# Logistics 4.0

## To what extent have logistics become digitised?

Results of a survey in ten European countries

TeamViewer

Handelsblatt RESEARCH INSTITUTE

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Prepared by the Handelsblatt Research Institute
in January 2022

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# Content

# 1 Introduction

Companies are dynamic organisations, not rigid objects. Lots of things must be able to flow within the company for these organisations to function properly. This might be materials, components or even information. Corporate logistics encompass all work that contributes to the transportation and storage of goods, from outgoing materials to the end users and consumers.

We last saw what can happen when the global flow of goods is restricted in the summer of 2021: since then, many companies have been forced to scale back their production due to a lack of materials and intermediate products resulting from logistical capacities being exhausted. As of November 2021, this situation has not yet been resolved.

That being said, the success and existence of a company also depend on its internal logistical and storage processes. If the necessary components are not in the right place at the right time in a manufacturing company, its entire production process might end up being disrupted. The same might happen to a commercial enterprise if its warehouse and point of sale are not coordinated.

More and more, logistics is transcending its administrative support role and gaining more significance in its own right. This is due in no small part to the globalisation of supply chains and the growing relevance of emerging economies, not to mention the ever-increasing individuality and complexity of customer requirements.

Logistical and warehousing processes in companies have undergone numerous changes in the past. Whereas most warehouses used to be large, they have been greatly reduced in size in line with the just-in-time concept. In doing so, logistical and production processes had to be much more highly coordinated. However, even just-in-time delivery was not enough in many cases to guarantee optimised stockless procurement logistics, and the system continued to evolve into just-in-sequence. Under this system, the material is not only delivered at the right time and in the required quantity, but also in the correct sequence for the production process.

In recent times, internal logistics have become the object of digitisation – like many other areas and functions in a company. It is less about developing new products, services and business models and more about improving processes. Under certain circumstances, Logistics 4.0 – also known as smart logistics – can cut costs, increase efficiency or improve the quality of processes. It can involve the use of technology such as artificial intelligence, big data analytics and augmented reality.

Logistics 4.0 goes hand-in-hand with the topic of Work 4.0 which the Handelsblatt Research Institute and TeamViewer have already examined in a previous report.

This is because the use of technology is just one aspect of the digitisation of logistics. The new technology will lead to changes in set processes and in turn the work processes of employees in those divisions. The work they do will adapt to the new conditions.

This report considers what these might be. The main basis of this investigation is a survey of companies in ten European countries. This offers a 'European' perspective of Logistics 4.0 along with the opportunity to identify differences between individual countries; whether, for example, French companies have already made great strides in digitising their logistics or are taking a different approach to companies in Spain.

Finally, the report includes concrete examples of practical applications to make the nature of the subject matter less abstract. These examples illustrate the approaches companies have already taken to the digitisation of their logistics. To begin, however, we should consider what Logistics 4.0 can mean in theory.

# 2 The digitisation of logistics

The use of new digital technology is one core aspect of the digitisation of corporate logistics. Artificial intelligence, networking, robotics, augmented reality, cloud computing and big data analytics can be used to make processes more efficient. By investing in this technology, companies can increase their flexibility, productivity and efficiency, lower costs and improve both the security of their supply and their working conditions.

## 2.1 Technologies and potential applications

### Artificial intelligence

Artificial intelligence (AI) simulates intelligent behaviour. Data-driven decisions are made with little human intervention, if any. In machine learning – one application of AI – computer programs build experience independently to improve their performance. Self-learning machines are already able to perform certain tasks as well as human workers – sometimes even better.

AI can be used in logistics to optimise warehousing or production processes. Autonomous control systems also rely on AI. For example, transporters can move around the warehouse or production area autonomously and deliver the necessary components and materials to individual workstations. These vehicles can even react to their environment using image, character and voice recognition.

### Augmented, mixed and virtual reality

Extended reality offers lots of new opportunities, including in terms of communicating with customers, education and further training, real-time assistance with complex work steps and the virtualisation of prototypes in the planning phase (see section 3.4).

This makes vision picking possible in logistics, for example. Vision picking is a process in which a warehouse picker collects and groups items for customer or production orders using smart glasses and contextual information. The smart glasses provide the worker with a constant flow of information about each order. For one, they point out the shelf or pallet where an item is stored. If the worker's position is being tracked, the glasses can even determine the most efficient route to the storage location.

Use of the camera in vision picking makes handling easier and no other hardware is required. Additionally, the processes are sped up as the smart glasses can confirm the action. Pick-by-vision can reduce the error rate even further. When, for example, the barcode printed at the storage location is scanned in the field of view of the smart glasses, the software installed on the glasses informs the picker whether they have picked up the right item and how many of that item need to be gathered.

Virtual reality can even be used to create digital twins of the warehouse or production area. This means that the areas are modelled accurately in a virtual environment. This makes it possible to test new processes or instructions in the warehouse or production area without disrupting real operations.

### Internet of Things

The Internet of Things (IoT) is made up of more and more networked machines, devices, materials and products. It enables machines to communicate with one another, for example, and control one another with AI, sensors and actuators. If an empty material container is detected, the machine or container can report this to the storage system. In turn, this activates an (autonomous) transporter which then refills the container with the correct materials.

### Big data analytics

The Internet of Things and numerous sensors mean that corporate logistics involve large amounts of data. However, this 'big data' is unstructured and therefore unusable to begin with. Only with big data analytics and AI can its true value be realised and useful findings be obtained. These findings can be used to optimise processes such as transport routes.

## Cloud computing

With cloud computing, infrastructures and workloads can be outsourced to third-party computing centres. Hardware and software are used over the Internet. Even data are not stored in one single place – they can be accessed from anywhere with ease.

This way, it is easier for companies to control multiple production sites and warehouses as all of the information is collected in the cloud. As the data are pooled, it is not difficult to use them for the purposes of administration and control in a control centre.

## Additive manufacturing/3D printing

3D printing is a type of additive manufacturing. Parts and products are built up layer by layer. The 3D printing process is based on a three-dimensional computer model.

This method is the opposite of methods which cut away, reshape or piece together materials.

Plastics and metals are currently the most commonly used materials in 3D printing. That being said, ceramics and biomaterials are now also used in 3D printing. Initially, the raw material is a powder or in the shape of a ribbon, wire or sheet. It is manufactured into a product layer by layer using heat from a heating coil or a laser.

Generally speaking, additive manufacturing techniques enable companies to play a larger role in the value-creation process. Some components that were once procured from suppliers can now be manufactured directly with little effort. This is especially attractive when batch sizes are small and also has an effect on warehousing.

## Autonomous robotics

Robots have been in use for decades. Unlike traditional stationary industrial robots, however, they are increasingly mobile and autonomous. They can move independently in their environment using sensors, actuators and artificial intelligence. Autonomous robotics are not limited to a few preprogrammed operations – they are able to cooperate with human workers flexibly.

In a warehouse, for example, autonomous robotics can move heavy goods. Ideally, they cooperate ‘hand-in-hand’ with human workers. Technical support systems such as exoskeletons are leading to humans and machines merging together as they are positioned on the body itself and relieve the strain on the worker’s bones and muscles.

## 2.2 Changing work processes

The implementation of digital technology and the resulting use of new applications are the key elements of the digitisation of corporate logistics. However, there are other aspects to digitisation that companies must also take into account for the process to succeed.

For example, work processes must also evolve. In their report entitled ‘Work 4.0: How Will We Work in the Future?’, the Handelsblatt Research Institute and TeamViewer consider what this might look like in a company under the umbrella term ‘Work 4.0’ and what expectations companies and employees have.

Work 4.0 will also seep into logistics. Some jobs will be performed by machines in the future. This will be the case, for example, if the individual stations in a production area are no longer supplied with parts by employees, but rather by autonomous transporters. In turn, human workers will be supported by machines in other jobs. For instance, warehouse robots can move heavy goods or workers wearing smart glasses can view relevant information relating to their current assignment in their field of vision.

This means that workers will be spared from performing monotonous routine tasks or

even from dangerous jobs such as handling heavy goods. This has a positive effect on job satisfaction and long-term ability to work. The potential of digitisation in terms of occupational health and safety cannot be understated in logistics.

However, companies must involve their employees in the Logistics 4.0 change process in order to realise the potential benefits of digitisation. This includes, for example, providing transparent information about the changes and especially the resulting benefits. As shown in the report on Work 4.0, companies and employees alike see potential resistance from the workforce as a major challenge when it comes to using digital technology. It is best to avert this resistance from the outset. This involves dispelling any fears employees might have, such as a loss of privacy or even their job, as well as making it clear that machines will not have far-reaching influence in decisions and instructions.

Moreover, teaching and training are part of this employee inclusion strategy. Working with digital technology and new applications requires additional skills and expertise, and employees must be given the tools they need to do it. As such, advanced training is an essential aspect of the digitisation of logistics.

Only when a company's employees accept the digital technology and new applications and possess the necessary skills and knowledge will the transformation process succeed and its benefits become a reality.

## 2.3 Data protection and cybersecurity

In Logistics 4.0, digital data will play an even larger role than they do at present in logistics. Where the data are sensitive, companies will have to make sure the necessary security is in place. The data might be sensitive because they are personal data from which conclusions can be drawn about employees or customers. Likewise, however, the data might relate to processes on which the company's competitiveness depends and which are therefore potentially of interest to competitors.

Furthermore, as Logistics 4.0 is more digital and more networked, a company will be more susceptible to cyberattacks. Cybersecurity will therefore become more relevant to companies. These security aspects should be factored in at the early stages of the digital transformation so that the protection is in place from the outset.

Cybersecurity is also an aspect of the aforementioned new skills and knowledge required by employees (see section 2.2). It is necessary to raise awareness of how to handle data more cautiously. At the same time, employees need to be more aware of digital risks to prevent them from accidentally leaving the company open to cyberattacks.

# 3 Logistics 4.0 – Results of a survey in ten European countries

## 3.1 Methods of investigation

The analysis is based on a survey that was carried out online by the market research firm YouGov. In total, 3,575 corporate decision-makers were surveyed between 15 and 26 July 2021. The survey was conducted in ten European countries: Denmark, Germany, France, Italy, the Netherlands, Norway, Poland, Sweden, Spain and the United Kingdom. This offers insights into 'pan-European' attitudes and trends as well as deviations from these in individual countries. The aggregated results of the ten countries that follow are the focal point as a 'European' picture, and deviations and differences between individual countries are highlighted in each case.

**The topic of the survey is Logistics 4.0. The questions look at the following aspects:**

- The state of digitisation in corporate logistics
- The challenges and risks of the digitisation of logistics
- Strategies and driving forces behind the digitisation of logistics
- Individual future technologies: how they are expected to shape the logistics of the future and their current and planned use by companies
- Potential applications of augmented reality
- Potential applications of the Internet of Things

As the survey is focused in this way, it is only relevant to companies whose logistical processes (e.g. procurement, warehousing and transport logistics) are important and therefore have a warehouse, have internal flows of materials (e.g. in production) and/or for whom product distribution is an important factor. The following results are therefore based on the responses given by a random sample of 1,700 companies in the chosen ten European countries that meet these criteria.

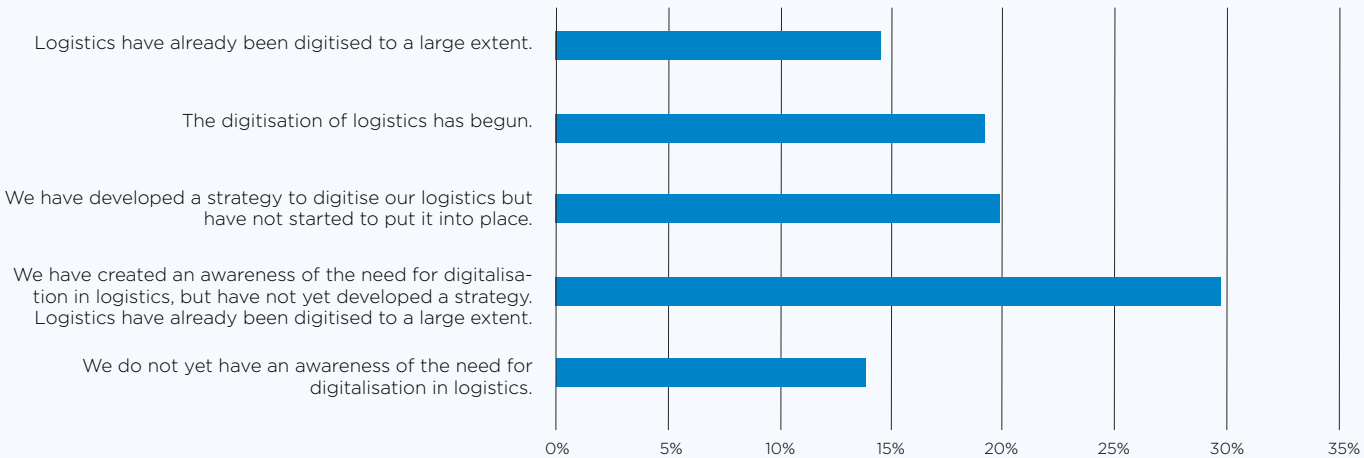
## 3.2 The digitisation of logistics

### 3.2.1 Progress of digitisation

Image 1: Status quo among companies with regard to the digitisation of logistics

Proportion of surveyed corporate decision-makers in %

Remaining percentage: Don't know/N/A




The majority of European companies[1] are still just getting started (see image 1) with the digitisation of logistics. Only around one third of the surveyed corporate decision-makers say that their company has already started to digitise its logistics. The subgroup of companies that have already made great progress in this process is even smaller, at just 15%.

As such, according to their own information, the majority of surveyed companies have not yet begun to digitise their logistics. More than two fifths (43 per cent) do not even have a digitisation strategy for their logistics. However, this is a key prerequisite to prevent the digitisation from ultimately being nothing more than a collection of separate individual measures.

Naturally, the implementation of digital technology and the digitisation of logistics are a question of available resources. As larger companies can be expected to have more resources, larger companies can be expected to have already made progress in the digitisation of their logistics. This is also reflected in the responses: the proportion of companies that do not have a strategy decreases as the number of employees increases. Consequently, the proportion of companies that have already begun to digitise their logistics increases with it.

