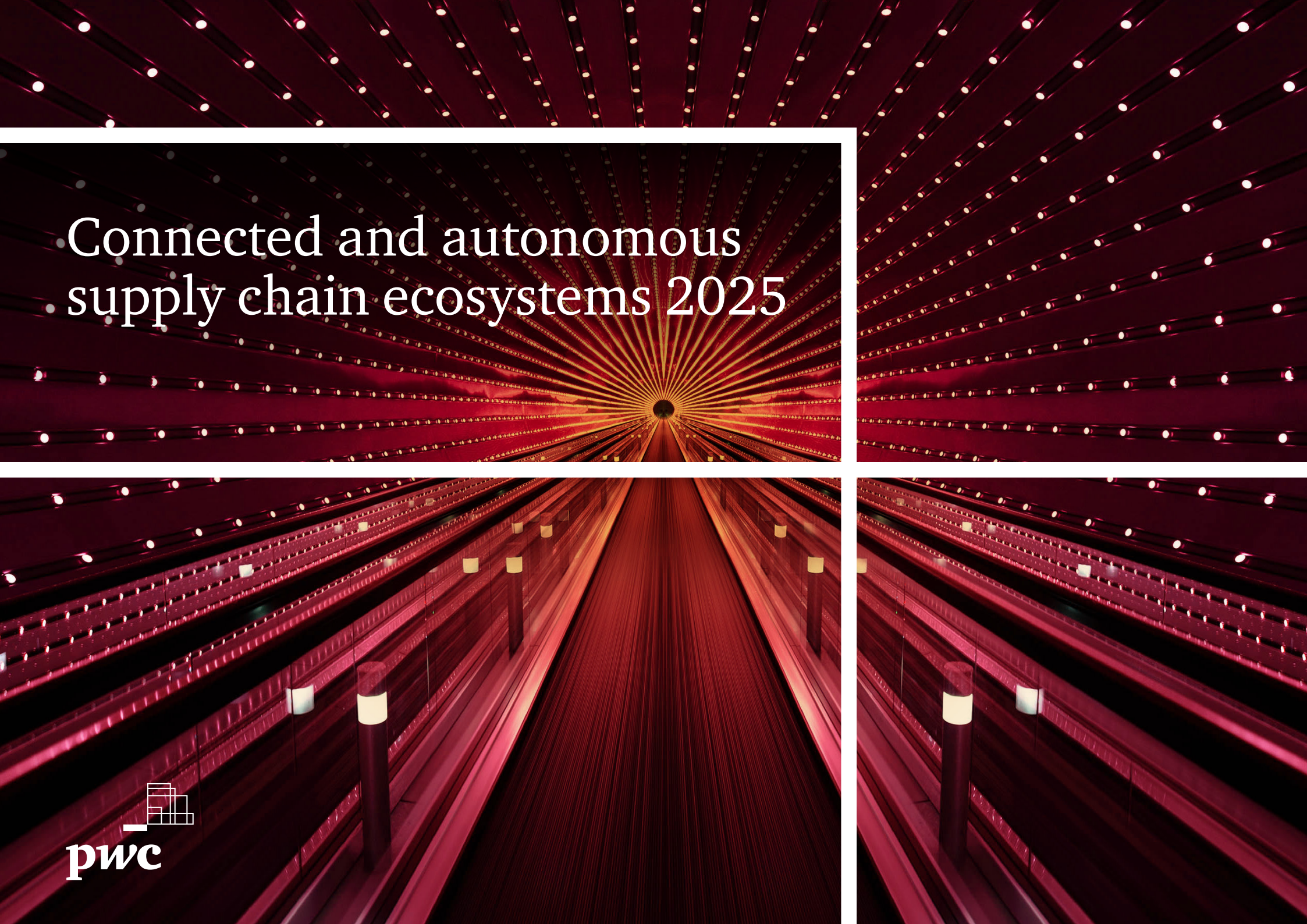
Connected and autonomous supply chain ecosystems 2025



pwc

Digital supply chain excellence in turbulent times

Customer behaviours and expectations are changing dramatically, challenging the established supply chain and operations setups of leading industrial companies. Customers now do their research and buy products across multiple channels and increasingly demand product personalisation. They expect not only transparency around order status and delivery, but near instant order fulfilment. And they're increasingly concerned about product origin and quality, as well as product and supply chain sustainability.

In most cases, these heightened expectations apply to customers in consumer-facing industries and B2B customers. Supply chains are also increasingly facing major disruptions such as changing and extreme weather conditions, global health crises and supply shortages. For example, many supply chains are being affected by the 2019–20 COVID-19 (coronavirus) outbreak — either through unexpected increases or drop-offs in demand as well as supply shortages.

These changes are taking place against the backdrop of the Fourth Industrial Revolution (4IR), with digital technologies impacting every aspect of how companies run their businesses — from creating digitally connected products and services to automating data-driven supply chains. Also known as Industry 4.0, this era of digital transformation ushers in new real-time data gathering across the supply chain, smart analysis, and algorithms to better simulate and predict different supply chain scenarios and foster data-based decision-making.

To succeed in this quickly evolving and increasingly digital marketplace, companies need to transform their supply chains. Supply chains are becoming more integrated with multiple value chain partners. They're also becoming not just automated but autonomous — able to act with limited human intervention — and ultimately self-orchestrating.

Developing advanced supply chain capabilities makes strong economic sense and gives companies the agility needed to respond to disruptions.

For many companies, improving the supply chain is a vital part of their efforts to become more customer-centric and quickly respond and adapt to changing demands and requirements while maintaining cost efficiencies. Next-level supply chains are also helping to increase product quality by supporting moves to expand portfolios of products and services, and even introduce entirely new business areas. And they are enhancing companies' ability to manufacture and deliver flexibly while operating a cost-efficient, competitive supply chain.

To take a closer look at how Digital Champions are transforming linear supply chains into connected and autonomous supply chain ecosystems, we surveyed more than 1,600 supply chain executives and decision-makers in 33 countries across the Americas, EMEA and Asia Pacific between October and November 2019. Further research was conducted through January 2020. We asked about their key supply chain capabilities, supporting technologies, organisational structures and challenges, as well as the benefits they are seeing from their investments into the supply chain. We asked about both their current state and their plans looking forward five years. In this report, we also provide in-depth perspectives on six companies whose digital supply chains are leading the way, and we explore in more detail how they are driving innovation and excellence in the supply chain. This report builds on our previous research in digital operations, where we showed how industry leaders are building integrated operations ecosystems to deliver end-to-end customer solutions.[1]

Our research found that some companies stand out as digital supply chain leaders. They have already implemented a wide range of advanced technologies, have developed sophisticated digital capabilities and are upskilling their employees to achieve a digital transformation. Their performance shows that it's worth the effort. We call these companies Digital Supply Chain Champions — in the rest of this report, we call them simply Digital Champions[2] — and they represent about 9% of our total sample. Here, we explore what they are doing differently, how that is boosting their results and how your company can learn from their success.

Reinhard Geissbauer | Stefan Schrauf | Judith Schneider | Mark Hermans

1 *Global Digital Operations 2018 Survey:* Digital Champions. How industry leaders build integrated operations ecosystems to deliver end-to-end customer solutions.

2 See 'About the Survey' for more information about how we identified Digital Champions and the other three stages of supply chain maturity: Digital Innovators, Digital Followers and Digital Novices.

Harald Geimer, Partner; Jörn Große-Wilde, Director; Martin Whyte, Director; Farboud Cheraghi, Senior Manager; and Jens Henning Krause, Senior Manager, all with PwC Germany, co-authored this report. Elizabeth Montgomery, Manager, PwC Germany, also contributed to this report.

Reinhard Geissbauer
Global Digital Operations
Partner, PwC Germany
reinhard.geissbauer@pwc.com

Stefan Schrauf
Operations and Supply Chain Europe
Partner, PwC Germany
stefan.schrauf@pwc.com

Judith Schneider
Connected Supply Chain
Senior Manager, PwC Germany
judith.schneider@pwc.com

Mark Hermans
Connected Supply Chain
Managing Director, PwC US
mark.hermans@pwc.com

