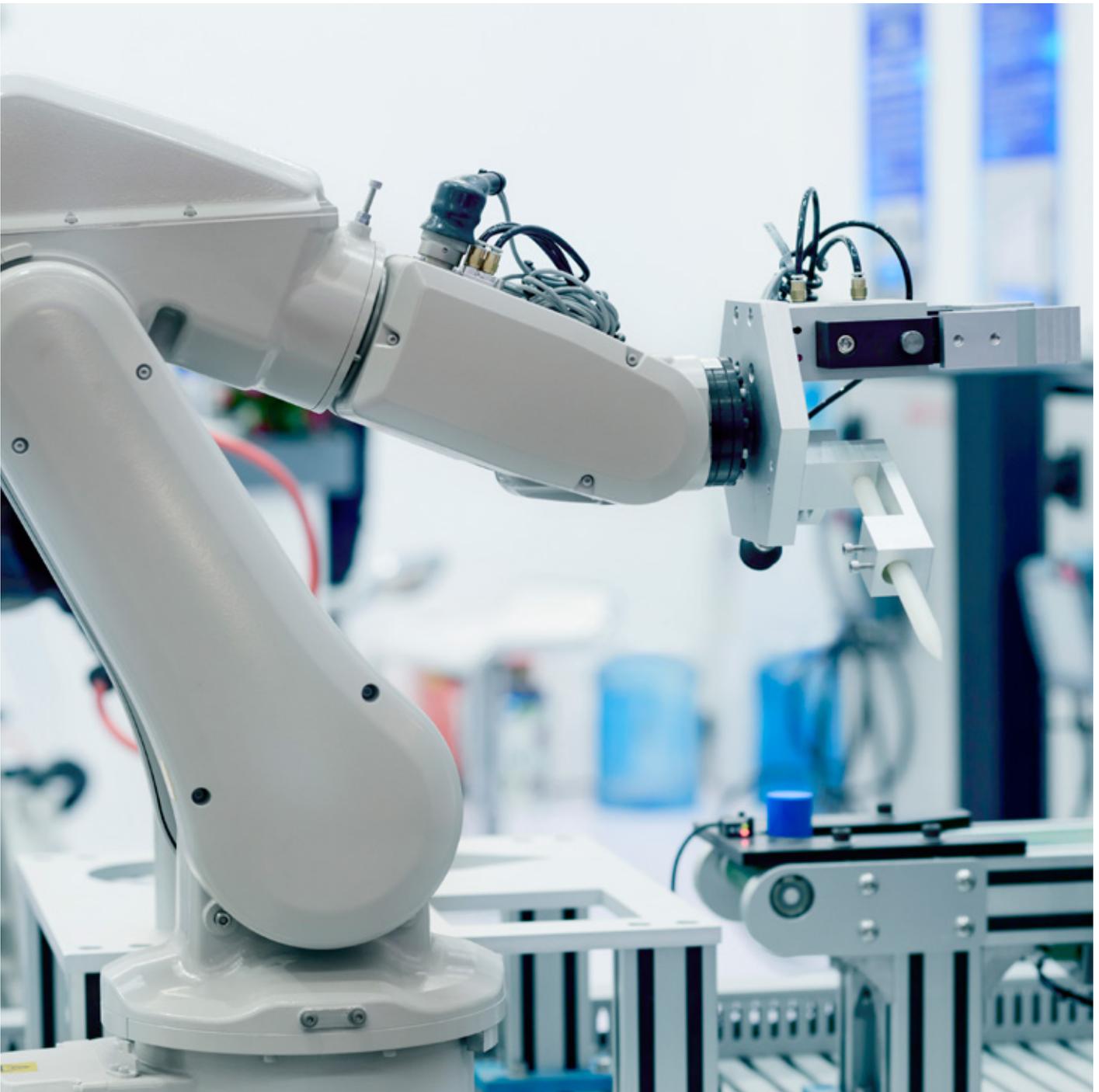
The framework is being designed as a self-assessment tool. It currently includes a total of 20 dimensions in three pillars:

- 10 dimensions covering application areas structured around manufacturing functions (such as quality, maintenance or supply-chain operations)

- five dimensions addressing technological enablers (such as data extraction, data platform or privacy and security)
- five dimensions related to organizational enablers (such as strategy and roadmap, ecosystem partnering or governance and processes)

The assessment allows the company to gauge its individual maturity, determine its strengths and areas for development and, ultimately, derive actions to increase its maturity.

The development of the framework driven by our global community is ongoing. Interested stakeholders are invited to contribute to shaping this tool.



Conclusion

A Manufacturing Data Excellence Framework to help companies build the foundations for successful value capture from data and analytics.

Manufacturing is shifting towards a hyperconnected network of assets, factories and supply systems. Data and analytics play a crucial role in unlocking value across three different areas: productivity improvement; enhanced customer experience; and societal and environmental impact.