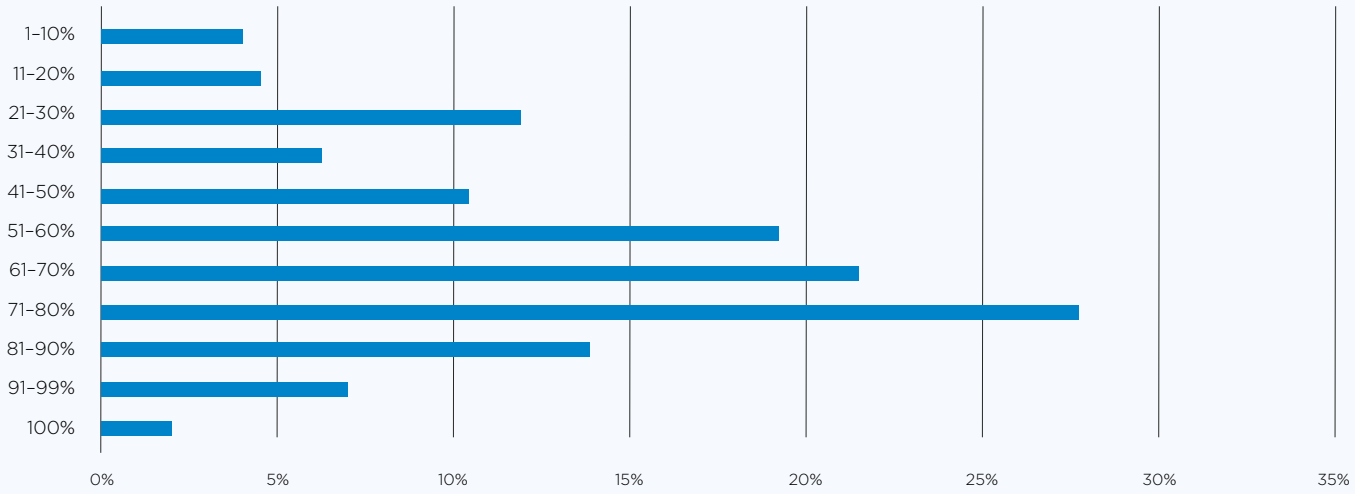
Comparing countries, we see that companies in Denmark and Sweden in particular have already made progress with digitising their logistics. For example, 42 and 41 per cent of surveyed companies respectively have already begun to digitise. French (21 per cent) and British (28 per cent) companies are somewhat further behind, on the other hand.

Overall, these results suggest that the digitisation of logistics has not generally taken off yet. In some situations, it is a corporate division where the transformation is not a high priority. As there is no overall strategy in many cases, it will not be possible to potentially catch up on digitisation immediately as a transformation that will be successful in the long term requires a strategy.

## Image 2: The progress of the digitisation of logistics in companies

Proportion of surveyed corporate decision-makers in %
Scale from 0% (= no digitisation) to
100% (= advanced where technologically possible)

Remaining percentage: Don't know/N/A



The status quo of the digitisation of corporate logistics is significantly more positive when the respondents are asked specifically about its state on a scale from 0 to 100 per cent (see image 2). Two thirds of surveyed European companies say that the digitisation of their logistics is more than 50 per cent complete. The average response is 60 per cent. Whereas companies with fewer than 1,000 employees see a positive correlation between company size and their perception of digitisation, this correlation is not as distinct among larger companies.

Comparing the ten examined countries, we see that companies in Italy, the Netherlands, Spain and Poland are more advanced with regard to this assessment – the country-specific averages are 63 per cent (Italy), 63 per cent (Netherlands), 62 per cent (Spain) and 61 per cent (Poland) – and are only slightly above the overall average. On the other hand, the perceived state of Logistics 4.0 is lower among companies in the United Kingdom (50 per cent) and Norway (55 per cent).

The results in image 1 and image 2 show two differing assessments of the state of digitisation in corporate logistics. Based on the percentage scale, most companies see themselves as 'relatively advanced' already, although this is not reflected by certain milestones such as a strategy having been accomplished. In some situations, companies score themselves more positively on the scale even though they have not done much at all in general because they are either unable or unwilling to do much in their individual situations. As such, the bar is set at a different level for every company.

## 3.2.2 Challenges in the digitisation of logistics

The fact that a relatively large number of companies have not made much progress with digitising their logistics can be due to various challenges they encounter. Available resources are certainly one important aspect in this regard.

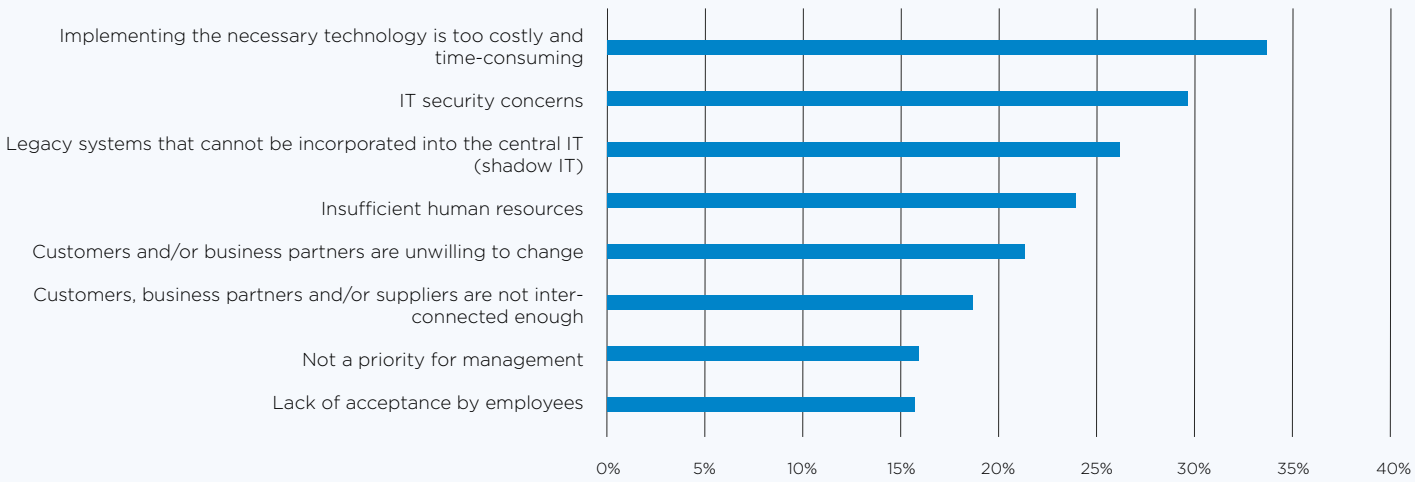
This is, at least, in the opinion of the surveyed corporate decision-makers in the ten European countries. The excessive time and costs of implementing the technology required to digitise is considered a major challenge by 34 per cent of the respondents (see image 3). This makes it the most commonly cited one. All of the technologies used as part of digitisation relate to IT. Data play a more important role and networking increases. Consequently, it is not surprising that IT security issues are of grave concern to the surveyed companies – at least 30 per cent of them. These are followed by legacy systems which are the third most frequently described challenge of digitising logistics. Naturally, companies were already using IT devices before the current digital transformation. Some of these legacy devices cannot be incorporated into the company-wide IT infrastructure. These answers – especially time and costs – seem to have no direct correlation with company size. As such, it is not the case that a potential lack of time and financial resources is only hampering digitisation for smaller companies.

On the other hand, the surveyed companies see a lack of acceptance by employees, a lack of prioritisation by management and insufficient networking with customers, sup-

### Image 3: The great challenges of the digitisation of logistics in companies

Proportion of surveyed corporate decision-makers in %

Multiple answers can be given



pliers and business partners as less serious problems.

A comparison of countries paints a somewhat more heterogeneous picture: in Great Britain, for example, 27 per cent of surveyed corporate decision-makers say that the lack of priority in management is one of the most significant obstacles – 27 per cent also say the same about the integration of legacy systems. IT security concerns dominate in Sweden and the Netherlands with 34 per cent and 35 per cent respectively, whereas the time and costs of implementation are at the forefront in Spain, Italy and Poland, with agreement by 46 per cent, 39 per cent and 37 per cent respectively – far above the European average.

When we consider what companies perceive to be the most significant challenges, we see that they are aspects that are fully within the field of influence of the companies. Therefore, if companies want to press on with digitisation, they are responsible for overcoming the challenges themselves – by investing more, for example.

## 3.2.3 The realisation of digitisation

There are various different aspects to digitisation. In some cases, companies transform their processes, their products and business models, their organisational structure and much more. The implementation of new digital technology is also a core element of the transformation. There are various different ways a company can arrive at these new types of technology.

The survey shows that almost half of the surveyed companies in Europe (44 per cent) will collaborate with customers and suppliers to this end (see image 4). This can be a wise decision as long as the technology is used all along the value chain and throughout the company. 'Connectivity' can be ensured by involving the other players – suppliers and customers – at an early stage.

At 41 per cent, however, the group of companies that use proprietary developments is of a similar size. In turn, two fifths (39 per cent) rely on specialised IT service providers to digitise their logistics. Cooperation with research institutes plays a less significant role, with only around one fifth (23per cent) of companies making use of this option. Perhaps somewhat unexpectedly, there is no clear correlation with company size in this case. The only striking thing is that very large companies with 10,000 or more employees are more likely to rely on the support of service providers.

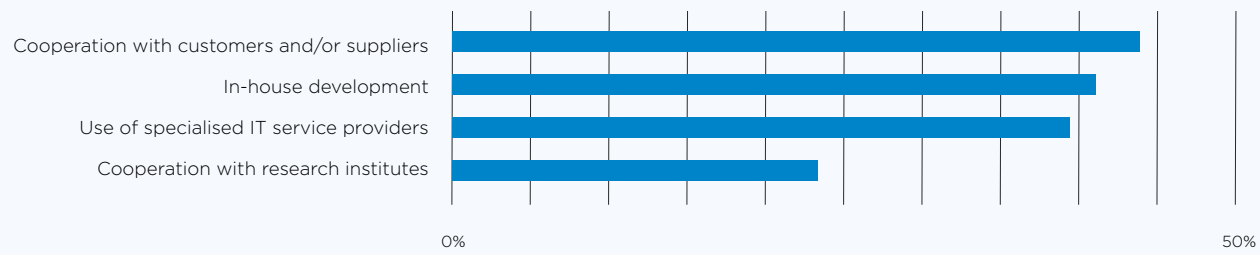
However, the approaches taken by companies differ from country to country in the ten countries in question. For example, companies in Germany prioritise using specialised IT service providers over in-house developments. The situation is similar in the United Kingdom, although somewhat less pronounced. In Norway, on the other hand, in-house developments are the primary approach to digitisation.

This shows that there is not one single approach to the digitisation of corporate logistics. That being said, various different types of cooperation with external partners do play an important role. This might indicate that the need for support and/or advice remains high.

### Image 4: The realisation of digitisation

Proportion of surveyed corporate decision-makers in %

Multiple answers can be given



## 3.2.4 The driving forces behind digitisation

Digitisation did not simply appear out of the blue one day. Rather, it is the result of decisions made by the management of each company. This might be in the pursuit of their own interests or in response to the requirements of suppliers, customers, employees or politicians, for example. This means that internal and external players alike can be the key drivers of digitisation.

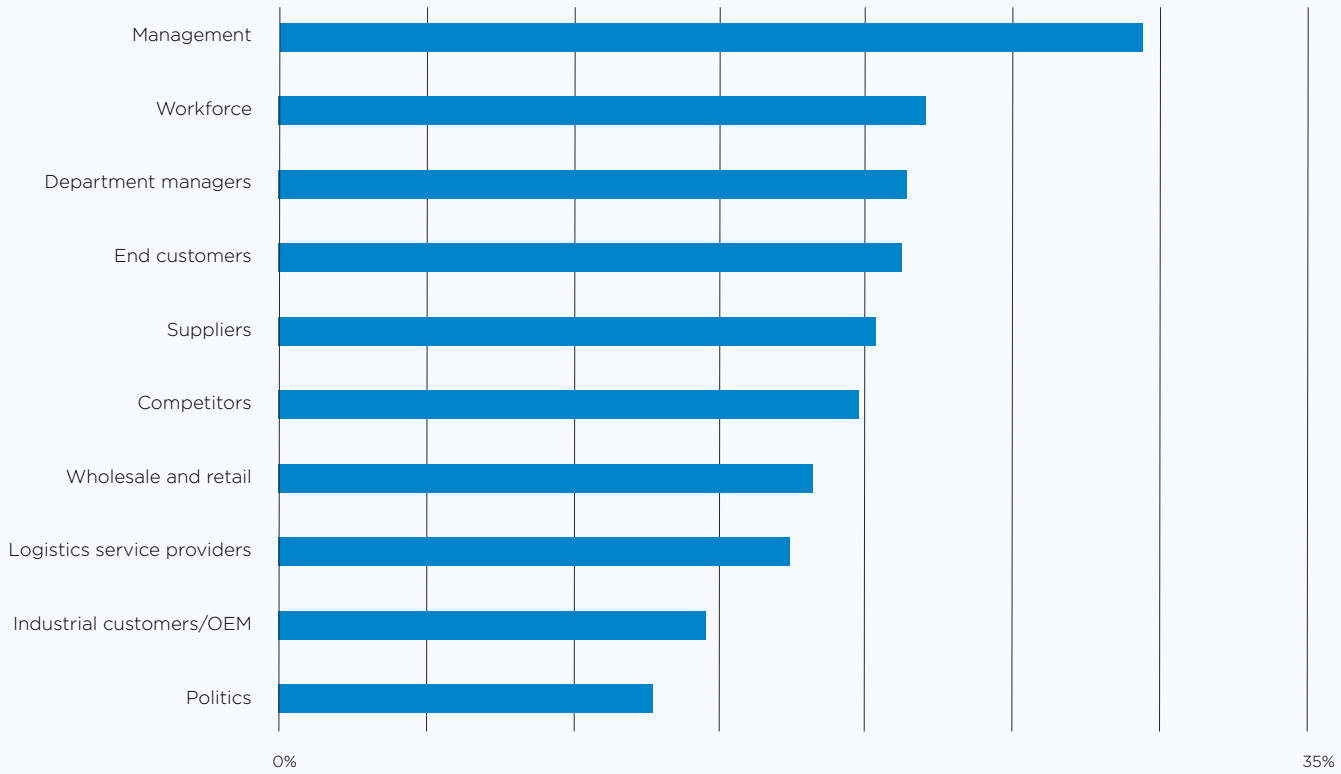
The survey of companies in the ten European countries shows that although external players play an important role in digitisation – especially customers and suppliers – the strongest initiative to digitise corporate logistics does not come from them (see image 5). In companies, this digitisation is primarily driven by the management. At least, this is the case for 29 per cent of the surveyed corporate decision-makers.