Contents

Executive summary 5

The vision 10

The benefits 14

Supply chain transparency and sustainability 18

Closed loop and integrated planning 24

Smart logistics flows 30

Dynamic supply chain segmentation 36

AI-driven supply chain management 40

Operating model development 46

Company snapshots

Continental 23

Advantest 29

Nokia 35

TRUMPF 39

Bayer Crop Science Division 45

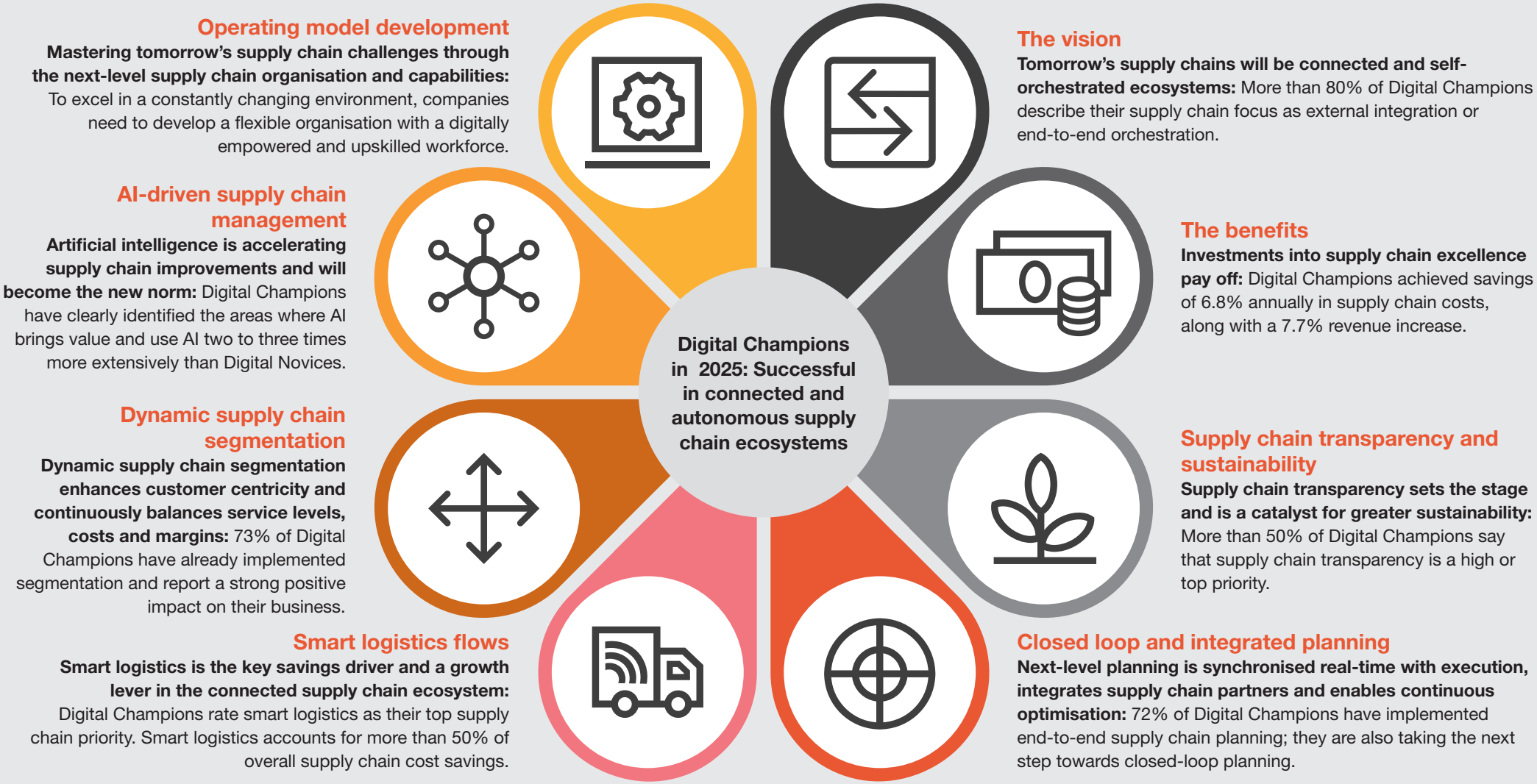
IKEA 50

About the survey 51

Contacts and acknowledgements 54

Executive summary

Exhibit 1: Digital Champions in 2025: Successful in connected and autonomous supply chain ecosystems



~7%

supply chain cost savings of Digital Champions last year

~8%

increased revenue of Digital Champions last year

The vision

Tomorrow's supply chains will be connected and self-orchestrated ecosystems. Next-level supply chains will be connected end-to-end. All relevant internal functions will be connected using one common data network, from R&D and procurement through manufacturing, logistics, and marketing and sales. In addition, all relevant supply chain partners, such as suppliers (including tier 1, tier 2 and even beyond), logistics service providers, customers and innovation partners will also be integrated within the supply chain. Rather than a linear chain, where data is transferred from one stage to the next, data is available continuously throughout the supply chain, now more accurately termed a supply chain ecosystem, giving partners near-real-time and simultaneous access to relevant information and enabling optimised and informed decision-making.

Data transparency across this ecosystem allows for synchronised demand and supply planning, as well as connected and transparent logistics. Companies will take advantage of artificial intelligence (AI) to make key activities self-orchestrating by defining optimisation parameters and embedding these in the algorithms which steer decision-making. Optimised choices — for example, which supplier to use for individual orders at the best manufacturing location, or which transport mode and logistics service provider to use — will be made autonomously, in near-real-time and across all functions. This also helps companies to proactively identify and manage supply chain risks. And as one size won't fit all, companies will use dynamic supply chain segmentation to be more customer-centric across multiple channels and optimise their cost-to-serve at the same time.

Our research — which included asking companies to report on the current state of their supply chains and how they expect them to look in 2025 — shows that most companies have begun this journey and have invested into new supply chain capabilities and organisational models, but that Digital Champions are far ahead.

The benefits

Investments into supply chain excellence pay off. Digital Champions are reaping the benefits of investments into digital supply chains: In 2019, they achieved operational savings of 6.8% annually in supply chain costs,[3] well ahead of less advanced companies, coupled with a 7.7% revenue increase. They're enhancing customer satisfaction through greater levels of on-time in-full (OTIF) delivery too.

Digital Champions will continue to enjoy the benefits of focussing on supply chain excellence — they invested 9.1% of their supply chain costs into advanced supply chain capabilities last year and plan to continue even stronger levels of investment. Both are higher investments than the other companies we surveyed.

The advantages go far beyond just the numbers. That's true for all the companies we surveyed, especially for the Digital Champions — in addition to enjoying higher profitability and better asset utilisation, they're also using supply chain to drive improvements across their business. For example, 28% of them say more effective risk management is one of three key benefits they are gaining from their investments into advanced supply chain capabilities.

3 We defined supply chain costs as procurement costs (excluding direct material) + supply chain planning and transparency + distribution costs (including warehouse and order management, and inbound and outbound transport). For companies where inbound transportation costs are included within their cost of goods sold, we requested they estimate accordingly.

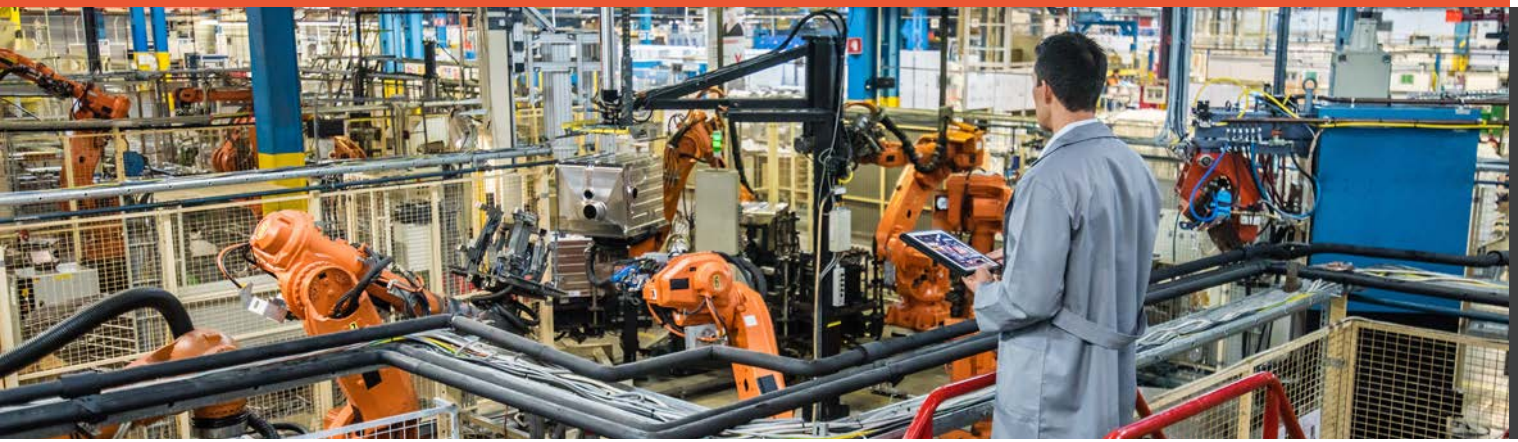
The capabilities

Supply chain transparency sets the stage and is a key catalyst for greater sustainability. Although the majority of companies see supply chain transparency as a priority, Digital Champions are significantly further along the road to achieving end-to-end transparency. They report much greater levels of visibility over product content, supply chain financials on a transaction level and logistics flows in near-real-time. Indeed, nearly half (47%) of Digital Champions implementing transparency are already able to use a digital twin of their supply chain. That enhances transparency and dynamic optimisation of the total cost of ownership. These high levels of transparency are also helping companies respond to increased sustainability requirements across their supply chains, for example by making it possible to track a product's full chain of custody.

Next-level planning is synchronised in near-real-time with execution, integrates supply chain partners and enables continuous optimisation. Demand and supply planning is at the heart of supply chain management (SCM). The best way to achieve a high level of accuracy and responsiveness in planning is by implementing approaches that cover the scope of the end-to-end supply chain, including suppliers, logistics service providers and customers. Such approaches cross relevant time horizons so that short-term, mid-term and long-term planning processes don't happen in silos but are fully integrated and linked with volume planning and financial planning. It's also critical to establish a strong connection between planning and execution (closed loop), including the ability to adjust planning data as needed based on actual orders, consumed materials or changes in production. Planning that ticks all of these boxes is known as synchronised closed-loop planning. Most Digital Champions have already implemented end-to-end planning, one of the key components. And some have gone further and taken the required steps to continuously balance demand and supply, increase precision in execution and improve operational efficiency.

Smart logistics is the key savings driver and a growth lever in the connected supply chain ecosystem. Managing and executing the physical flow of goods from the point of origin to the point of consumption is an essential part of the supply chain. Smart logistics — the next level of this coordination — connects the physical shipment and information flow between suppliers, manufacturers, distributors and customers interactively and in near-real-time, building on supply chain transparency and integrated planning. Digital Champions rate smart logistics — including automated warehouses and next-level transportation management systems (TMS) — as their top supply chain priority. Smart logistics accounts for more than half of overall supply chain cost savings, making it the key lever to maximise efficiency. It is also a key contributor to new revenue streams and resulting growth, as it is a key enabler for new business-to-business-to-consumer (B2B2C) and B2C business models. By fully orchestrating all the partners and processes in their logistics ecosystem, leading companies can turn their logistics network into a strategic asset that helps them better manage diverse channel requirements.

Dynamic supply chain segmentation enhances customer centricity and continuously balances service levels, costs and margins. While during the first wave of supply chain segmentation companies might have assigned each customer–product combination to a predefined segment, they are now moving beyond this practice towards a flexible, requirement-driven configuration in which each transaction can be dynamically allocated to one of the supply chain segments. Key processes along the supply chain (plan, source, make, deliver) can then be tailored to best match specific business needs. Digital Champions in particular are making greater use of this enhanced, dynamic supply chain segmentation, which is based on smart algorithms that are applied to the individual product or transaction level. That helps to achieve greater customer centricity, flexibility and higher throughput, contributing to significant improvements in performance. Dynamic segmentation also enables companies to continuously simulate and balance different tradeoffs when making decisions, such as costs versus service level, demand versus supply, product portfolio options (e.g., product introductions and phase-outs) and supply chain flows by individual product. When all these factors are considered, optimisation decisions can be made based on a holistic total cost of ownership perspective.



AI-driven supply chain management

AI is accelerating supply chain improvements and will become the new norm. AI can be an enormously powerful accelerator of key supply chain capabilities, with the potential to drive efficient decision-making and build systems that can autonomously adapt to changing conditions. By applying sophisticated AI methods, such as machine learning and natural language processing, to supply chain capabilities, companies can increase transparency, improve planning and enhance logistics flows. Digital Champions are well ahead of the rest of the sample in this area; they're making more extensive use of data and are more likely to be applying AI to turbocharge key supply chain decisions.