Applications driving value in these areas can sometimes be implemented using internal company data only. Many applications, however, require the exchange of data across corporate boundaries, which involves connecting multiple stakeholders in data ecosystems. Many companies are struggling to leverage data and analytics solely within their own four walls. They are struggling even more to create data ecosystems because they have difficulty implementing the right applications and lack both the organizational and technical foundations.

To build these foundations and pave the way to successful value capture from data and analytics, manufacturing companies should address six priorities:

1. Define a data-to-value strategy and roadmap
2. Incentivize internal and external ecosystem partners
3. Build capabilities to capture and use data
4. Implement an open data platform to unlock data silos
5. Enable connectivity for low-latency, high-bandwidth data flows
6. Ensure data security and privacy

On an individual level, each company should assess its level of maturity with respect to capturing value from applications, as well as setting up organizational and technological enablers.

To support this effort, a Manufacturing Data Excellence Framework is being developed by the initiative's global community. The World Economic Forum's Platform for Shaping the Future of Advanced Manufacturing and Production provides a unique space for collaborations to advance this framework and help companies achieve the highest maturity stages in terms of capturing value from data and analytics across their value networks.

Stakeholders are invited to join this initiative to shape the framework, share best practices, incubate new partnerships and disseminate insights, supporting a journey towards globally connected manufacturing data ecosystems.

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Endnotes

1. Boston Consulting Group, *Global Data & Analytics in Manufacturing Survey* (N=1,320), 2020, Unpublished.
2. Boston Consulting Group, *AI in the Factory of the Future*, April 2018, <https://www.bcg.com/publications/2018/artificial-intelligence-factory-future> (link as of 16/12/20).
3. World Economic Forum, *Unlocking Value in Manufacturing through Data Sharing*, January 2020, <https://www.weforum.org/projects/data-sharing-for-manufacturing> (link as of 16/12/20).
4. Boston Consulting Group, *Advanced Robotics in the Factory of the Future*, March 2019, <https://www.bcg.com/publications/2019/advanced-robotics-factory-future> (link as of 16/12/20).
5. World Economic Forum, *Share to Gain: Unlocking Data Value in Manufacturing*, 2020, <https://www.weforum.org/whitepapers/share-to-gain-unlocking-data-value-in-manufacturing> (link as of 16/12/20).
6. Boston Consulting Group, *The Factory of the Future*, December 2016, <https://www.bcg.com/publications/2016/leaning-manufacturing-operations-factory-of-future> (link as of 16/12/20).
7. Boston Consulting Group, *Global Data & Analytics in Manufacturing Survey* (N=1,320), 2020, Unpublished.
8. Ibid.
9. Ibid.
10. Ibid.
11. Boston Consulting Group, *AI in the Factory of the Future*, April 2018, <https://www.bcg.com/publications/2018/artificial-intelligence-factory-future> (link as of 16/12/20).
12. Use case provided by Johnson & Johnson, December 2020.
13. Airbus, *About Skywise*, <https://skywise.airbus.com/en/about-skywise.html> (link as of 4/1/21).
14. Boston Consulting Group, *The Green Factory of the Future*, June 2020, <https://www.bcg.com/publications/2020/green-factory-of-future> (link as of 16/12/20).
15. CDP, *Cascading Commitments: Driving Ambitious Action through Supply Chain Engagement*, 2019, https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/004/072/original/CDP_Supply_Chain_Report_2019.pdf?1550490556 (link as of 16/12/20).
16. Boston Consulting Group, *Global Data & Analytics in Manufacturing Survey* (N=1,320), 2020, Unpublished.
17. Ibid.
18. Use case provided by EVERYTHING, December 2020.
19. Airbus, *About Skywise*, <https://skywise.airbus.com/en/about-skywise.html> (link as of 4/1/21).
20. Groupe Renault, *Groupe Renault and Google Cloud Partner to Accelerate Industry 4.0* [Press release], 9 July 2020.
21. Volkswagen, *Volkswagen Brings Additional Partners to Industrial Cloud* [Press release], 23 July 2020.
22. Microsoft, *Open Manufacturing Platform Expands: Anheuser-Busch InBev, BMW Group, Bosch, Microsoft and ZF Team Up to Accelerate Manufacturing Innovation at Scale* [Press release], 19 February 2020.
23. Federal Ministry for Economic Affairs and Energy (BMWi, Germany), *GAIA-X: Technical Architecture*, June 2020 <https://www.bmwi.de/Redaktion/EN/Publikationen/gaia-x-technical-architecture.html> (link as of 16/12/20).
24. Use case provided by Telefonaktiebolaget L. M. Ericsson, December 2020.
25. Boston Consulting Group, *Blockchain in the Factory of the Future*, July 2019, <https://www.bcg.com/publications/2019/blockchain-factory-future> (link as of 16/12/20).
26. SIMBA Chain, *Supply Chain Early Warning System*, <https://simbachain.com/resources/use-cases/supply-chain-early-warning-system/> (link as of 16/12/20).



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