With regard to significance, this is followed in second and third place by employees and department managers who are seen as the driving forces behind the digitisation of their logistics by 22 per cent and 21 per cent of European companies respectively.

### Image 5: The driving forces behind the digitisation of logistics in companies

Proportion of surveyed corporate decision-makers in %

Multiple answers can be given



The feedback regarding driving forces is very similar in the ten surveyed countries in terms of its ranked order, especially concerning the role of management. Only in Spain are competitors the most important influential factor, whereas in the Netherlands it is the workforce.

This shows that it is predominantly internal factors that are currently paving the way for the digitisation of corporate logistics, and not external pressure from consumers, suppliers or competitors. And in many companies, whether and to what extent logistics will be digitised ultimately depends on the management and its position on digitisation. Digitisation remains, at least in the beginning, in the hands of executives.

### 3.2.5 The risks of digitised logistics

Many companies rely on specialised IT service providers to digitise their logistics (see section 3.2.3). However, almost one third (31 per cent) of surveyed corporate decision-makers also see a certain risk in this (see image 6). Once the new technology has been deployed, a company might end up dependent on technology providers.

However, 33 per cent of companies say that the greatest risk that is potentially inherent in the digitisation of logistics is the large amount of investment through the incorporation of isolated solutions and information silos resulting from legacy systems that lack interfaces. Furthermore, digitised logistics can be expected to involve more extensive data use and more advanced networking. This has the potential to negatively affect data security and increase the risk of industrial espionage; a considerable risk for 27 per cent of the surveyed corporate decision-makers.

The surveyed companies are relatively optimistic with regard to their workforces and digital infrastructure: a lack of acceptance by employees, poor stability of network-based communications and insufficient broadband infrastructure were seen as risks by the fewest companies.

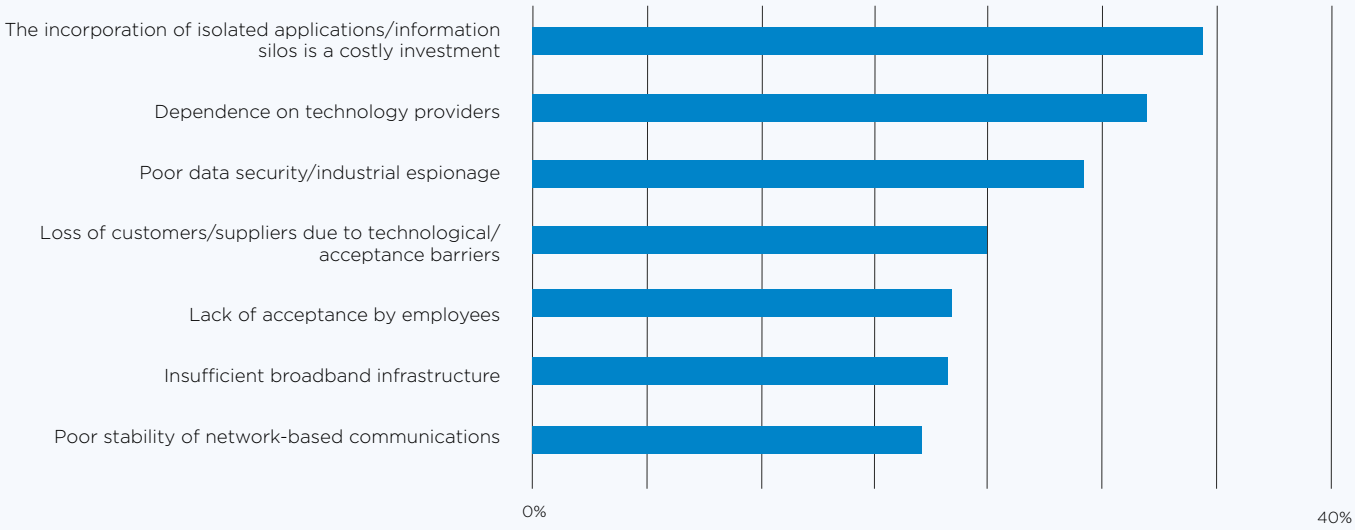
These assessments have relatively similar relationships in the ten countries. Likewise, there is no specific correlation with company size. Larger companies do not less frequently consider the amount of investment to be a risk of digitisation, even if they potentially have more financial resources at their disposal.

Even if these risks might hamper the progress of the digitisation of logistics, companies can face these challenges with a certain degree of optimism. The most significant risks are aspects which companies can take proactive steps to avoid. They

## Image 6: Risks to companies from the use of Logistics 4.0 applications

Proportion of surveyed corporate decision-makers in %

Multiple answers can be given




can potentially reduce the amount of investment through good planning and an informed approach. Additionally, they can intensify their cybersecurity measures and strive for greater diversification in terms of cooperation with technology providers so as to minimise dependencies.

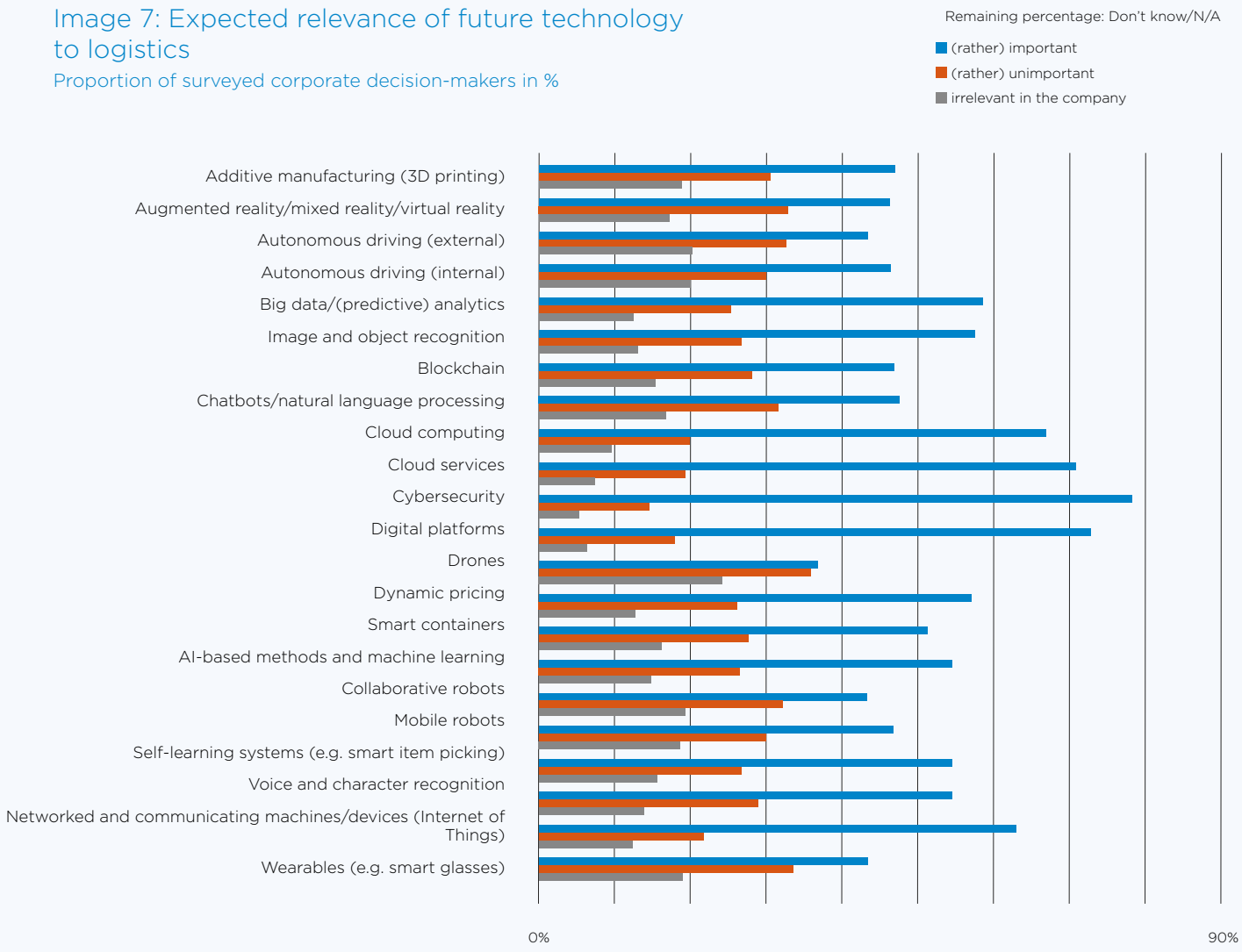
## 3.3 Future technology

One key element of Logistics 4.0 is the use of new digital technology which makes new applications, solutions and business models possible in companies (see section 2.1). However, the relevance of individual technologies that are already available in the market can vary from the perspective of logistics. For example, the Internet of Things might be of different relevance to augmented reality.

In light of the fact that the companies have made different amounts of progress in the digitisation of their logistics (see section 3.2.1), not only does the relevance of each individual future technology differ, but they are also used to different extents by companies.

### Image 7: Expected relevance of future technology to logistics

Proportion of surveyed corporate decision-makers in %



## 3.3.1 Expected relevance of innovative technology to the logistics of the future and its implementation

The surveyed corporate decision-makers in the ten European countries believe that corporate logistics will mainly be shaped by cybersecurity, digital platforms, cloud services, cloud computing and the Internet of Things. Most respondents say that these technologies are particularly relevant (see image 7). On the other hand, drones, collaborative robots, augmented, mixed and/or virtual reality, autonomous vehicles outside of company premises and wearables are considered to be rather less relevant. With regard to pattern recognition, image and object recognition is seen as more relevant than voice and character recognition.

Looking at the bigger picture of all types of digital technology, it becomes evident that these are deemed to be more relevant by companies in Italy, Poland and Spain (see image 8). In contrast, their estimated relevance is below average in the United Kingdom, Sweden and Denmark.

### Image 8: Expected relevance of future technology to logistics – comparison of countries

Proportion of surveyed corporate decision-makers who consider each technology as (rather) important, in %
Highlighted: Proportion above the national average of European countries

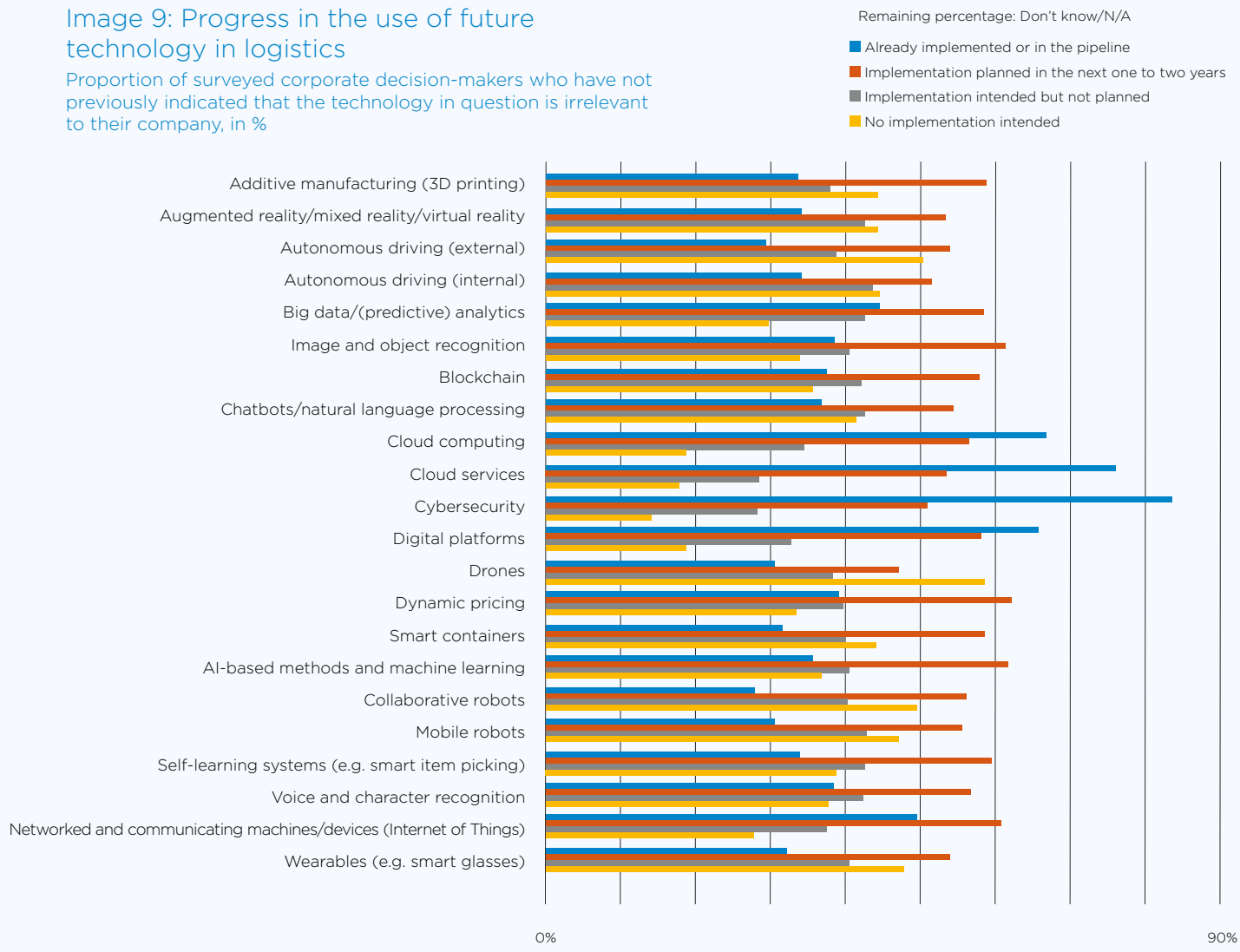
| | ø | DE | UK | FR | ES | IT | DK | SE | NO | NL | PL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Autonomous driving (external) | 43% | 45% | 24% | 47% | 50% | 56% | 29% | 22% | 40% | 41% | 52% |
| Autonomous driving (internal) | 46% | 46% | 27% | 49% | 51% | 57% | 34% | 27% | 49% | 46% | 55% |
| Drones | 37% | 39% | 25% | 42% | 36% | 48% | 22% | 29% | 23% | 31% | 45% |
| Smart containers | 51% | 55% | 33% | 47% | 59% | 71% | 34% | 36% | 41% | 43% | 60% |
| Mobile robots | 47% | 45% | 33% | 46% | 57% | 60% | 26% | 36% | 40% | 38% | 58% |
| Digital platforms | 73% | 76% | 67% | 62% | 79% | 79% | 73% | 68% | 79% | 62% | 77% |
| Wearables (e.g. smart glasses) | 43% | 41% | 29% | 42% | 47% | 65% | 16% | 34% | 30% | 36% | 56% |
| Voice and character recognition | 54% | 66% | 42% | 49% | 59% | 70% | 40% | 45% | 31% | 41% | 65% |
| Image and object recognition | 57% | 62% | 44% | 55% | 64% | 72% | 44% | 48% | 46% | 49% | 62% |
| Chatbots/natural language processing | 47% | 49% | 26% | 51% | 55% | 63% | 30% | 37% | 38% | 43% | 53% |
| Dynamic pricing | 57% | 48% | 39% | 52% | 63% | 74% | 40% | 50% | 44% | 61% | 69% |
| Cloud services | 71% | 66% | 66% | 59% | 79% | 78% | 57% | 66% | 76% | 70% | 79% |
| AI-based methods and machine learning | 54% | 55% | 39% | 48% | 65% | 68% | 35% | 48% | 53% | 47% | 63% |
| Augmented reality/mixed reality/virtual reality | 46% | 44% | 29% | 43% | 51% | 57% | 26% | 42% | 44% | 43% | 59% |
| Self-learning systems (e.g. smart item picking) | 54% | 54% | 35% | 55% | 63% | 68% | 33% | 43% | 56% | 46% | 64% |
| Big data/(predictive) analytics | 58% | 59% | 44% | 51% | 71% | 73% | 49% | 44% | 54% | 53% | 64% |
| Networked and communicating machines/ devices (Internet of Things) | 63% | 61% | 50% | 58% | 65% | 76% | 50% | 55% | 68% | 60% | 71% |
| Blockchain | 47% | 47% | 21% | 48% | 59% | 60% | 28% | 32% | 28% | 49% | 54% |
| Additive manufacturing (3D printing) | 47% | 48% | 30% | 43% | 54% | 62% | 27% | 36% | 38% | 43% | 57% |
| Cloud computing | 67% | 68% | 63% | 57% | 80% | 74% | 55% | 58% | 75% | 65% | 66% |
| Cybersecurity | 78% | 76% | 63% | 69% | 80% | 87% | 81% | 78% | 81% | 78% | 81% |
| Collaborative robots | 43% | 43% | 25% | 49% | 48% | 61% | 31% | 32% | 41% | 37% | 44% |