But leveraging AI isn't always easy. Companies need to master the challenges posed by ensuring relevant data is being generated throughout the supply chain. Intelligently combining structured and unstructured data provides the foundation for data analytics. Data points flow from diverse sources and may be generated internally, externally or from publicly available data sources. So establishing a data network that is able to read, clean and analyse all of these diverse sources is key. It's also important to employ AI responsibly and with sufficient governance in place, for example by considering the interpretability and explainability of algorithms and taking possible biases into account.

Operating model development

Mastering tomorrow's challenges through next-level supply chain organisations and capabilities. For companies in our survey overall, the top three challenges are managing profitability, improving volume flexibility, and increasing visibility and traceability. Digital Champions have already mastered these; they see circularity and sustainability, and technological maturity and reliability of master data, as the key supply chain challenges. To master these, companies are using a few key strategies to drive advanced capabilities and encourage continuous innovation. Supply chain centres of excellence (CoEs) are a common starting point, and establishing a strong technology backbone is critical too, including state-of-the-art IT infrastructure. Digital Novices and Digital Followers are placing the most emphasis on the basics — integrating the IT function with supply chain to bring IT and business closer together — while for Digital Champions, embedding advanced analytics into supply chain functions is the top priority. That helps them establish an autonomous supply chain with the ability to be self-orchestrating.

With environments constantly changing, companies need to be able to continuously adapt and improve. That means focussing on people above all, for example by upskilling the supply chain workforce or attracting digital talent and managing them in cross-functional teams. Ultimately, companies will need to encourage supply chain collaboration with external partners in a wider ecosystem to increase efficiency, speed up innovation in the supply chain and enhance organisational agility.

The vision

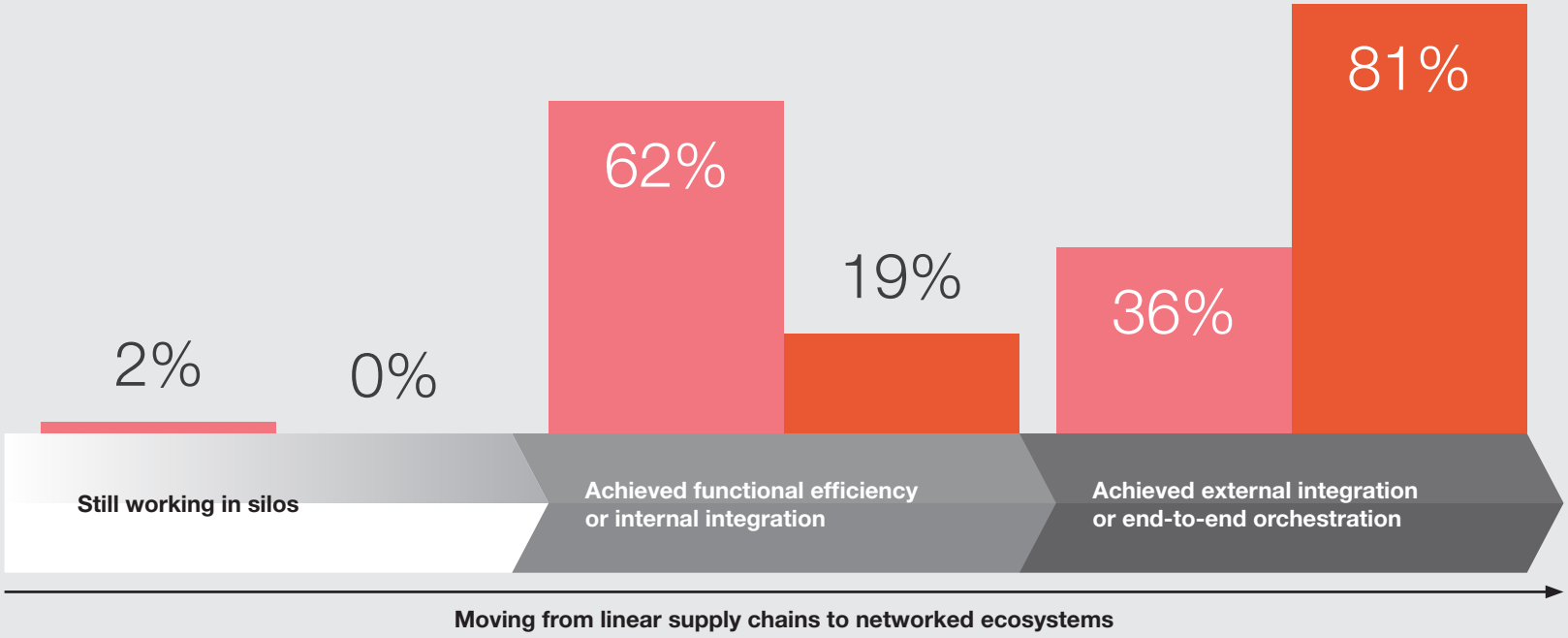
Tomorrow's supply chains will be connected and self-orchestrated ecosystems

Next-level supply chain ecosystems will be far more sophisticated than today's supply chains. One focus will be on connecting the supply chain with other functions across the enterprise, such as R&D (e.g., design for supply chain), finance, sales and customer service (e.g., enabling online and other new customer channels). Leaders will also use digital technologies to establish a two-way, near-real-time connectivity across the entire supply chain.

The links will run both internally and externally — from receiving orders, to sourcing raw materials, to production, to delivery and even to reverse flows, where companies become responsible for taking back products at the end of life. Companies will self-orchestrate these supply chain ecosystems, working closely with suppliers on the one hand — including not just direct tier 1 suppliers but also tier 2 suppliers and even beyond — and with logistics service providers and customers on the other hand to optimise all aspects of supply chain performance. Because they will be able to make autonomous 'course corrections' that respond dynamically, according to the company's priorities and AI-based decision parameters, these new supply chain ecosystems will be truly self-orchestrated and self-learning.

How far have companies already come on this journey? In our research, we found that most respondents already recognise that their companies need to go beyond basic supply chain capabilities, where individual functions within a company work in silos. Most companies report placing their focus either on achieving functional efficiency or internal integration, such as connecting R&D, finance, sales and customer service, within their supply chain (62%) (see Exhibit 2). Those are good first steps, but to get to the next level, companies will need to go much further.

Exhibit 2: Leading companies go beyond functional efficiency towards an end-to-end orchestrated ecosystem

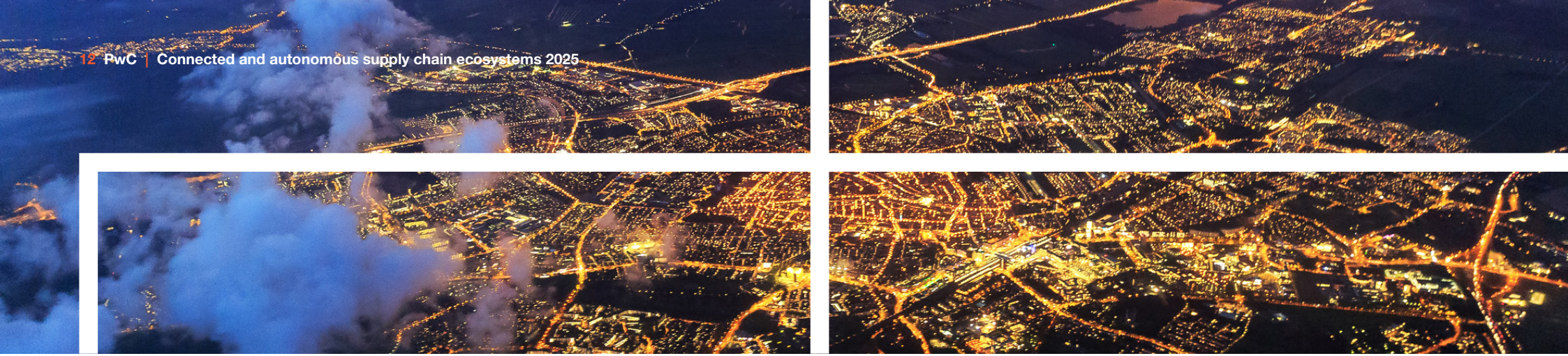


All Companies ■ Digital Champions

Which statement best describes your supply chain today? Base: 1,601 companies

>80%

of Digital Champions describe their supply chain focus as external integration or even end-to-end orchestration, compared to just 36% of all companies



By collaborating externally with suppliers, logistics service providers and customers in a broader ecosystem, companies can achieve much tighter coordination and better understand demand patterns. The ultimate goal is what we call end-to-end orchestration, in which companies achieve near-real-time comprehensive integration of planning and execution, including the automation of most of their supply chain processes and decisions, both internally and with external partners. In connecting the supply chain end-to-end, we observed a dramatic gap between Digital Champions and the rest of the respondents. Although only 36% of companies overall describe their supply chain as having achieved external integration or end-to-end orchestration, that number rises to 81% for Digital Champions.

The building blocks of an autonomous and self-optimising supply chain

Although the evolution from an analogue supply chain to a connected, autonomous and self-optimising supply chain ecosystem is complex, we believe there are some core building blocks that every company will need to consider (see Exhibit 3).

Supply chain transparency and sustainability: Multilevel data flow and seamless connection of all data across the supply chain providing a 360-degree view of products, supply chains, customers and finance, a fully transparent and sustainable supply chain, reusing materials, extending the life cycle of finished products and services, integration of suppliers and other partners

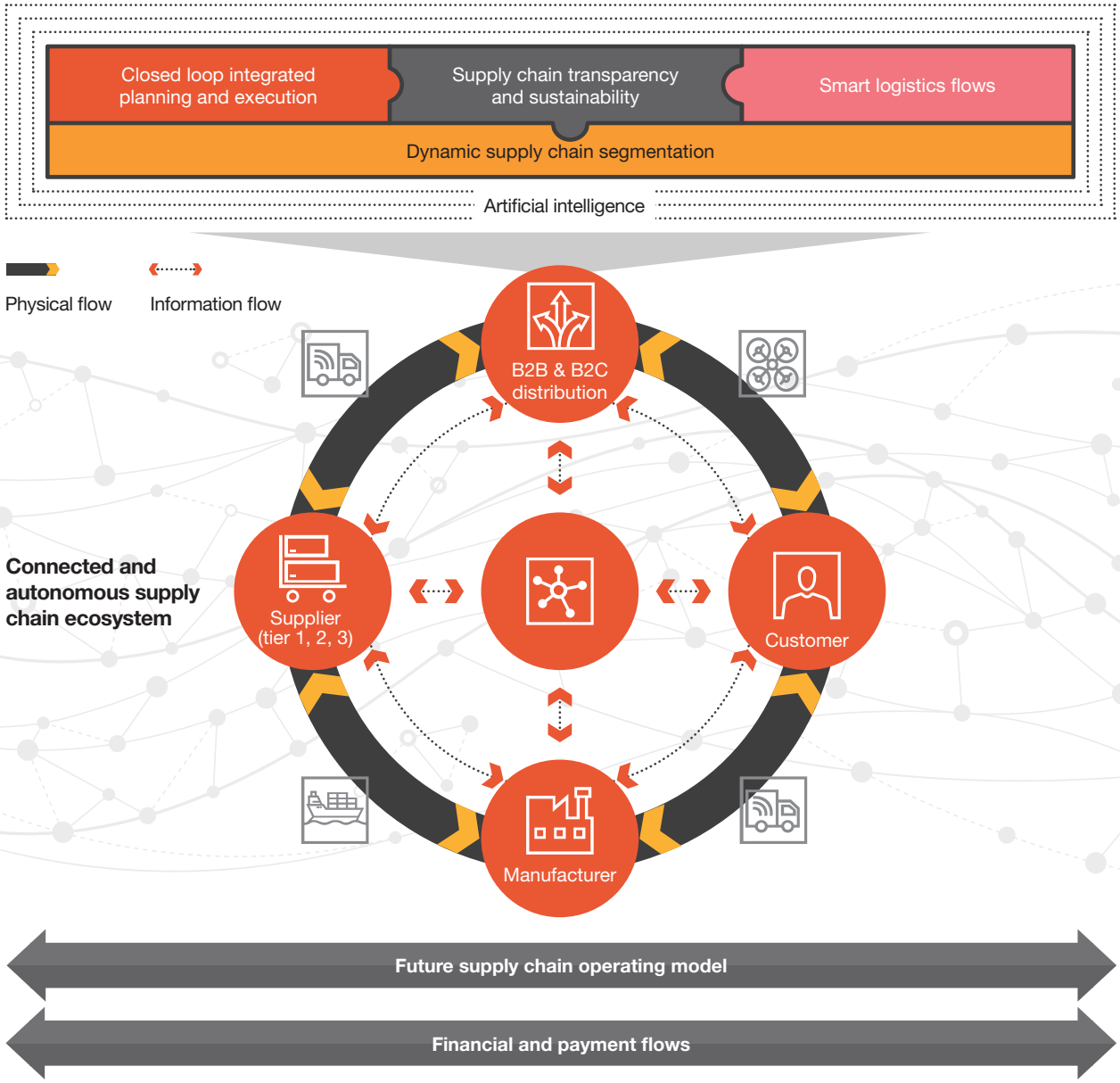
Closed loop integrated planning and execution: End-to-end planning from customers to sub-suppliers covering short- and longer-term time horizons and integrating financial and volume plans, continuous balancing of demand and supply, direct connection to execution activities, collaborative workflows and automated decision-making through advanced analytics

Smart logistics flows: Multimodal inbound and outbound transportation, automated warehouses, effective transport management systems (TMS) and warehouse management systems (WMS), optimised and dynamic distribution footprints, omnichannel order management, B2B2C/B2C delivery models

Dynamic supply chain segmentation: Establish segmentation strategies and execution options to support key business requirements, which analyse consequences on the parameters service, margin, cost and inventory. Make supply chains flexible enough to be segmented again for each customer order, as well as reconfigurable in response to market conditions and product specifics

AI-driven supply chain management: Leverage fully connected data networks and AI along the supply chain to provide improved demand forecasts through demand sensing. Detect patterns based on the use of machine learning within the supply chain and triggering appropriate measures in response, which ultimately enables a fully autonomous supply chain and effective optimisation decisions.

Exhibit 3: Overview of a connected and autonomous supply chain ecosystem



Mastering these areas will help companies manage the physical flow of goods and the (sometimes virtual) delivery of services on more granular levels and far more efficiently. And they'll be able to keep getting better along the way through machine learning–based continuous improvement measures. The supply chain will become an integral part of business transformation and a source of real competitive advantage (see Exhibit 3).

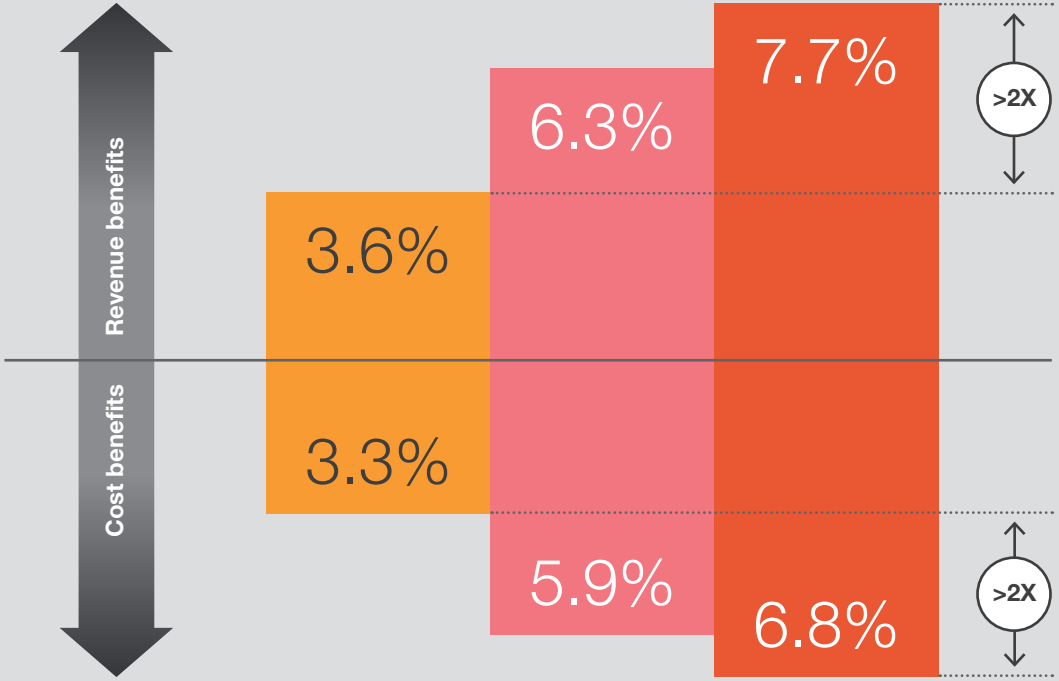
But getting there, and overcoming the hurdles that arise along the way, will require substantial changes — especially in employee mindset and education programmes, which will need to include true transformation upskilling. Companies will also need to make use of innovative processes and ways of working. That means selectively implementing enabling technologies and carefully considering a variety of issues around the setup of their organisation, including digital processes and redesigned roles and responsibilities. In short, companies will need to implement a next-level supply chain operating model. When they can do so, they can effectively have the best of both worlds — centralised control and visibility while retaining the flexibility of locally organised supply chains.

The benefits

Investments into supply chain excellence pay off

A sharp focus on building advanced supply chain capabilities is already paying off for the companies we surveyed, and the biggest benefits are being seen by our Digital Champions. Last year they reported 6.8% supply chain cost savings, coupled with a 7.7% revenue increase. These results are not only significantly higher than the average for companies overall, they're more than double those achieved by Digital Novices (see Exhibit 4).

Exhibit 4: Champions reap more benefits from investments into advanced capabilities



■ Digital Novices ■ All Companies ■ Digital Champions

What revenue and cost benefits did you gain last year from your investments in advanced supply chain capabilities? Base: 1,601 companies

Where are those additional revenues coming from? In our experience, investments into supply chain result in higher customer centricity and faster lead times, thus helping companies win more business. Leading companies are introducing new business models or innovative digital services, or opening new customer channels — all of which are potential revenue drivers.

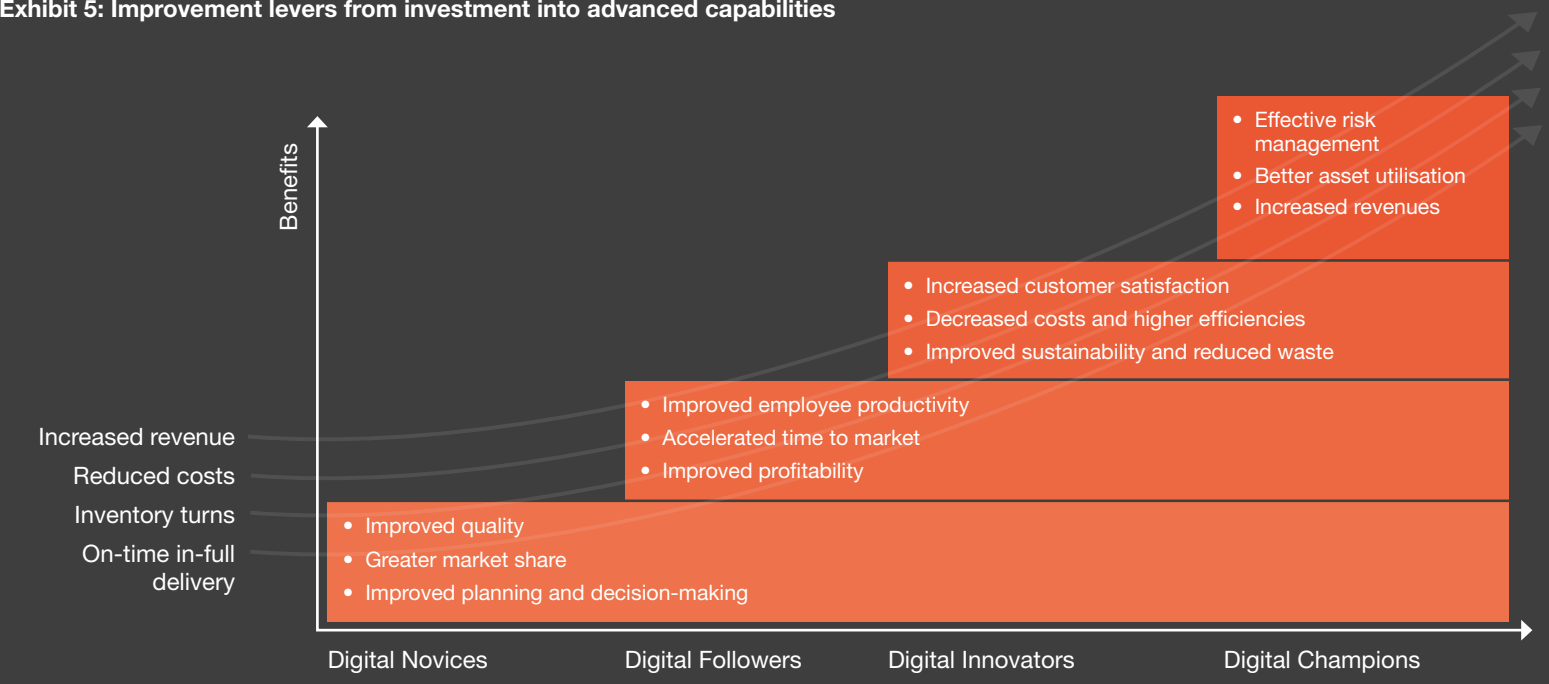
Our respondents report that they are seeing a wide range of benefits from their investments into advanced supply chain capabilities. Some of the biggest advantages are strategic, such as improved planning, better quality, and higher levels of customer satisfaction and retention. Other benefits are financial, such as greater profitability and asset utilisation. Yet others are operational, such as accelerated time to market and reduced time to delivery. However, the kinds of benefits experienced can vary depending on where firms are in their supply chain journey.