This shows that the estimated relevance of the various types of technology to the corporate logistics of the future is thoroughly varied. The reason why technology such as AR, MR and VR might (still) be considered less relevant despite there being potential applications including pick-by-vision could be that many companies are not aware of concrete business cases and the related benefits. One piece of evidence to support this hypothesis is that companies which have already made progress with the digitisation of their logistics largely considered the technology to be more relevant.

There is a certain correlation between the extent to which this technology is being or set to be used by companies and its estimated relevance. The types of technology that tend to be deemed relevant are already more widespread in the field of corporate logistics (see image 9). For example, cybersecurity or cloud service applications have already been implemented or are currently

## Image 9: Progress in the use of future technology in logistics

Proportion of surveyed corporate decision-makers who have not previously indicated that the technology in question is irrelevant to their company, in %



being rolled out in 46 per cent and 42 per cent of surveyed companies respectively. Another roughly one third of companies are going to catch up on this in the next one to two years.

Overall, according to the surveyed decision-makers, some progress will be made with the use of technology in the next couple of years. Around one third of companies want to roll out the individual technologies. As such, around half of the companies could be expected to use augmented and virtual reality applications in two years' time.

Financial resources are always the deciding factor when it comes to rolling out and using such future technology. As larger companies usually have more resources at their disposal, it is less surprising that each type of future technology is already being used mainly by larger companies.

## Image 10: Progress in the use of future technology in logistics – comparison of countries

Proportion of surveyed corporate decision-makers who have not previously indicated that the technology in question is irrelevant to their company, and for whom that technology has already been or is currently being implemented in their company, in %

Highlighted: Proportion above the national average of European countries

| | ø | DE | UK | FR | ES | IT | DK | SE | NO | NL | PL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Autonomous driving (external) | 16% | 13% | 8% | 28% | 15% | 16% | 12% | 16% | 10% | 18% | 15% |
| Autonomous driving (internal) | 19% | 21% | 14% | 21% | 17% | 21% | 14% | 21% | 11% | 23% | 19% |
| Drones | 17% | 17% | 16% | 20% | 17% | 17% | 14% | 23% | 13% | 13% | 14% |
| Smart containers | 17% | 19% | 12% | 20% | 19% | 23% | 7% | 19% | 12% | 13% | 16% |
| Mobile robots | 17% | 17% | 15% | 21% | 17% | 19% | 14% | 15% | 10% | 14% | 18% |
| Digital platforms | 36% | 38% | 39% | 33% | 40% | 36% | 41% | 45% | 40% | 34% | 27% |
| Wearables (e.g. smart glasses) | 18% | 19% | 15% | 26% | 15% | 21% | 11% | 23% | 14% | 14% | 15% |
| Voice and character recognition | 21% | 34% | 17% | 22% | 18% | 23% | 18% | 23% | 12% | 17% | 18% |
| Image and object recognition | 21% | 28% | 15% | 24% | 23% | 21% | 14% | 23% | 16% | 19% | 19% |
| Chatbots/natural language processing | 20% | 23% | 20% | 22% | 21% | 19% | 13% | 24% | 16% | 19% | 21% |
| Dynamic pricing | 22% | 16% | 18% | 22% | 23% | 22% | 12% | 24% | 16% | 20% | 29% |
| Cloud services | 42% | 43% | 55% | 30% | 51% | 40% | 41% | 49% | 37% | 42% | 38% |
| AI-based methods and machine learning | 20% | 18% | 12% | 23% | 22% | 19% | 16% | 29% | 15% | 18% | 18% |
| Augmented reality/mixed reality/virtual reality | 19% | 15% | 16% | 22% | 23% | 19% | 10% | 26% | 11% | 17% | 20% |
| Self-learning systems (e.g. smart item picking) | 19% | 20% | 7% | 24% | 22% | 20% | 13% | 15% | 15% | 20% | 17% |
| Big data/(predictive) analytics | 25% | 27% | 22% | 33% | 26% | 24% | 22% | 24% | 16% | 27% | 21% |
| Networked and communicating machines/ devices (Internet of Things) | 27% | 30% | 33% | 28% | 31% | 27% | 23% | 30% | 19% | 27% | 24% |
| Blockchain | 21% | 23% | 17% | 29% | 21% | 19% | 11% | 21% | 14% | 24% | 18% |
| Additive manufacturing (3D printing) | 19% | 17% | 18% | 18% | 19% | 21% | 21% | 18% | 10% | 18% | 20% |
| Cloud computing | 37% | 43% | 56% | 31% | 46% | 31% | 33% | 45% | 36% | 33% | 27% |
| Cybersecurity | 46% | 47% | 62% | 38% | 46% | 45% | 59% | 56% | 39% | 43% | 42% |
| Collaborative robots | 15% | 16% | 9% | 20% | 18% | 13% | 16% | 17% | 14% | 12% | 14% |

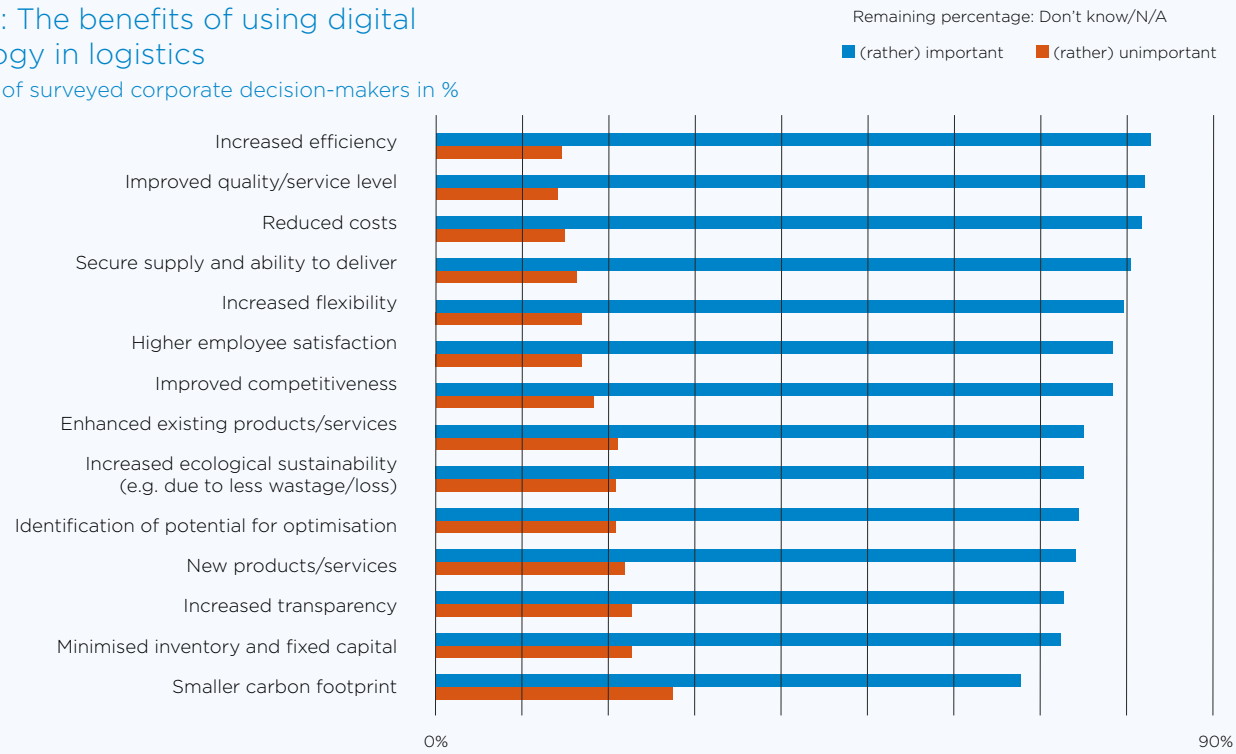
On a national level, companies in France, Germany, Spain and Sweden in particular are often above average in terms of (planned) implementation (see image 10). On the other hand, the technology is used by fewer companies than average in Denmark, Norway and the United Kingdom.

## 3.3.2 The benefits of using digital technology in logistics

There is a reason why these types of technology are used – just as there is a reason for digitisation itself. Companies associate real benefits and value with it. At 83 per cent, an overwhelming majority of surveyed companies in Europe see digital technology in their logistics as a way of increasing efficiency (see image 11). Other benefits that more than four fifths of companies consider important include improved quality and service level, lower costs, security of supply and ability to deliver. The aspects motivating companies to use digital technology are therefore primarily economic in nature. However, more than half of the companies also describe reduced $CO_2$ emissions, minimised inventories or increased transparency as potential benefits.

## Image 11: The benefits of using digital technology in logistics

Proportion of surveyed corporate decision-makers in %




## 3.4 Extended reality

Augmented reality (AR), mixed reality (MR) and virtual reality (VR) are types of computer-assisted reality ('extended reality'). Virtual reality completely masks reality and replaces it with artificial three-dimensional worlds. In contrast, augmented reality retains the real environment in principle and adds supplementary digital information in the form of text, images or videos. Mixed reality is a hybrid form where physical and digital objects coexist and interact with one another. Virtual elements are normally incorporated by smart glasses or a standard mobile device (a tablet or smartphone).

Extended reality applications are rapidly on the rise and promise lots of new possibilities, especially in logistics. Packaging, handling, warehousing, transport, delivery, maintenance and other processes depend on decisions made by human beings. Consequently, individual factors including character, current mood, concentration and tiredness play an important role and can potentially lead to performance fluctuations. The purpose of digital technology is to help warehouse staff carry out these procedures.

For example, AR applications can distribute the workload more effectively, facilitate decision-making or make routine tasks less tedious. For instance, vision picking with smart glasses makes it possible to work with both hands free. Additionally, augmented reality can increase interactivity at work and reduce the rate of errors.

As an example, pickers – one of the most important tasks in intralogistics – can be shown supplementary digital information to help them locate an item more quickly. This includes the visualisation of information that is otherwise available on paper. The information can be processed more quickly directly in the picker's field of view. This way, AR can shorten the time it takes to pick goods and individual parts warehouses.

## 3.4.1 Expected applications and benefits of augmented reality in logistics

In principle, around 62 per cent of decision-makers see potential applications for augmented reality in their corporate logistics (see image 12). This is despite the fact that AR, MR or VR are only used or currently being rolled out by 19 per cent of the surveyed European companies which see this technology as relevant to logistics (see image 10). There are various possible reasons for this discrepancy: not all companies might currently be convinced of its business potential. Alternatively, some of the currently available tools are not advanced enough, require too much consultation and/or are not well enough known due to a lack of market transparency. Ultimately, it might also be that investment plans simply take a certain amount of time within a company.

In a comparison of countries, Italy, Poland and France have the highest expectations of AR applications, whereas companies in Denmark and the United Kingdom are relatively sceptical about its benefits.

There are also significant differences with regard to company size: larger companies with more than 250 employees tend to see more potential applications than small and medium-sized companies (see image 13).