Digital Novices gain the greatest value from improved quality, market share and planning (see Exhibit 5). More advanced companies have these basics down and continue to see improvements, but are also benefitting from other aspects such as accelerated time to market, increased customer satisfaction, and decreased lead time and waste. Companies that are further along the supply chain maturity curve reported cumulatively greater benefits, with Digital Champions realising the most total benefits. They also gain operational advantages from an improved ability to mitigate supply chain risks, optimise asset utilisation and increase revenue, for example by using digital capabilities to introduce innovative business models and services.

Effective risk management

Digital Champions are ahead in gaining benefits from an improved ability to mitigate supply chain risks

Exhibit 5: Improvement levers from investment into advanced capabilities



What are the key benefits that you are gaining from your increased investment in advanced supply chain capabilities? Select up to three.
Base: 1,601 companies

Efficient supply chain performance can be disrupted by a number of risk factors. For example, supply can be impacted by global health, or delivery schedules can be impacted by weather risks, port congestion, strikes or unusual traffic. Integrated and efficient TMS and transparency solutions are able not only to identify these risks but to automatically suggest ways to compensate for them. These and other digital tools have a dramatic impact on companies' ability to manage on-time delivery performance. Similarly, manufacturing sites face quality or material availability risks, such as understocking of critical parts. Managing these operational risks effectively requires advanced digital solutions, such as integration with smart manufacturing execution systems (MES) or inline quality management.

Digital Champions have implemented these solutions, and it's not surprising that they are far ahead of less advanced companies on key supply chain performance metrics, such as inventory turns and OTIF delivery performance. Our study shows that Digital Champions are also well ahead in optimising inventories. They achieve 53% more inventory turns than Digital Novices. And they show similarly strong performance in OTIF levels, where four out of five (84%) Digital Champions achieve more than 90% OTIF.

These metrics underscore the gains that companies can achieve by taking their supply chains to the next digital maturity level. Achieving more inventory turns can free up valuable working capital, while strong delivery performance reduces supply chain costs and enhances customer satisfaction.

Nearly all our respondents are already investing in advanced supply chain capabilities, and these investments pay off — the average payback period on investments into advanced supply chain capabilities was less than two years across all companies that participated.

With 9.1% of total supply chain cost dedicated to digital investments, Digital Champions invested at much higher levels last year than did companies overall. They also plan to invest more going forward (see Exhibit 6) — an average of 11.8% over the next five years. With much lower investment levels, Digital Novices are at risk of falling even further behind.

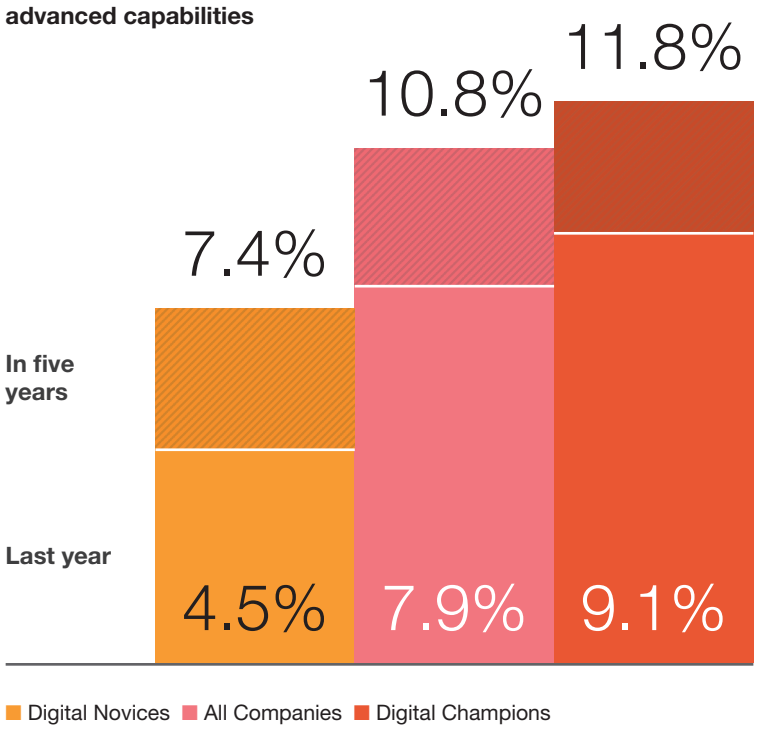
84%

of Digital Champions achieve greater than **90%** OTIF

1.8 years

payback for investments into advanced supply chain capabilities

Exhibit 6: Champions outpace others in investments into advanced capabilities



How much did your company invest in advanced supply chain capabilities including costs for people, process, data and IT/technology as a percentage of your total supply chain costs last year, and how much do you expect to spend in five years? Base: 1,601 companies

Supply chain transparency and sustainability

Supply chain transparency sets the stage and is a catalyst for greater sustainability

Supply chain transparency isn't a new concept, but advanced capabilities are making an entirely new level of visibility possible (see Exhibit 7). Companies are beginning to use data networks that capture the full range of data and relationships being generated across their entire supply chain from very heterogeneous sources — all the way from raw materials to customers and back.

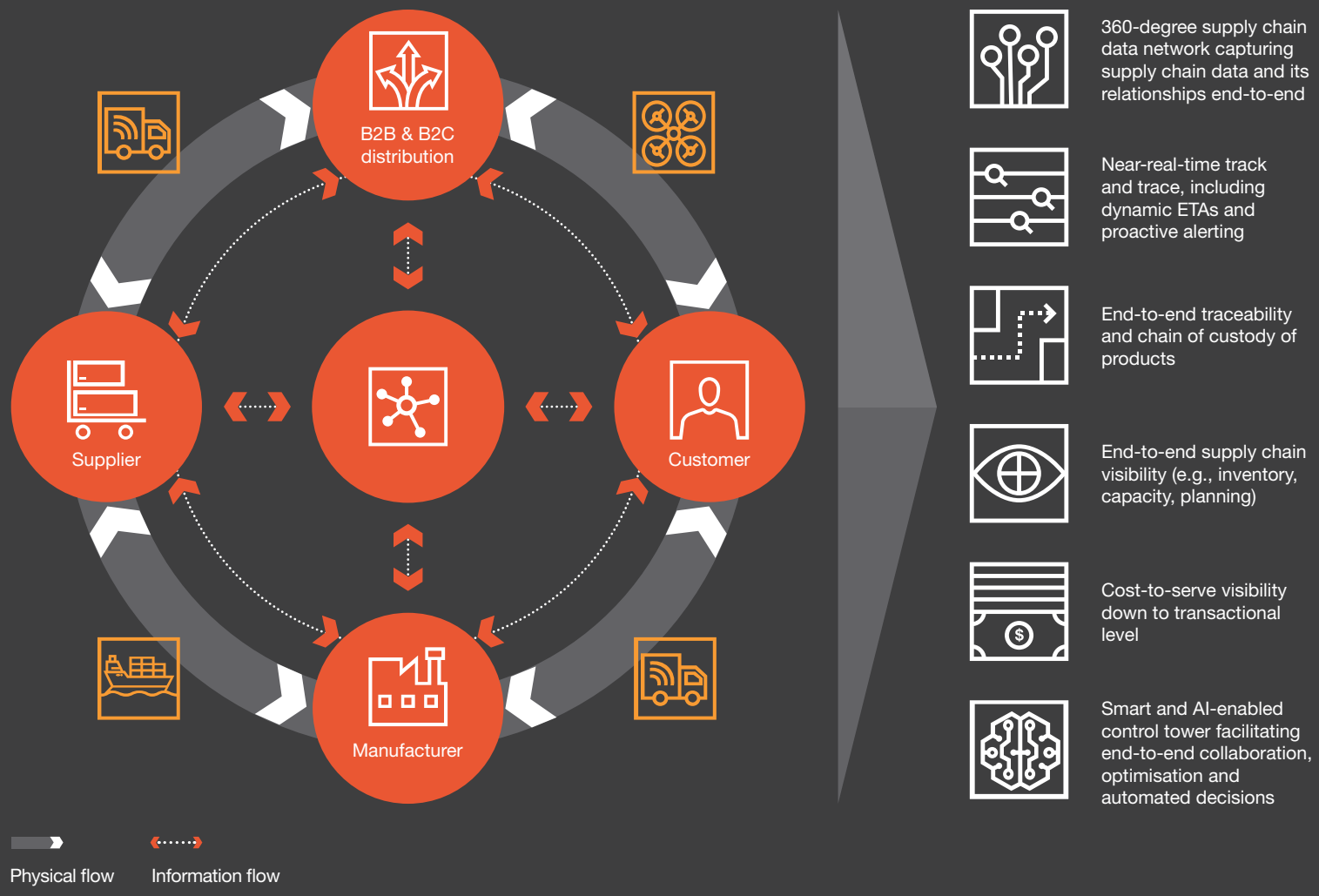
By taking a 360-degree perspective on the full life cycle of a product covering:

- product origin (who produced the product and its component parts, which raw materials did they use and from where were they sourced?)
- the delivery cycle (where was the product warehoused, when did it ship, which transport mode was used and what happened along the way?)
- customer behaviour (how are customers using the product and what is their feedback to the product?).

It is now possible to achieve transparency around what is actually happening across the supply chain, from suppliers across different tiers and then through to customers. This includes visibility over product origins and materials, orders, shipments, inventories, capacities, and cost-to-serve over particular batches, articles or serial numbers, down to the level of individual transactions.

Because products can be traced end-to-end, companies can also establish a clear chain of custody, for example to show that raw materials are not sourced from war zones or in environmentally damaging ways, making it possible for companies to meet increasing demand for greater insight around the environmental and social impact of their products. Companies can also communicate the origin of products to their customers and boost confidence in their products. This makes possible entirely new service offerings and even business models.