### Image 12: Potential applications of AR in corporate logistics by country

Remaining percentage: Don't know/N/A

Proportion of surveyed corporate decision-makers in %

Highlighted: Proportion above the national average of European countries

| | ø | DE | UK | FR | ES | IT | DK | SE | NO | NL | PL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| There are definitely potential applications | 26% | 29% | 11% | 37% | 27% | 30% | 11% | 25% | 21% | 18% | 30% |
| There are some potential applications | 36% | 33% | 25% | 35% | 36% | 48% | 24% | 30% | 29% | 40% | 44% |
| No potential applications | 28% | 33% | 48% | 25% | 30% | 19% | 34% | 35% | 29% | 31% | 15% |

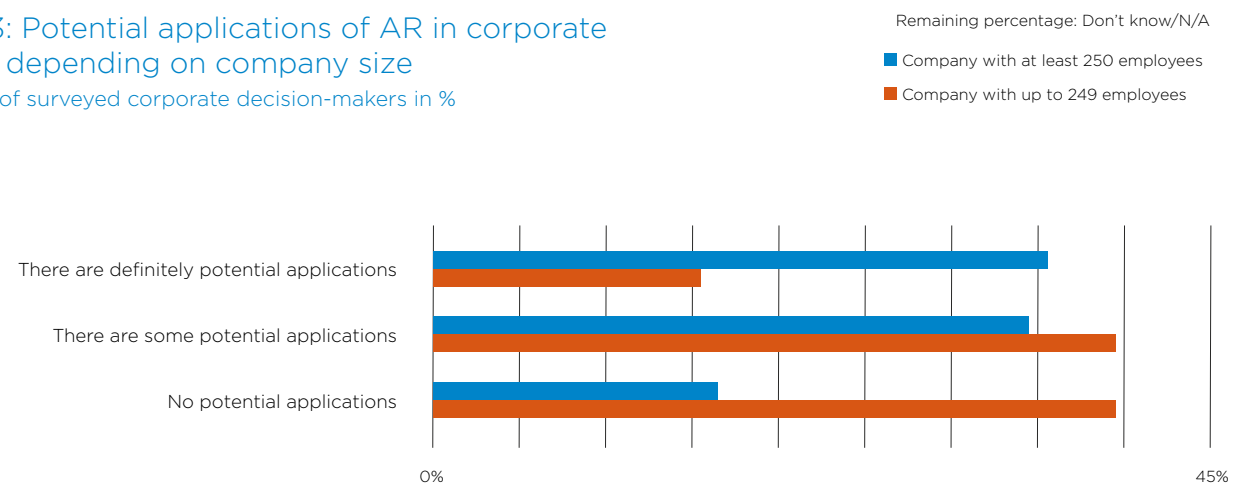
The reason for this might be that the relevance and complexity of logistical processes tend to increase with the size of the company.

The type of existing logistical processes also affects the expected potential of AR (see image 14). It is primarily companies with internal transport logistics that support potential applications – more than 68 per cent agree with this sentiment. On the other hand, companies with warehousing logistics even have slightly below-average representation at 60.7 per cent.

According to the companies, specific fields of application of AR would be the onboarding and integration of workers, the improvement of picking quality and completeness checking in particular, although only around one third of corporate decision-makers in Europe on average are able to imagine one of these three potential applications being relevant to their logistics. In a comparison of countries, the most potential uses are described by companies in Spain, Poland and Germany (see image 15).

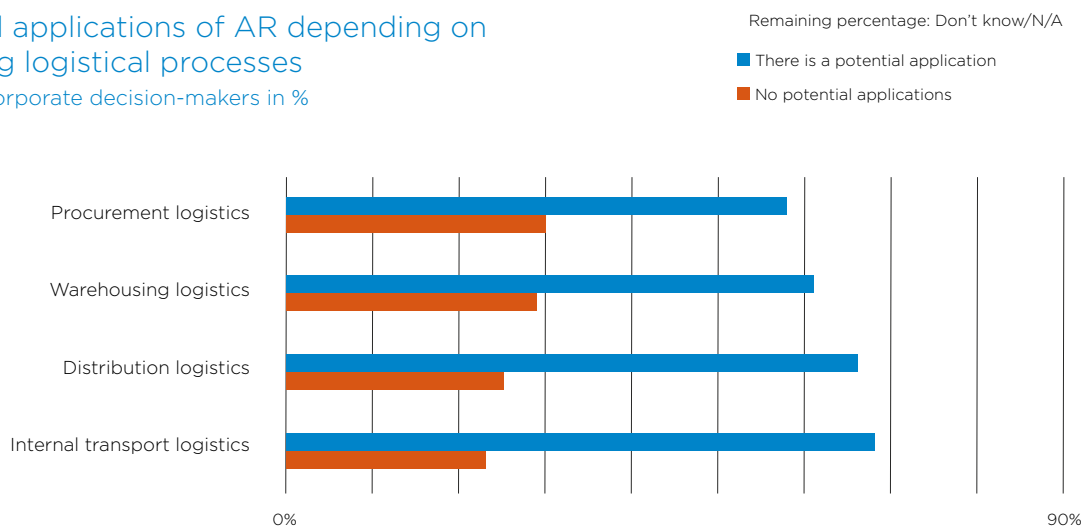
## Image 13: Potential applications of AR in corporate logistics depending on company size

Proportion of surveyed corporate decision-makers in %




## Image 14: Potential applications of AR depending on companies' existing logistical processes

Proportion of surveyed corporate decision-makers in %



## Image 15: Specific potential applications of AR in corporate logistics

Multiple answers can be given

Proportion of surveyed corporate decision-makers who generally see potential applications for AR in their logistics, in %

Highlighted: Proportion above the national average of European countries

| | ø | DE | UK | FR | ES | IT | DK | SE | NO | NL | PL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Onboarding and integration of workers | 35% | 33% | 40% | 28% | 35% | 32% | 29% | 30% | 38% | 44% | 41% |
| Improvement of picking quality | 34% | 32% | 23% | 34% | 42% | 30% | 20% | 33% | 28% | 34% | 40% |
| Completeness checks | 32% | 40% | 29% | 22% | 33% | 36% | 32% | 29% | 13% | 42% | 30% |
| Increased picking efficiency with pick-by-vision | 31% | 37% | 23% | 31% | 45% | 24% | 20% | 35% | 23% | 27% | 32% |
| Assembly, maintenance and repair services | 31% | 36% | 23% | 27% | 44% | 26% | 20% | 36% | 23% | 18% | 33% |
| Optimisation of loading | 30% | 27% | 17% | 35% | 29% | 31% | 22% | 26% | 25% | 35% | 33% |
| Remote support for remote expert assistance | 30% | 25% | 31% | 24% | 36% | 30% | 39% | 29% | 33% | 32% | 27% |
| Optimisation of 'last mile' delivery | 29% | 31% | 14% | 27% | 36% | 34% | 22% | 24% | 25% | 17% | 31% |
| Optimisation of the packaging process | 28% | 33% | 9% | 30% | 35% | 32% | 34% | 24% | 15% | 22% | 26% |

According to companies, other fields of application of AR outside of the potential answers offered by the survey include punctual dispatching, the presentation of products to customers, the customer journey and the improvement of operating performance.

The individual countries differ when it comes to prioritising each application: whereas the onboarding and integration of workers is the most important aspect in the Netherlands, Poland, the United Kingdom and Norway, increased picking efficiency with pick-by-vision is most important in Spain, completeness checking is most important in Germany and Italy and remote support for remote expert assistance is the highest priority in Denmark. In contrast, corporate decision-makers in Sweden are more focused on support for assembly, maintenance and repair services while corporate decision-makers in France prefer the optimisation of loading.

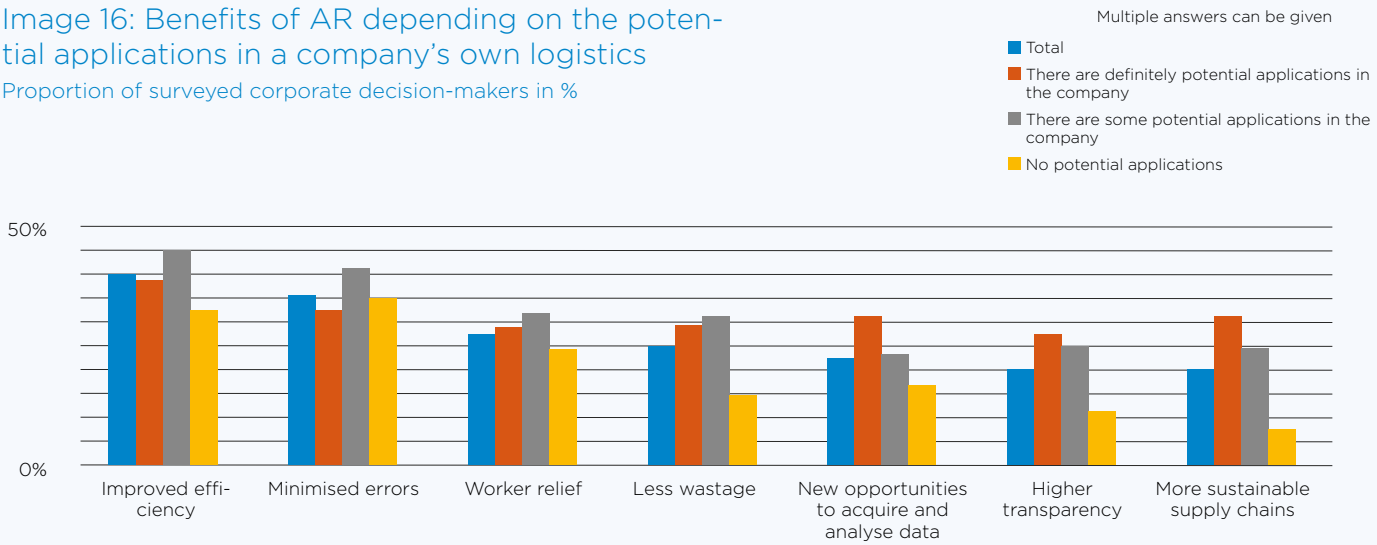
Improved efficiency, error minimisation and worker relief are the three most important benefits of AR applications identified by corporate decision-makers in Europe (see image 16). It is worthy of note that the respondents who see unlimited potential uses for AR in their own companies do not necessarily expect more benefits than corporate decision-makers who only see some potential applications. However: New opportunities to acquire and analyse data and more sustainable supply chains are ranked third and fourth by the former group, and are therefore weighted much more heavily than by all companies on average. Additionally, managers who see no potential applications for AR in their own companies are generally able to conceive of benefits to using this technology in supply chain

management and in logistics, even if the benefits in question are expected to be on a significantly smaller scale.

Companies in Poland, Italy, Spain, Germany and France are promising themselves an above-average number of benefits of AR applications in logistics (see image 17).

## Image 16: Benefits of AR depending on the potential applications in a company's own logistics

Proportion of surveyed corporate decision-makers in %



## Image 17: Benefits of AR by country

Proportion of surveyed corporate decision-makers in %
Highlighted: Proportion above the national average of European countries

Multiple answers can be given

| | ø | DE | UK | FR | ES | IT | DK | SE | NO | NL | PL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Improved efficiency | 39% | 40% | 43% | 38% | 42% | 43% | 25% | 39% | 36% | 34% | 40% |
| Minimised errors | 35% | 38% | 33% | 31% | 38% | 38% | 30% | 37% | 39% | 33% | 35% |
| Worker relief | 27% | 29% | 8% | 27% | 31% | 14% | 28% | 34% | 25% | 31% | 33% |
| Less wastage | 24% | 22% | 26% | 29% | 25% | 28% | 22% | 22% | 18% | 22% | 25% |
| New opportunities to acquire and analyse data | 22% | 22% | 21% | 24% | 24% | 21% | 18% | 22% | 25% | 17% | 25% |
| Higher transparency | 20% | 23% | 13% | 21% | 16% | 24% | 8% | 17% | 15% | 21% | 31% |
| More sustainable supply chains | 19% | 19% | 9% | 19% | 19% | 27% | 10% | 10% | 13% | 28% | 24% |

## 3.4.2 Use and expected benefits of smart glasses in logistics

Smart glasses are a flexible hardware requirement for AR applications. Only around one sixth of the surveyed companies in Europe are currently using smart glasses in their logistics (see image 18). Almost one quarter are planning to roll them out, however. That being said, more than half consider this technological solution irrelevant to them and are not planning to use it.

Companies in France express an above-average willingness to use smart glasses, followed by companies in Italy, Poland and Germany. In contrast, 80 per cent of corporate decision-makers in Denmark consider the technology irrelevant or at least do not intend to use it. Companies in Norway, the United Kingdom and the Netherlands also tend to be sceptical.

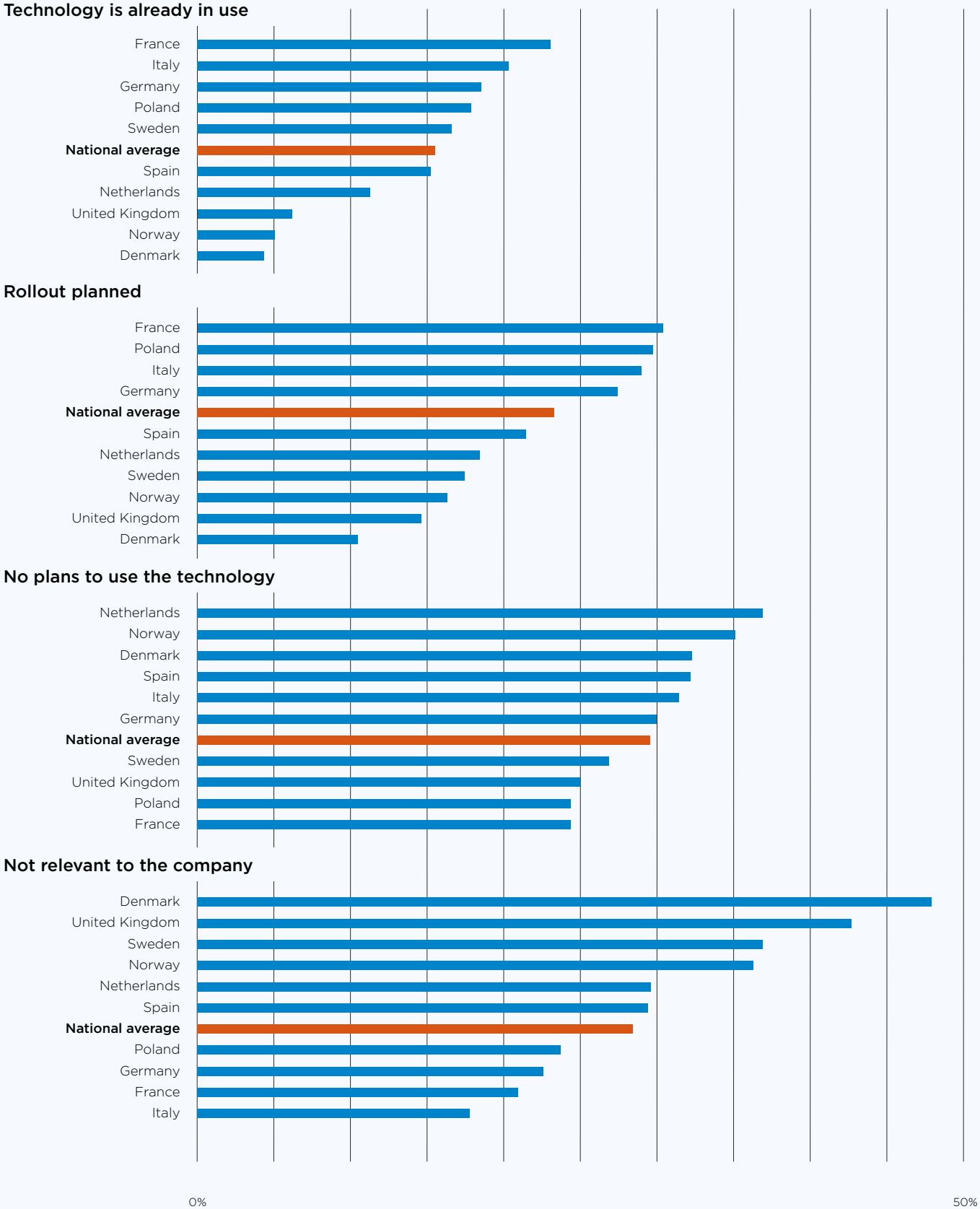
Almost 80 per cent of the companies that definitely see potential applications for AR are already using smart glasses or are planning to use them (see image 19). And inversely, almost 92 per cent of decision-makers state that the use of smart glasses is not planned or not relevant as long as they see no uses for AR in their corporate logistics. This highlights the close link between hardware and applications: the use of smart glasses correlates closely with the expected benefits of augmented reality.

Companies see roughly equally substantial benefits of using smart glasses with regard to the areas covered by the survey – production, warehouse and inspection and maintenance (see image 20): in each case, more than three fifths of European decision-makers say that smart glasses are a great or at least moderate benefit to these corporate functions. It is evident that appreciation increases with experience since companies that already use smart glasses show more acceptance across the board.

## Image 18: Use of smart glasses in logistics

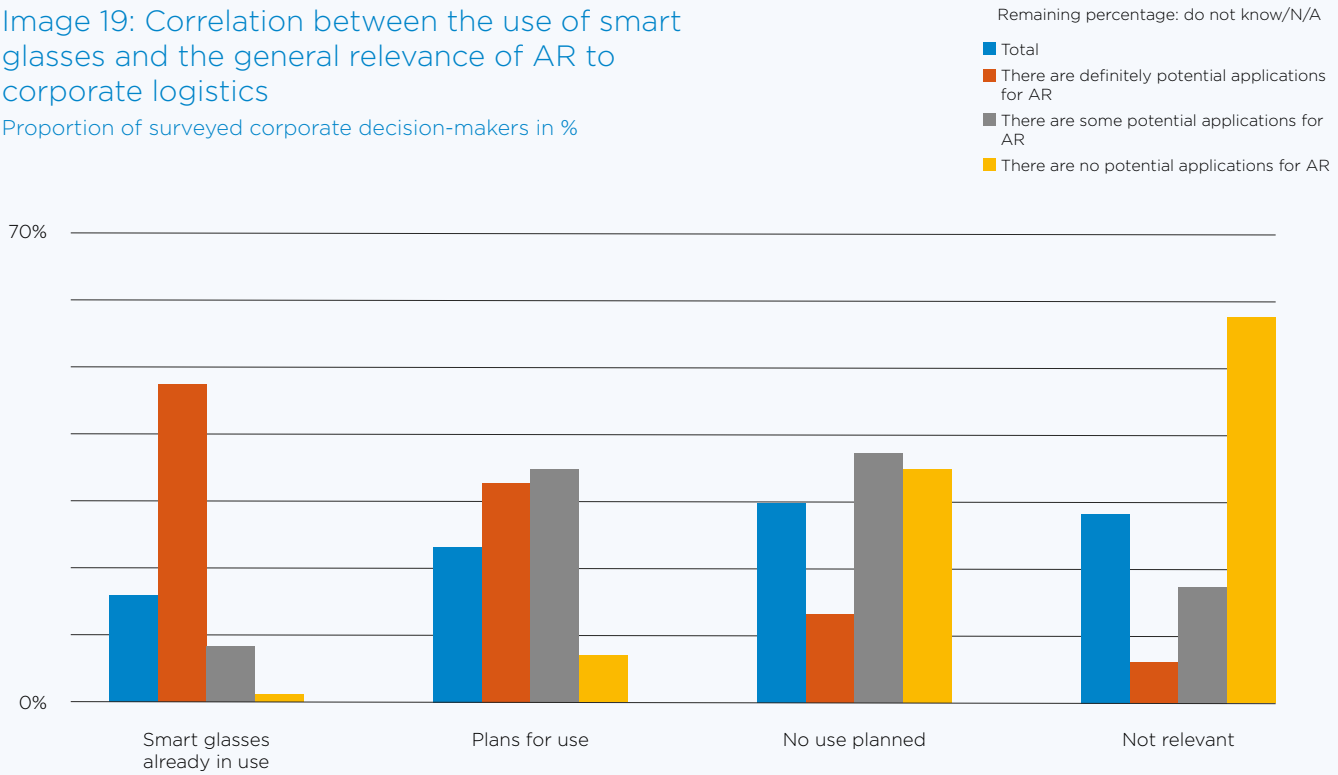
Proportion of surveyed corporate decision-makers in %

Remaining percentage: Don't know/N/A



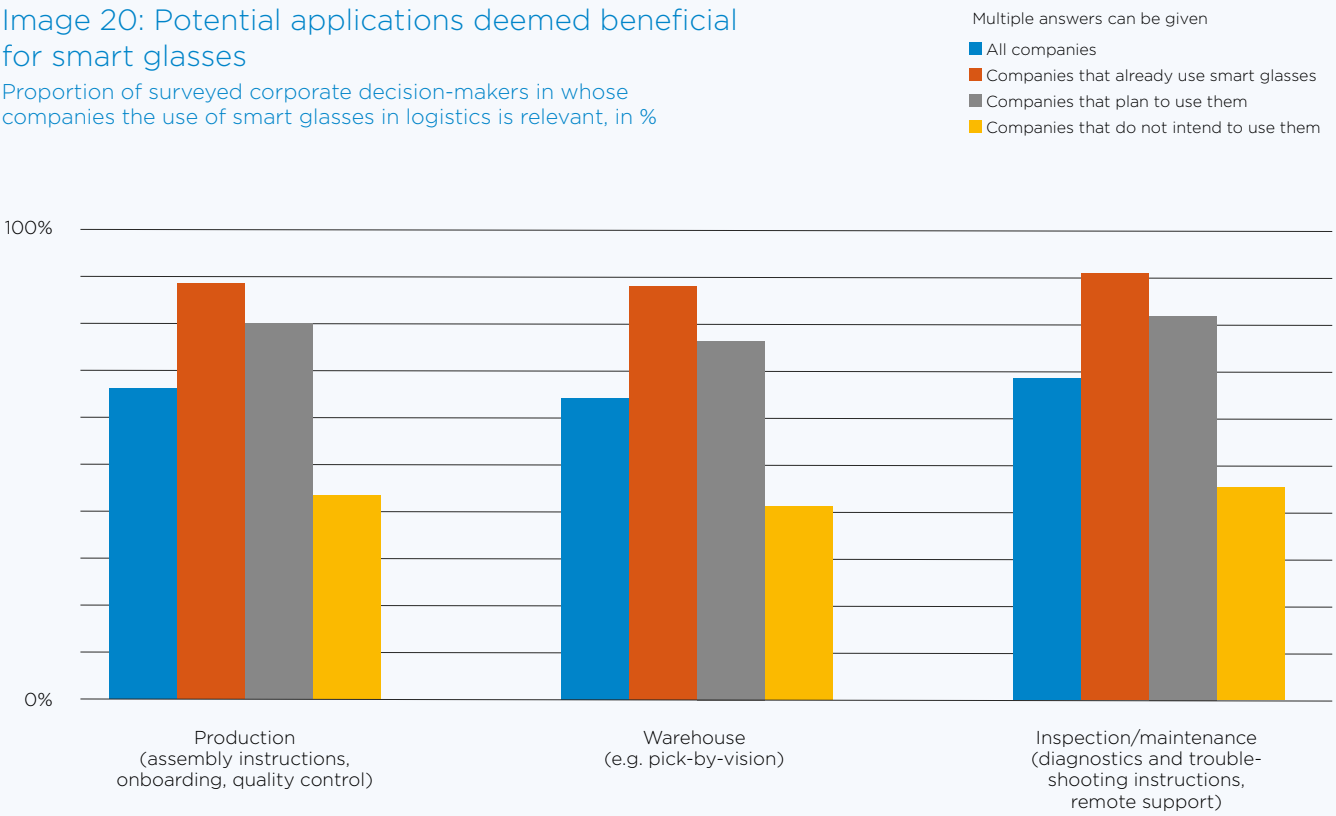
## Image 19: Correlation between the use of smart glasses and the general relevance of AR to corporate logistics

Proportion of surveyed corporate decision-makers in %




## Image 20: Potential applications deemed beneficial for smart glasses

Proportion of surveyed corporate decision-makers in whose companies the use of smart glasses in logistics is relevant, in %



## Image 21: Benefits of smart glasses for various corporate divisions by country

Multiple answers can be given

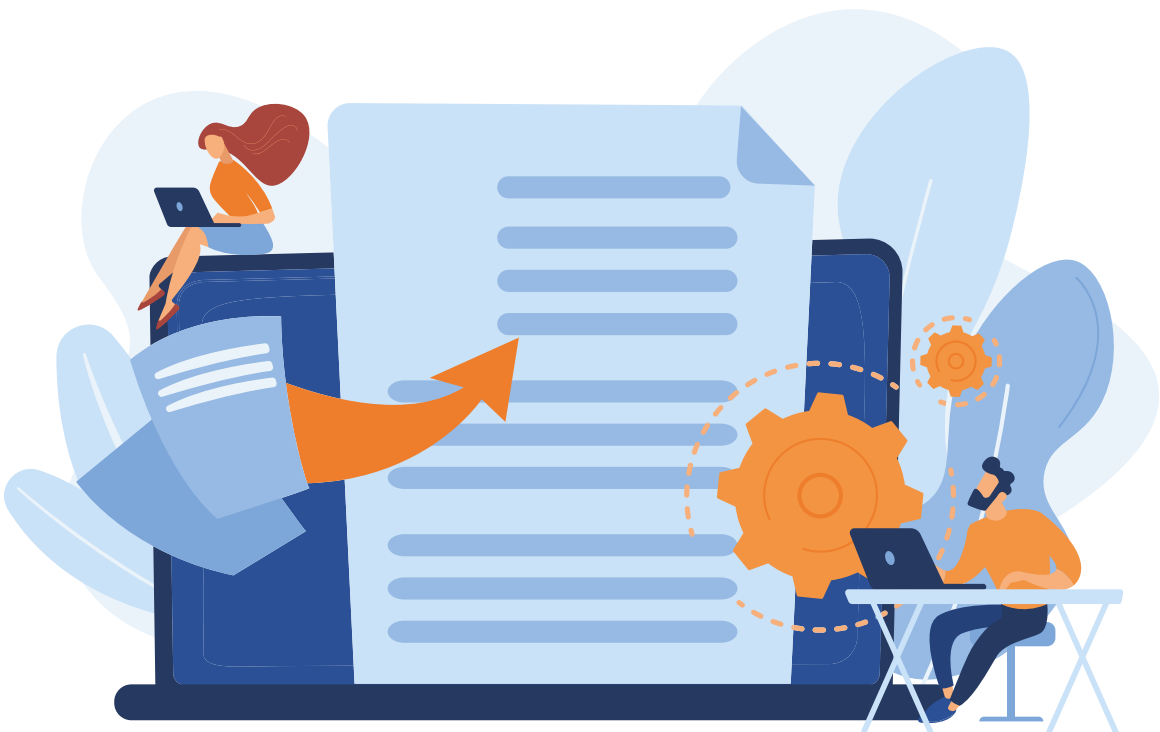
Proportion of surveyed corporate decision-makers in whose companies the use of smart glasses in logistics is relevant, in %

Highlighted: Proportion above the national average of European countries

| | ø | DE | UK | FR | ES | IT | DK | SE | NO | NL | PL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Production (assembly instructions, onboarding, quality control) | 66% | 65% | 52% | 72% | 69% | 76% | 43% | 67% | 56% | 54% | 72% |
| Warehouse (e.g. pick-by-vision) | 64% | 64% | 52% | 69% | 71% | 75% | 39% | 56% | 53% | 54% | 67% |
| Inspection/maintenance (diagnostics and troubleshooting instructions, remote support) | 68% | 73% | 52% | 70% | 71% | 73% | 44% | 62% | 60% | 63% | 75% |

However, 40 per cent of companies that do not intend to use smart glasses do recognise the general benefits they can deliver in the three potential applications.

On a national level, decision-makers in Italy, Poland, Spain and France in particular expect benefits from using smart glasses in the various divisions (see image 21). In contrast, rates of acceptance in Denmark, the United Kingdom, Norway and the Netherlands are significantly below the European national average.



## 3.5 Internet of Things

Machines, devices, materials and products are increasingly networked in the Internet of Things (IoT). Data levels and physical processes are merging into so-called cyber-physical systems so that more and more machines are able to communicate with one another autonomously and share information about their status and/or environment. This way, every object is uniquely identifiable and has access to the network; its position and status are known. These characteristics promise great potential benefits to logistics. Smart logistics applications based on the Internet of Things range from intelligent freight transport to warehousing to delivery. For example, they make it easier to deal with rapidly changing customer expectations and make it possible to develop new business models.

The increasing complexity and variety of customer orders are a great logistical challenge that makes it necessary to collect real-time data and contextual information. In this context, IoT applications can increase the efficiency of logistical processes, such as in terms of monitoring, production management, information collection and sharing, supply chain modelling and security.