Exhibit 7: Overview of supply chain transparency



Near-real-time track and trace helps companies manage their supply chains more efficiently and optimise operations. Companies can manage stock levels more precisely, as information on the arrival of raw materials or components to production lines, or of finished goods in warehouses, is constantly updated. Track and trace also helps attract customers and build existing relationships by making it possible not only to estimate arrival times but to continuously update them based on near-real-time information and to provide proactive alerts to keep customers aware of shipment status.

This kind of visibility across the entire supply chain — from materials to customers and back, and all the steps in between — is a prerequisite for achieving our vision of integrated, connected and self-optimising supply chain ecosystems. Digital Champions already recognise this; 86% see supply chain transparency as a priority, and 55% rate it a high or top priority. They've also invested in making it a reality; 62% have already implemented solutions, more than twice as many as across our sample overall (see Exhibit 8). Transparency is an area where they've already seen the power of AI, with 43% of Digital Champions saying they are making use of AI solutions to generate transparency (see Exhibit 9).

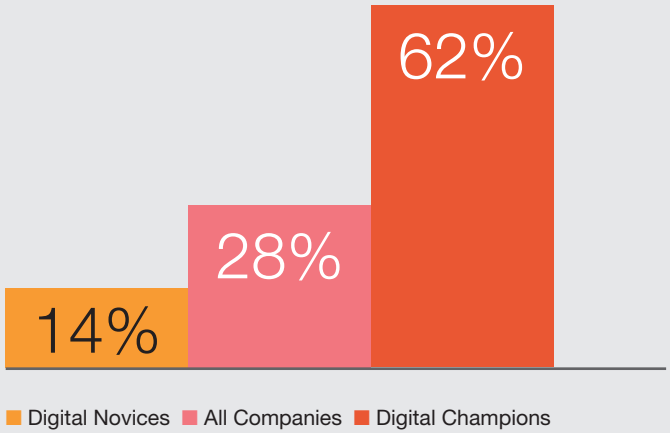
By detecting relevant patterns in the vast amount of data flowing from the supply chain, AI helps supply chain managers improve visibility over key metrics and better understand the complex workings of their supply chain. This is the first step on the way to an autonomous supply chain.

AI-powered supply chain transparency solutions also help companies to more proactively identify and manage supply chain risks, such as supply shortages, shipment delays, weather risks or financial risks of supply chain partners. By simulating different options to address potential threats (e.g., selecting an alternative supplier, rerouting shipments), companies gain a better understanding of their potential impact on service levels, lead times and costs. That makes it possible to take proactive countermeasures to mitigate risks and minimise their impact on the supply chain.

55%

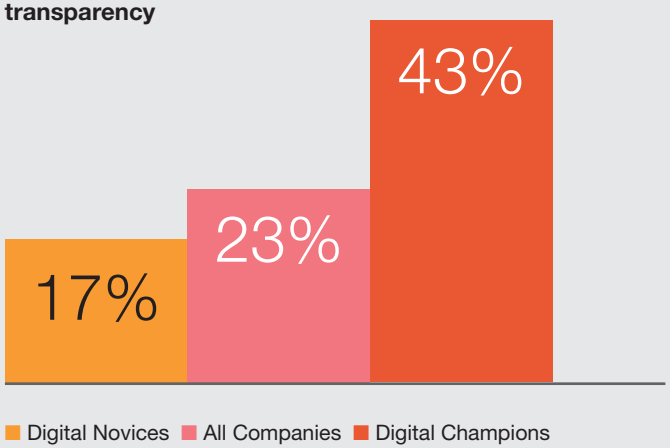
of Digital Champions consider supply chain transparency as a top priority

Exhibit 8: Champions excel at supply chain transparency



To what extent have you already implemented supply chain transparency? (For those reporting partially or fully implemented transparency) Base: 1,601 companies

Exhibit 9: Champions pull ahead, using AI to gain transparency



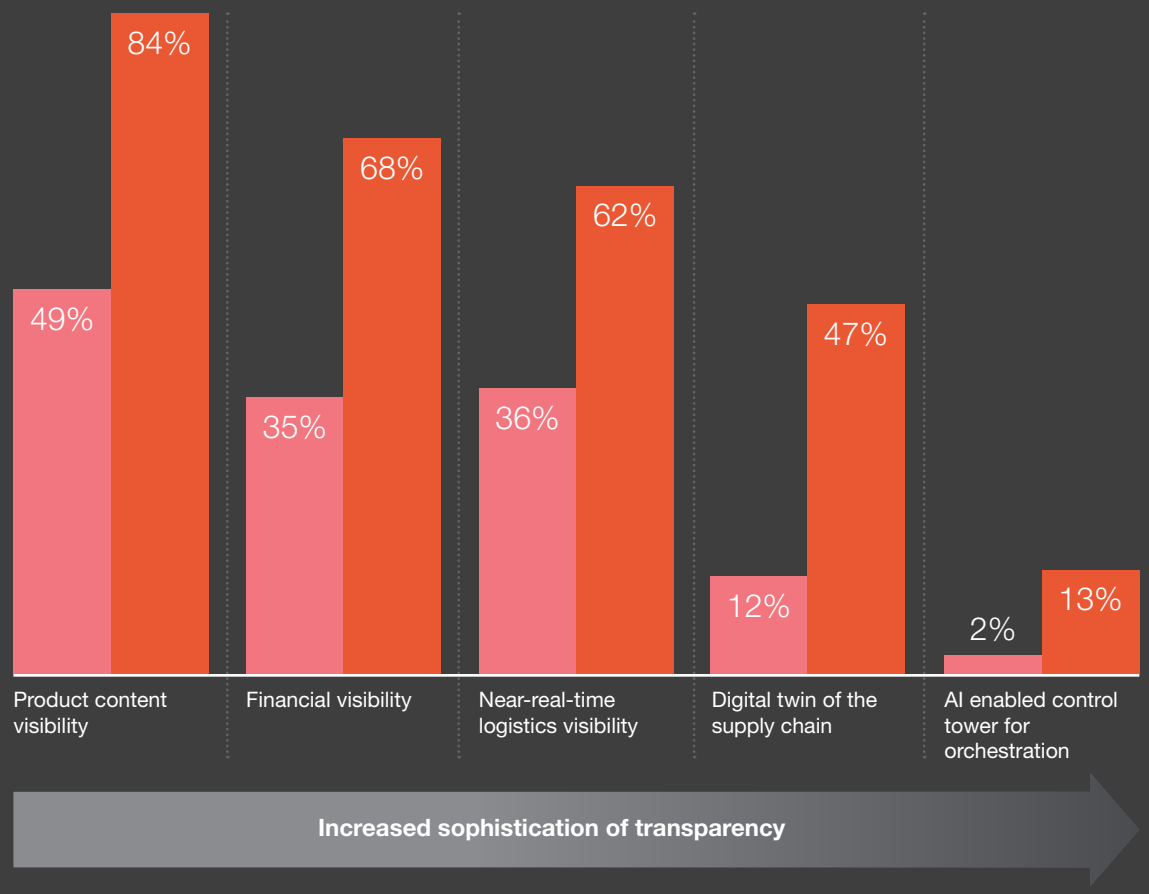
Are you applying AI, machine learning or deep learning for supply chain transparency? (For those reporting 'yes')
Base: 1,601 companies

Digital Champions have come a long way towards achieving a high level of supply chain transparency. Most have visibility over product contents, key financial metrics and logistics flows in near-real-time (see Exhibit 10). That's in stark contrast to our sample overall, in which most companies haven't yet mastered these basics.

More impressive is the large number of Digital Champions who already have the capacity to use a control tower to generate a digital twin of what's happening in their supply chains. A digital twin is essentially a virtual replica of the supply chain that can be used to run simulations, for example by comparing what is actually happening in the supply chain against plans (e.g., on capacities, demand, inventories), with the ability to make recommendations. About 13% of Digital Champions implementing transparency in their supply chains already have next-level supply chains in place — they're using an AI-enabled control tower, which facilitates orchestration of the end-to-end supply chain. An AI-enabled control tower automates decision-making and enables optimisation of the supply chain ecosystem. For example, it captures actual lead times as well as near-real-time shipment, order and consumption information. By linking this information to the planning layer, inventory plans can be dynamically and autonomously optimised, bringing companies closer to an autonomous supply chain.

Here too, scale matters. The larger enterprises implementing transparency have notably more visibility over their supply chains than do smaller companies. For example, more than half of companies with more than US$5bn in revenues have achieved visibility over financial metrics and logistics flows in near-real-time, compared to just 16% of such companies from US$100m to US$999m.

Exhibit 10: Areas of supply chain transparency



In which areas, if any, do you currently have supply chain transparency? Base: 1,081 companies

By achieving a strong level of transparency, Digital Champions also open up new possibilities to achieve sustainable and circular supply chains — the top supply chain challenge of Digital Champions over the next five years. There are a number of factors that go into supply chain sustainability. Companies want to make sure that they are working with partners who meet their own standards for corporate social responsibility — for example, when it comes to fair labour practices, health and safety, and environmental protection. So they need to have a strong understanding of how their suppliers and other partners operate. As already noted, they are looking to meet customer requirements for traceability of their products, such as making sure that wood products come from certified forests. They're striving to make their supply chains as CO2 neutral as possible, for example by using electric vehicles in logistics fleets or enhancing the energy efficiency of factories and warehouses. And in some cases they are also working on 'reverse logistics' — taking products back at the end of life, driven either by regulation or ambitions to build a 'circular' business.

Ultimately, enhancing sustainability in the supply chain has the potential to enhance a company's reputation by helping increase confidence that it is sourcing material ethically and leading on social issues. PwC's *23rd Annual Global CEO Survey* found that, compared with ten years ago, CEOs today are far more likely to see the benefits of going green, such as reputational advantage, new product and service opportunities, and government or financial incentives. For example, 30% of CEOs strongly agree that their response to climate change initiatives will provide a reputational advantage for their organisation among key stakeholders, including employees.

Technology viewpoint: Looking at blockchain

Digital technologies are vital to making this kind of transparency possible, and Digital Champions are way ahead in deploying them. Fully 72% have already implemented supply chain transparency platforms, and a large majority (87%) are relying on standard software solutions, the highest share of standard solution usage across all supply chain technologies. Almost all of the Digital Champions (97%) have already decided on a vendor, and that's true for most companies across our sample too (84%).