### Image 22: Potential IoT applications in corporate logistics by country

Proportion of surveyed corporate decision-makers in %

Highlighted: Proportion above the national average of European countries

Remaining percentage: Don't know/N/A

| | ø | DE | UK | FR | ES | IT | DK | SE | NO | NL | PL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| There are definitely potential applications | 29% | 28% | 21% | 34% | 36% | 36% | 15% | 25% | 14% | 23% | 31% |
| There are some potential applications | 41% | 41% | 26% | 42% | 45% | 47% | 30% | 34% | 40% | 38% | 48% |
| No potential applications | 21% | 26% | 35% | 23% | 13% | 10% | 33% | 28% | 25% | 28% | 10% |

## 3.5.1 Expected applications of the Internet of Things in logistics

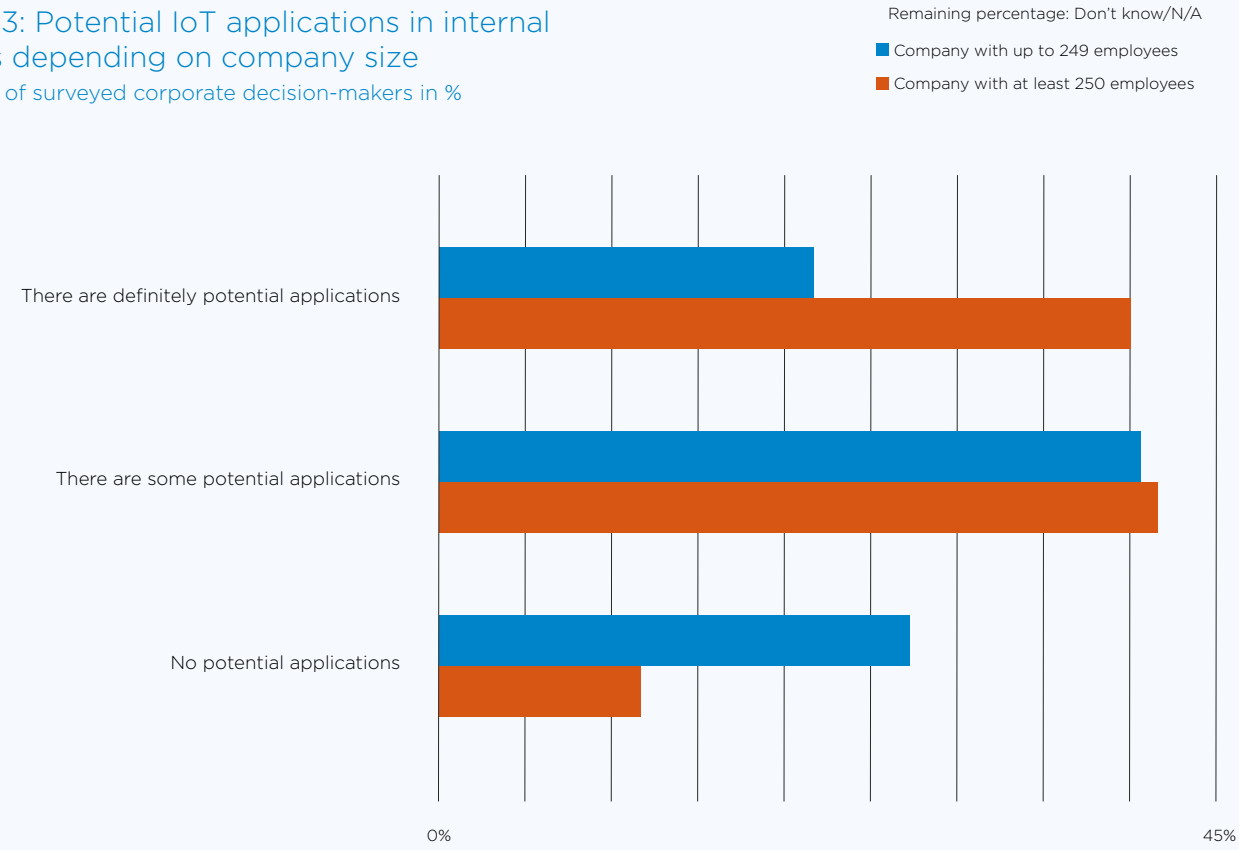
Around 70 per cent of the respondents see potential applications for the Internet of Things in their own logistics (see image 22). Decision-makers from Italy, Spain, Poland and France are particularly confident about the benefits of this technology for their company, whereas an above-average number of decision-makers in the United Kingdom and Denmark in particular are dismissive – despite the fact that they are outnumbered by optimists in these countries.

However, just 27 per cent of companies that consider the Internet of Things relevant to their logistics are already using this technology or are in the middle of an introductory phase (see image 10). Therefore, as with augmented reality, there is still marketing potential for providers of IoT solutions. In some cases, some companies are still not convinced about the economic benefits of the tools that are available in the market, even though they are generally open to the idea of using IoT applications in their logistics.

It is also evident that the use of digital technology tends to be more attractive to larger companies: at around 82 per cent, the proportion of decision-makers who see potential applications for the Internet of Things in their logistics is significantly higher in com-

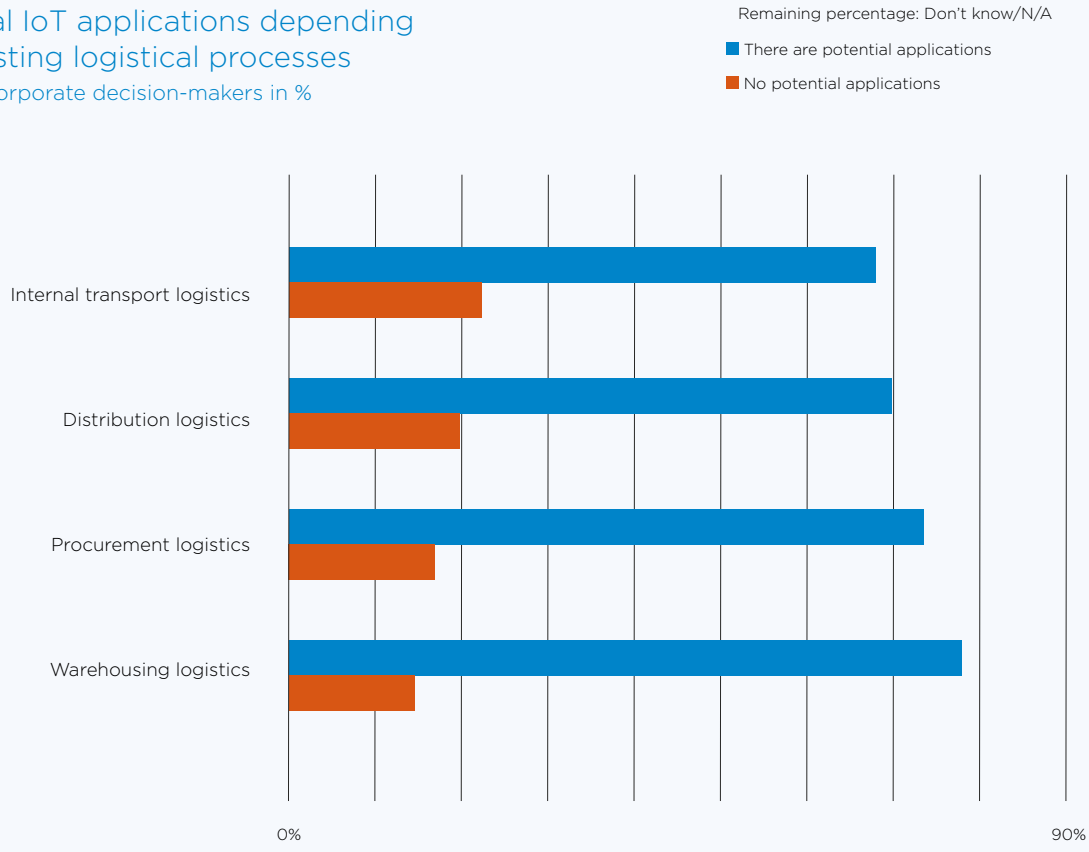
## Image 23: Potential IoT applications in internal logistics depending on company size

Proportion of surveyed corporate decision-makers in %




## Image 24: Potential IoT applications depending on companies' existing logistical processes

Proportion of surveyed corporate decision-makers in %



panies with 250 and more employees than in small and medium-sized companies (see image 23). Although logistical processes are also important to the surveyed smaller and medium-sized companies, they are much more manageable and less complex than in large companies if at all possible.

Companies with warehousing logistics view IoT applications as exceptionally relevant (see image 24). Nevertheless, companies with procurement logistics or distribution logistics also show (slightly) above-average rates of acceptance.

Consequently, inventory tracking is at the very top of the list of fields of application for European companies that see potential uses for the Internet of Things in their logistics in principle (see image 25). It is followed by warehouse management systems with which order processes can be carried out automatically and with no direct employee involvement, then by location management systems which monitor parameters such as driver activity, vehicle position and delivery status.

Decision-makers from Spain, Germany, Denmark, Italy and the United Kingdom see an exceptionally large number of uses for the IoT in their corporate logistics. Companies from Norway and Sweden tend to be cautious. It is interesting that although the relevance of the Internet of Things to corporate logistics tends to be considered relatively low in Denmark and the United Kingdom, companies in both of these countries that do deem it relevant describe an above-average number of potential applications.

## Image 25: Specific potential IoT applications in internal corporate logistics

Multiple answers can be given

Proportion of surveyed corporate decision-makers who generally have potential IoT applications in their logistics, in %

Highlighted: Proportion above the national average of European countries

| | ø | DE | UK | FR | ES | IT | DK | SE | NO | NL | PL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Inventory tracking | 47% | 50% | 58% | 41% | 43% | 50% | 53% | 44% | 44% | 51% | 48% |
| Automated order processing (warehouse management systems) with no direct employee intervention | 44% | 50% | 36% | 43% | 56% | 43% | 41% | 32% | 40% | 48% | 40% |
| Location management systems (monitoring of driver activity, vehicle position, delivery status, etc.) | 41% | 38% | 44% | 43% | 49% | 40% | 35% | 41% | 30% | 37% | 42% |
| Pre-emptive order processing based on predictive analytics | 36% | 41% | 42% | 33% | 38% | 36% | 45% | 31% | 33% | 36% | 34% |
| Remote monitoring of freight quality parameters (temperature, vibrations, etc.) | 36% | 39% | 24% | 36% | 37% | 36% | 35% | 31% | 21% | 37% | 39% |
| Use of autonomous vehicles | 23% | 22% | 22% | 28% | 24% | 25% | 22% | 17% | 21% | 18% | 24% |
| Use of mobile robots | 22% | 21% | 24% | 20% | 23% | 26% | 25% | 19% | 14% | 19% | 23% |

## 3.5.2 Expected benefits of IoT applications in logistics

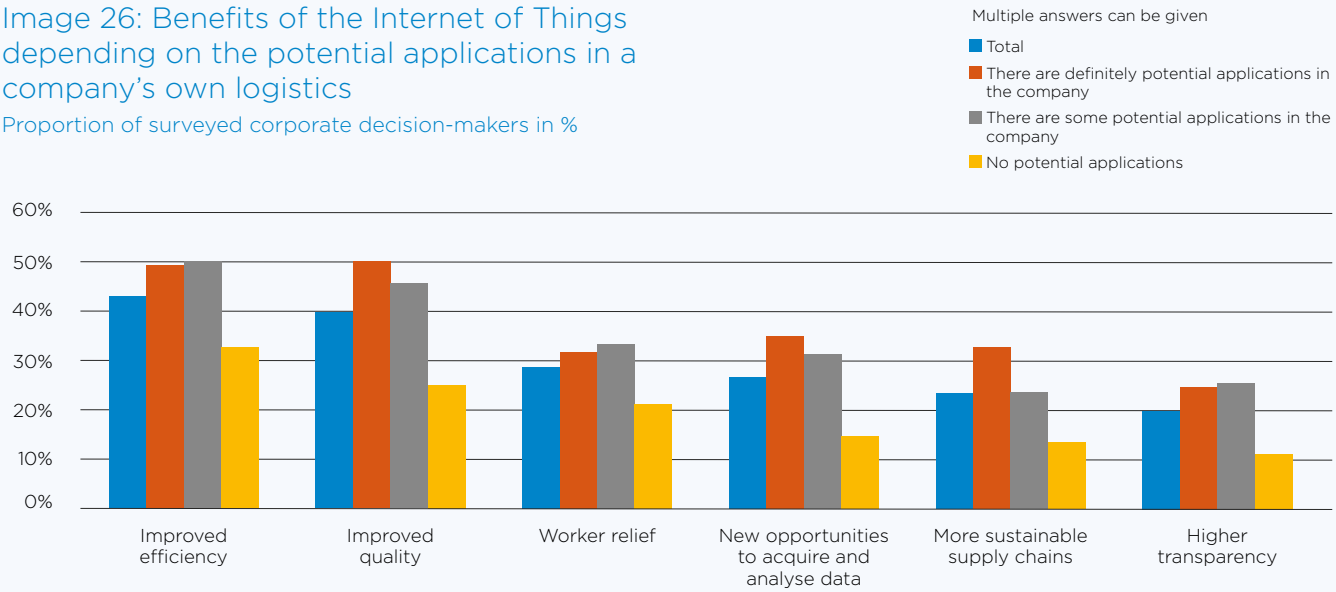
Not unlike augmented reality, the surveyed companies say that improved efficiency, improved quality and worker relief are the three most important benefits of the Internet of Things (see image 26). In contrast, higher transparency and more sustainable supply chains tend to be less of a priority. This might change as supply chain legislation becomes increasingly widespread in Europe.

It is worthy of note that companies that do have a complete range of potential uses for the Internet of Things more often tend to expect benefits from that technology. They also have somewhat different priorities than average; new opportunities to acquire and analyse data and more sustainable supply chains are ranked third and fourth, even ahead of worker relief.

Companies in Poland, Spain, France, Germany and Italy describe the benefits of the technology with disproportionate frequency (see image 27). Additionally, the companies in the various countries weigh the benefits of the Internet of Things differently – considerably so. For example, this is evident from the two countries with the lowest rates of acceptance in Europe with regard to the benefits of the technology: worker relief is the lowest priority in the United Kingdom, whereas it is at the top of the ranking in Denmark.

### Image 26: Benefits of the Internet of Things depending on the potential applications in a company's own logistics

Proportion of surveyed corporate decision-makers in %



## Image 27: Benefits of IoT applications by country

Proportion of surveyed corporate decision-makers in %
Highlighted: Proportion above the national average of European countries

Multiple answers can be given

| | ø | DE | UK | FR | ES | IT | DK | SE | NO | NL | PL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Improved efficiency | 43% | 41% | 47% | 42% | 47% | 45% | 31% | 47% | 41% | 41% | 42% |
| Improved quality | 40% | 43% | 29% | 40% | 40% | 43% | 30% | 39% | 38% | 38% | 43% |
| Worker relief | 28% | 31% | 9% | 28% | 29% | 16% | 35% | 32% | 25% | 31% | 38% |
| New opportunities to acquire and analyse data | 27% | 25% | 26% | 27% | 29% | 33% | 25% | 18% | 24% | 24% | 29% |
| More sustainable supply chains | 23% | 21% | 11% | 30% | 25% | 27% | 10% | 19% | 13% | 31% | 25% |
| Higher transparency | 20% | 26% | 13% | 21% | 20% | 22% | 18% | 19% | 18% | 14% | 24% |

## 3.6 Interpretation of the results

We can draw the following conclusions from the results of the survey: although the digitisation of logistics has begun, it has not yet found its way into every company that might benefit from digital technology. Only around one third of companies in Europe have already begun the digital transformation of their supply chain management and logistics.