One technology that has not yet gained traction as a means to generate transparency is blockchain. Just 5% of all companies and fewer than one-third of Digital Champions (27%) have already implemented blockchain. That said, there's clear interest in exploring the possibilities, especially from Digital Champions — 37% have begun piloting blockchain solutions and a further 33% are planning to do so within the next five years. That compares with around half of companies overall (49%) that are piloting blockchain or expressed interest in doing so. There's still a great deal of uncertainty about the best way to pursue such initiatives, though; 64% of companies overall haven't yet decided whether to develop a solution in-house or purchase standard software, far more than for any of the other software-based supply chain technologies we asked about. Our experience suggests that, for many companies, there are also still challenges involved in developing a clear business case for blockchain.

Company snapshot
Continental

The technology company Continental develops technologies and services for sustainable and connected mobility and offers safe, efficient, intelligent and affordable solutions for vehicles, machines, traffic and transportation. The supply chain of the Continental group sector Automotive Technologies, which is the subject of this portrait, is hugely complex, with approximately 50 production sites, 3,000 suppliers and 100bn purchased components worldwide.

Making the vision of an autonomous supply network a reality

To keep pace with the rapidly changing automotive industry, Continental has developed its 'Fast Forward 2030' vision. This vision is driving Continental's digital transformation of the supply chain into an autonomous supply network. By 2030, Continental aims to connect all systems, with data stored in the cloud and information shared in real-time with all relevant users. Decisions will be optimised using big data and AI. Transparency and visibility are an important part of this evolution. That includes real-time connectivity during transport and integration with internal and external business partners. A 'Control Tower' will autonomously monitor and steer the whole supply network, making it possible for Continental to proactively orchestrate its highly complex activities.

Continental's vision and strategy for its supply network builds the framework for all its Industry 4.0 activities, including digital factory initiatives and the digitalisation of industrial engineering, as well as IT infrastructure plans, AI and data analytics. Within the strategy, Continental has defined 22 strategic areas, including six specifically focussed on its digital supply network. Each of these has a five-year plan and a cost-benefit analysis.

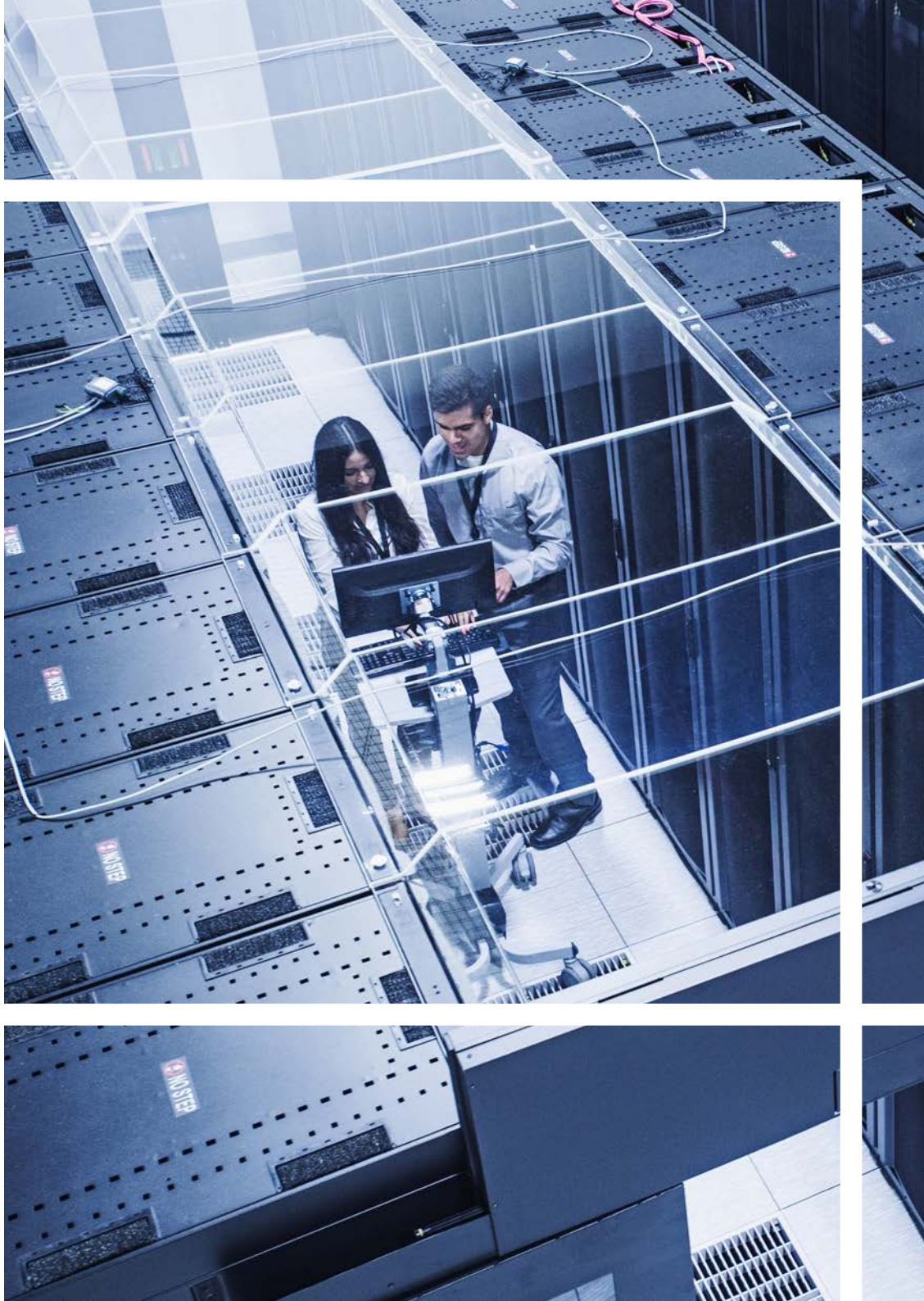
Continental has begun putting the vision into practice with pilots at two Industry 4.0 model plants: one in Regensburg, Germany (electronics), and the other in Zvolen, Slovakia (mechanical plant). In Regensburg, 7,000 sensors help drive touchless material flows using geolocation technology with a precision of 5cm. The use of geofencing and geolocation analysis ensures seamless asset tracking and real-time localisation — a must for an autonomous supply network. Coupling this information with manufacturing and supply network planning has resulted in more accuracy in planning and the ability to predict deviations in the supply network. Integrated transportation systems that make use of software-enabled booking for truck drivers and a fastlane system to prioritise urgently required goods are also being implemented.

Continental has already begun developing a digital twin of the supply chain and using a cloud solution for its material supply flows. Intelligent algorithms enable the company to quickly and proactively identify whether material supply failures could cause bottlenecks. As a result, countermeasures such as the redistribution of stocks or production programmes can be taken quickly, and customer delivery disruptions can be avoided. The lead time to information in the event of possible delivery disruptions is also significantly shortened, from days to hours. In addition, this solution facilitates integrated risk management for component supply and serves as a fully integrated interface between Continental and its suppliers. Risk prevention is supported by advanced methods from the field of data analytics (data mining, descriptive and predictive analytics, alerts) and the use of big data and cloud technology.

Closed loop and integrated planning

Next-level planning is synchronised real-time with execution, integrates supply chain partners and enables continuous optimisation

For companies that have established transparency along their end-to-end supply chain, a range of opportunities open up to improve supply chain planning. In the past, planning often happened in different silos within the organisation, and was mostly based on historic data and experience from planners rather than current market dynamics and forward-looking data. That has already begun to change, and advanced planning approaches have proven to be an effective building block for companies looking to make operations more responsive, efficient and integrated.



These approaches include:

- Integration of customer and supplier ecosystem data into the planning process
- Cross-functional or company-wide long-term planning (integrated business planning) and collaboration
- Integration of volume and financial data across the entire planning pyramid
- Direct link between the planning and the execution layers.

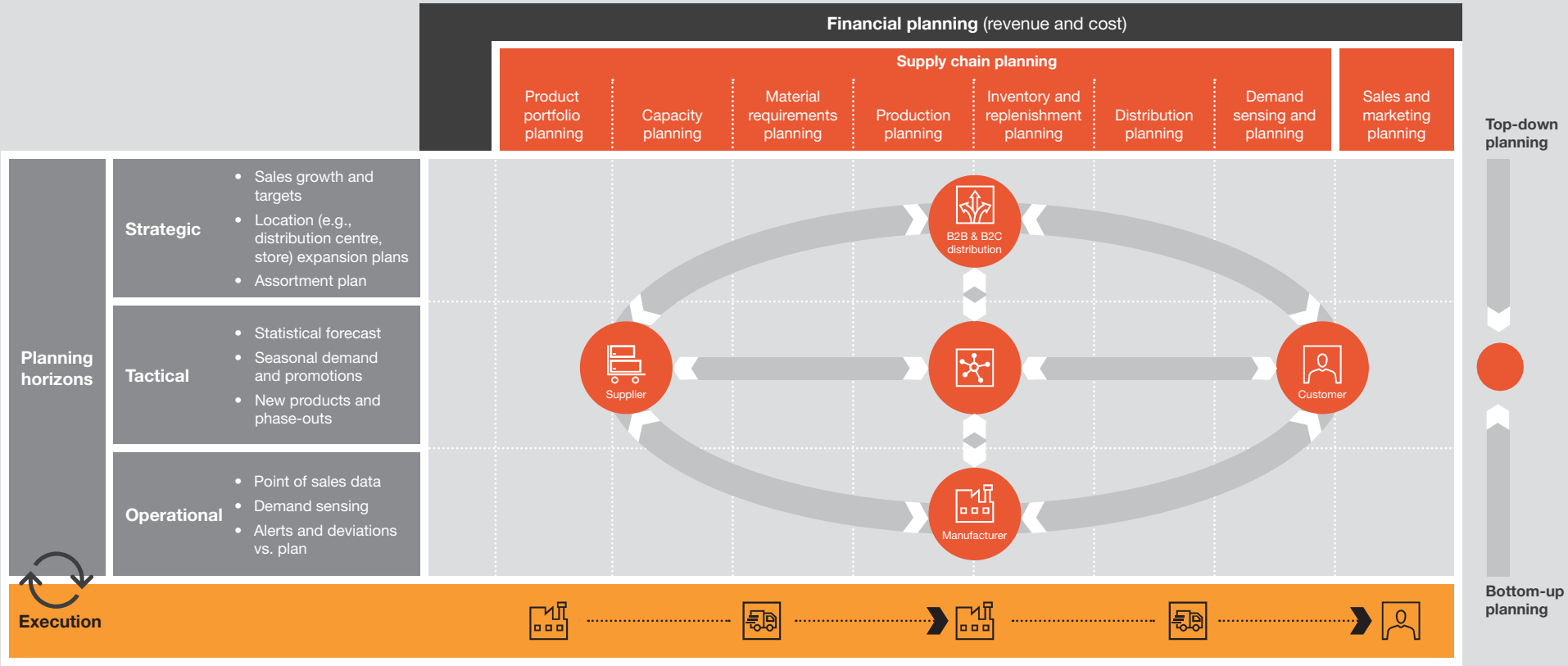
These approaches are helping companies maintain a balance between demand and supply, and adjust operations to maximise impact by using automated and differentiated replenishment, as just one example.