They see potential applications in principle, but are not yet making the necessary use of digital technology. The considerable time and money required to implement digital technology is cited as the greatest challenge.

Augmented reality and IoT applications support this pattern: with both types of technology, there is a significant discrepancy between the number of companies that see potential uses for one of the two types of technology in its own logistics and those that have already rolled it out or intend to use it in the near future. Larger companies tend to see more beneficial applications than small and medium-sized companies. We must assume that the significance and complexity of logistical processes increase with the size of a company, and consequently that digitisation promises greater benefits.

The results might indicate that not all potential users are currently convinced of the business advantages of the digital applications that are available in the market because the expected additional income does not outweigh the time and costs that are seen as obstacles. This might also be due to a lack of market transparency. In this respect, the decision-makers are still unable to make a concrete assessment because efficiency and quality improvements can be accomplished through Logistics 4.0.

# 4 Practical examples

Logistics 4.0 and the related applications are no longer a vision of the future – they have become a reality in some companies and the results of the survey substantiate this. Technologies such as artificial intelligence and augmented reality are already being used to various degrees. The following practical examples illustrate the form these applications might take in practice.

## Blechwarenfabrik Limburg

Every year, the tin factory Blechwarenfabrik Limburg manufactures several million tins, canisters and buckets from around 20,000 tonnes of tin. In 2014, the company acquired a new production and business facility on a greenfield site. Blechwarenfabrik Limburg digitised its production and logistical processes to coincide with the move. Its inventory is now managed in automated high-bay warehouses by a warehouse management system. At all times, the system has information about what item is on which carrier and where it is at that moment. As a result, there is no longer undefined storage in the factory and no more unnecessary inventory. This also means that space is being used more efficiently.

Moreover, the warehouse management system controls the flow of materials within the warehouse by means of autonomous transport systems. This results in less damage in transit resulting from manual handling. Thanks to these measures, Blechwarenfabrik Limburg saves around 100 tonnes of tin each year.

Additionally, the warehouse management system adapts material movements to accommodate the current power supply. Solar power plays a major role at the new site. Many warehouse processes are initiated when there is a strong supply of electricity so that the electricity is not fed into the grid, but rather is used by the company itself.

## BMW

The car maker BMW has pooled its digital logistical applications under the concept ‘Logistics NEXT’ since 2016. This concept aims to make all of BMW’s logistics more sustainable and more efficient. Numerous individual measures are used to achieve this goal.

One aspect is autonomous transport systems in the factory halls as well as in exterior areas. This includes an autonomous outdoor transport robot which independently moves HGV trailers on the factory grounds from their parking spaces to the loading and unloading points. This ‘AutoTrailer’ has a maximum load of 40 tonnes and connects independently underneath the trailers. As the system uses lasers to navigate, no additional guidelines or markings are necessary. Initially, the system operated in a pilot phase at the factory in Leipzig before it was placed in live operation in autumn 2019 and rolled out at other factories.

Additionally, the 'AutoBox' is used in the factory halls; it can transport loads of up to 25 tonnes autonomously. It uses scanners which determine its position based on fixed points to navigate the halls. It even has sensors to help it avoid people and collisions.

Once the materials have been delivered to the workstations by the transport systems, the employees who work there are assisted by autonomous robots. For example, various different types of robots pick up and sort small load carriers that might be on pallets.

Although the individual systems operate autonomously and move around the hall freely, there is still a cloud-based master control system to make sure that the rate of production is maintained.

## Bosch

The technology and service company Bosch is itself a creator of many applications for digital production and logistics. Therefore, it is no surprise that Bosch uses these solutions itself.

Bosch brings these smart factory applications together under the name 'Nexeed'. In its logistics, this also includes the central management of all transport orders in a factory with transparent real-time information about material drop-off points, vehicle fleet status and transport routes. As up-to-date information is always available about the status of materials at every production station, internal supply runs (known as 'milk runs') can be made up to 35 per cent more efficient with no negative impact on supplies. Instead of travelling the same route every single time, milk runs are flexible so that only workstations that actually need materials are visited. At the Bosch factory in Nuremberg, for example, the flow of materials is supported by automated guided vehicles.

Its proprietary solution ProCon links the production management system with internal transport. It covers logistical processes ranging from customer requirements to machine and system scheduling to the management of traditional and autonomous means of transport. This solution is in use in more than 50 factories. Bookings and repeat orders are made automatically in real time through synchronised data transfers and networked digital process steps. This reduces warehouse inventories and manual jobs. And employees are spared from hav-

ing to perform routine tasks, enabling them to focus on more intellectually challenging jobs that in turn have a positive effect on productivity.

## DHL

The logistics company DHL has been using augmented reality smart glasses in all of its warehouses around the world since 2017. Vision picking has been the standard method of picking ever since. Back in 2014, DHL's trend research team examined the potential applications of augmented reality in logistics in a trend report. The report was followed by pilot projects with smart glasses in the USA and Europe which demonstrated benefits such as productivity increases.

Under the new picking standard which DHL was one of the first logistics companies to put in place and establish in the sector, work instructions appear on the smart glasses worn by DHL pickers so they can follow the instructions step by step. The glasses even show details about where the items can be found in the warehouse and how they should be positioned on the trolley. Smart glasses leave the employees' hands free, enabling them to work more efficiently. Written instructions are a thing of the past too. According to DHL, vision picking has led to an average productivity increase of 15% while also reducing the rate of errors. DHL also reports that the solution has halved the time required for the onboarding process.

The smart glasses will not only scan barcodes in future, but also identify complex objects to make picking easier.

## MAN Truck & Bus

MAN Truck & Bus has been using the software ConMa – short for 'container management' – to optimise empty container management in its facilities since October 2016. The goal is to deliver empty containers to the suppliers of MAN Truck & Bus in an efficient manner. In total, the software has already scheduled and dispatched more than six million containers. ConMa combines an automated process with dynamic transport management.

All orders are monitored and prioritised by intelligent algorithms. On the basis of these calculations, suppliers are supplied with the empty containers they need. ConMa even optimises the transport plans of the trucks in order to use as much cargo space as possible. This cuts transport costs and reduces $CO_2$ emissions.

Furthermore, ConMa generates the necessary paperwork and provides a real-time transport status overview. This has halved the amount of scheduling work overall, freeing up resources for special cases.

Another remarkable aspect of ConMa is that since everyone who was involved in the process throughout the company was involved in its development, everyone is happy with the solution.

## Schnellecke Logistics

Schnellecke is a reliable provider of complex logistical and transport services for automotive, industrial and consumer goods. The family-run company develops tailored concepts to optimise the efficiency and process security of its customers, controls and optimises delivery flows, assembles to individual specifications, offers just-in-time and just-in-sequence delivery and both assembles components and pre-assembles entire groups of components. With 17,000 employees in 13 countries, the company connects suppliers and manufacturers.

Digitisation has been of great importance to the company for a number of years already. Schnellecke Logistics uses numerous types of technology for new applications, including augmented reality, artificial intelligence and the Internet of Things.

For example, it uses wearables such as smart glasses and RFID wristbands for picking and sequencing. This makes it easier for workers when it comes to picking larger vehicle parts that require both hands. The hand-held scanners that were once used slowed down the processes. With the AR applications on the smart glasses, the process stages appear directly in the worker's field of vision and are sorted into the correct production sequence automatically. The RFID wristband confirms and logs the picking steps at the same time.

Schnellecke Logistics also uses artificial intelligence to optimise its warehouse. More ancillary conditions can now be taken into account than was the case before the company began using intelligent algorithms. Products are not only allocated to storage locations based on their size; health and safety regulations for workers, load and fire prevention regulations, forklift access and removal from the warehouse to loading and unloading zones are factored in for each product so as to optimise their allocation.

Containers are a very important part of logistical processes. With the Internet of Things and networked containers, the company knows where its containers are located at any given time as well as the processing status of the orders associated with each container. This information is made available on a central cloud. With information about each site, customer requests can be fulfilled quickly and bottlenecks can be resolved promptly. The company is even able to optimise its transport routes.

The Digital Control Tower (DCT) is the central point in the cloud where this information about the containers is stored. It builds virtual models of the logistical processes and visualises all process-related information on a dashboard. Every employee has access to that information through a mobile device, for example. They can even add more information to it. If, for example, there is a problem with a forklift, the operator can report the issue via the DCT and follow the instructions that are then issued. The DCT is a dynamic system that is under continuous development. Finally, Schnellecke Logistics has even implemented digital shift logs, fault report management and dynamic material range calculation.

Furthermore, company's employees are assisted by robots. They are used in applications including welding and packaging. They also handle the monotonous task of putting together dividers for the shipping boxes in which fragile individual parts are then going to be transported. Alongside robotic hardware, Schnellecke Logistics uses robot software in the form of robotic process automation (RPA). It performs recurring, rule-based tasks that have been identified within the company by RPA scouts. This includes, for example, sorting SAP postings for invoices that are submitted by email.

## Interview with Karsten Keil, member of the Management Board of Schnellecke Logistics SE, who is in charge of IT and digitisation

*Mr Keil, smart logistics plays an important role in your company. When did Schnellecke Logistics begin its digital transformation?*

We started looking at Industry 4.0 and smart logistics four to five years ago.

*Did you have any particular reason to do so?*

The automotive industry is one focal point of Schnellecke Logistics. That industry is in the middle of transitioning away from combustion engines towards electric motors and mobility services. Consequently, companies like Schnellecke Logistics are also being forced to change.

The cost pressure on logistics is tremendous in today's market. In order to counteract this pressure through efficiency improvements, the company has pressed and is still pressing on with digitisation.

*Besides efficiency improvements, are you pursuing any other goals by digitising your company?*

Through digitisation, we also want to develop new digital business models. These can absolutely be based on radical innovations and do not have to have anything to do with our existing business model.

There is also another completely different aspect: Schnellecke Logistics can position itself as an attractive employer by using the latest technology.

*With these goals in mind, have you already been able to make progress through digitisation?*

Yes, absolutely. Many jobs are now unimaginable without the tools. For example, digitisation has enabled us to generate more turnover with a constant number of personnel in administration.

*The benefits of digitisation are real. But before that, rolling out new applications involves large investments and therefore costs. In your opinion, have these investments already (partially) paid for themselves?*

Yes, they have already paid for themselves in the long term.

*Some of the new digital applications at Schnellecke Logistics also relate to customers and their processes. So are those customers involved early on in the rollout?*

Yes, it would not be possible otherwise. We often operate right in the customer's environment. In these cases, we need permission to introduce solutions and IT infrastructure and link applications with one another.

That is why we get the customers on board at the very beginning.

At the beginning, however, we need to impress our customers with the new solution. A customer will not purchase our service because we are using innovative technology, but rather because it offers additional value. And we discuss that additional value in advance with our customers.

*Based on your experience with the new applications at Schnellecke Logistics so far, what aspects are critical for the rollout and use of the technology to be successful?*

For it to be a success, you must involve people in the transformation process. It is important to listen to their concerns, include them, test applications and let them contribute to projects. You cannot roll out technology if there is resistance from the workforce.

Support from C-level management is also necessary. You will not succeed without their commitment.

Additionally, smart logistics should not just be a collection of local isolated solutions. Rather, the individual applications should be embedded in an overall framework.

Schnellecke Logistics aims to achieve its vision of heavily digitising and automating its logistics through its 'Smart 2025' strategy, a comprehensive digitisation plan.

And finally, you need partners – customers, suppliers or even competitors – as you cannot make isolated optimisations to things in the supply chain.

*Do partners also play a role in the development and implementation of the applications or do you tend to rely on in-house developments?*

Partners are very important to our digital transformation. The IT department at Schnellecke Logistics would not have the necessary capacity on its own. Internally, we use our process expertise and our understanding of our business models to look at how we can develop new solutions with technology. But we don't necessarily develop these ourselves.

*So how do you find the right partner?*

Our company has technology scouts who observe the market. If they identify an interesting technology or an interesting partner, we examine whether our company might have a use for it. If so, we try it out and prepare a proof of concept.

At the same time, however, we analyse our processes internally to see where improvements can or need to be made. We then have our scouts scour the market to see what technology and partners can make this possible.

*What do you do then?*

Then comes the rollout in the company, with employees heavily involved in it. This was what happened with robotic process automation (RPA), for example. Once a suitable application within the company had been identified for RPA and proven itself to be impressive, that application was implemented. Alongside this, employees who had not previously had much to do with RPA and had no prior knowledge of RPA were trained as RPA scouts and citizen developers.

The benefits resulting from this example were very clear too: we have now automated more than three times the development time in processes. Employees can now use this time to do other tasks and generate additional income.

# 5 Summary

The digitisation of corporate logistics is making lots of new applications possible. Augmented reality, artificial intelligence and the Internet of Things are the starting points for a dramatic evolution of existing processes. As in many other corporate divisions, the digitisation of logistics can also lead to increased flexibility and efficiency and lower costs.

However, the survey has shown that many companies are still cautious when it comes to embracing Logistics 4.0. In many cases, although they are aware of the significance of the types of digital technology, they are not (yet) making full use of the technology. There can be a variety of reasons for this: some companies might believe that the costs of digitisation are higher than its attainable benefits, causing it not to be cost-effective for them. However, this might be the result of an erroneous assessment if the decision-makers are unable to imagine the real efficiency and quality improvements that can be achieved with Logistics 4.0 due to a lack of experience and information.

Moreover, some companies might not know exactly how they would make effective use of artificial intelligence, for example. Small and medium-sized companies in particular often say that while they are aware of the significance of technology such as augmented reality, they do not know how they might apply it themselves.

More easily accessible information and experience-sharing, as depicted in the practical examples, might therefore be a key to accelerate the digitisation of corporate logistics.

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Düsseldorf, January 2022

Image sources: Freepik