Once companies achieve transparency over their supply chains, all planning activities, including production planning, capacity planning, inventory planning and distribution planning, can be connected to execution. That means anticipated demand and supply can constantly be compared with actual results and reconciled, and plans can be adjusted accordingly. When volume and financial forecasts are part of one plan that's integrated across time, operational information can help planners adjust tactical and strategic plans, for example around seasonal promotions, sales growth and targets, or possible new locations. In this type of environment, supply chain planning is integrated, so data from customer services or sales can flow into product portfolio planning processes, which can in turn influence product design and development.

A next-level planning function doesn't just take historical or even current information into account — it looks to the future by applying advanced analytics and automated 'what-if simulations,' for example by applying demand sensing. This technique takes all potential factors that could influence demand into consideration and applies machine learning that uses self-learning algorithms to derive forecasts on much more accurate and granular levels than are commonly available today (e.g., by SKU, point of sales and hour) (see Exhibit 11).

A volatile global market environment, increasing competition and the need for reduction in cost and environmental impact are a few of the reasons that lead companies to seek more responsive and integrated operations. Advanced planning approaches have proven to be an effective building block.

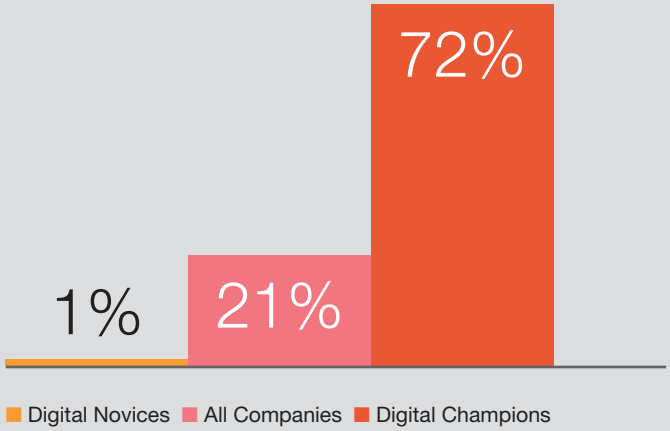
Exhibit 11: Overview of closed-loop integrated planning and execution



72%

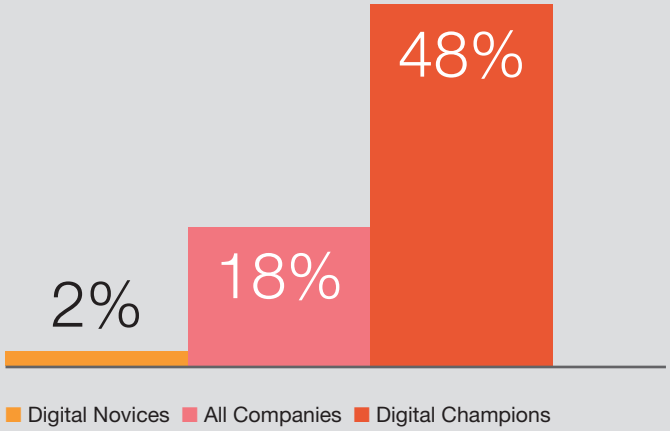
of Digital Champions across the entire sample are already using end-to-end planning – and that number drops to just 1% of Digital Novices

Exhibit 12: Champions surpass other companies in implementing partial or full end-to-end planning



To what extent have you already implemented end-to-end planning? (For those reporting partially or fully implemented)
Base: 1,601 companies

Exhibit 13: Companies reporting that end-to-end planning is a high or top priority



What are your priorities for implementing end-to-end planning? (For those reporting high or top priority)
Base: 1,601 companies

Although many companies recognise the value of an end-to-end integrated planning approach, they still have a long way to go to create one. Only 21% of respondents across the entire sample are already using end-to-end planning — and that number drops to just 1% of Digital Novices (see Exhibit 12). More companies, 27%, are at the pilot stage, so we may see some significant changes over the next several years. Digital Champions are far ahead of the pack when it comes to making the most of end-to-end planning. Nearly three-quarters (72%) have gone beyond the pilot stage and have partly or fully implemented end-to-end planning. For around half (48%), it's a high or even top priority (see Exhibit 13). Those efforts are paying off — 90% of Digital Champions report a positive impact from their planning.

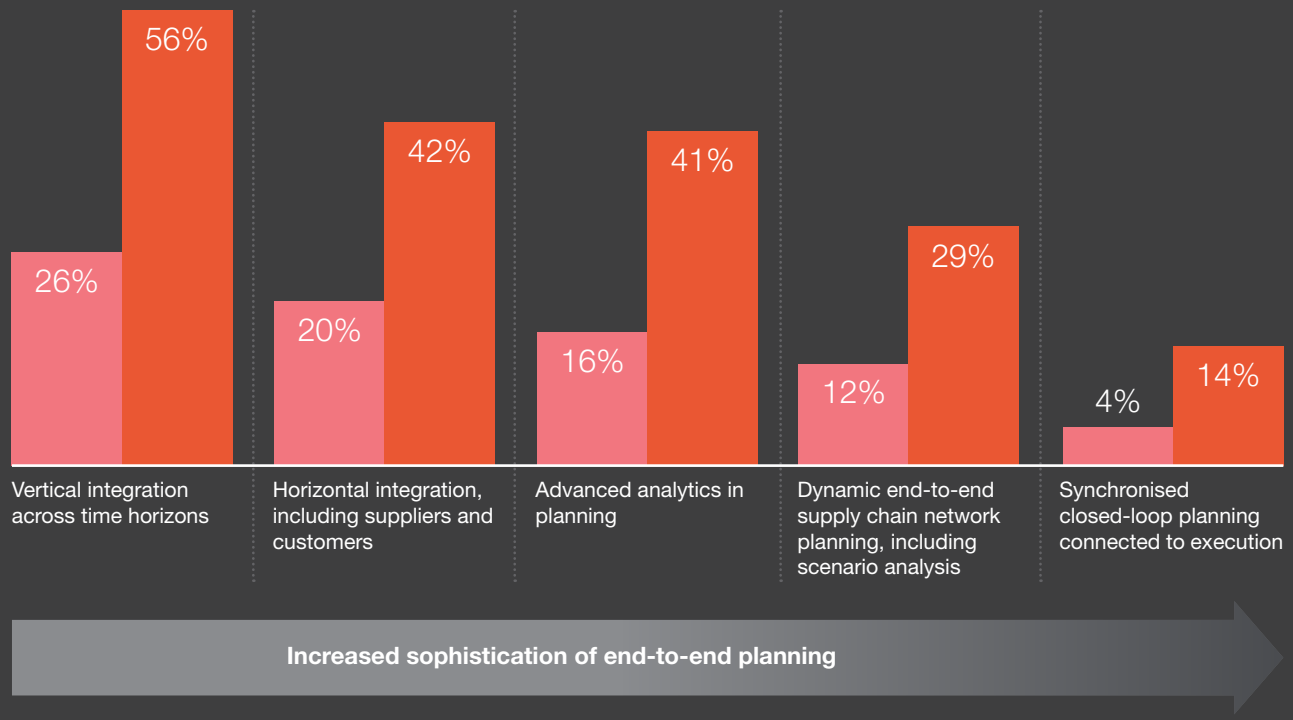
One of the ways better planning pays off is in improved volume flexibility. Although 30% of Digital Novices report it as one of their top-three challenges, that number drops significantly for Digital Champions. This is because they are already well on their way when it comes to mastering volume flexibility through more accurate and dynamic planning.

A more detailed look also shows that Digital Champions are significantly ahead when it comes to implementing advanced planning approaches. More than half of the companies who are implementing planning approaches vertically integrate across time horizons, meaning that their short-term operational planning is linked to mid-term tactical goals and long-term strategic planning. Around two out of five of these companies also apply advanced analytics in planning, for example in demand sensing and forecasting applications. And a similar number horizontally integrate their planning activities, including integrated and collaborative planning with suppliers and customers. That compares to less than one in five companies implementing planning across the overall sample.

For companies implementing planning, the gap between companies overall and Digital Champions is even more dramatic as the level of sophistication increases (see Exhibit 14). Nearly a third of these Digital Champions (29%) are already enhancing their end-to-end planning with dynamic approaches that include scenario analyses, compared to 12% of all companies. And 14% of these Digital Champions have already embarked on building closed-loop planning capabilities — where they are connected across the entire supply chain, covering all time horizons, integrating both volume and financial planning, and with a direct link to execution activities (e.g., near-real-time replenishment and warehouse configuration) — compared to only 4% of all companies.

Our research suggests that scale does matter when it comes to planning excellence. Larger companies implementing planning were far more likely to be making the most of advanced approaches. Take the use of analytics for demand sensing. One in four companies with revenues over US$5bn that implement planning capabilities are already deploying such tools, while only one in 20 companies with revenues between US$100m and US$1bn do so.

Exhibit 14: Approaches to supply chain planning



Which of the following do you already use in your supply chain planning today?
Base: 722 companies (companies implementing supply chain planning)

Technology viewpoint: Software solutions

Not surprisingly, Digital Champions are ahead when it comes to implementing technology solutions to enable integrated end-to-end planning — 70% have already done so, compared to just 26% overall. A number of different software solutions are available, and 83% of Champions say they will purchase standard solutions rather than developing their own software in-house. Many companies are still on the fence when it comes to technology, though. More than a quarter (27%) say they are undecided on which systems to choose. That's in sharp contrast to Digital Champions, of which 96% have already made a vendor decision.

Company snapshot
Advantest

Advantest Corporation is a leading manufacturer of automated testing equipment (ATE) for the semiconductor industry. Founded in Tokyo, Japan, Advantest is a global company with a workforce of nearly 5,000 and an international commitment to sustainable practices and social responsibility.

Living the connected enterprise by integrating suppliers and customers

Semiconductors are at the heart of nearly all electronic devices. This naturally includes the computers, wearables and smartphones that consumers depend on, but also many applications that aren't as immediately obvious. For example, today's cars and trucks already use a wide range of embedded electronic systems for everything from braking to engine management. As vehicle connectivity increases and cars get ever-more autonomous, electronics will be even more important. It's critical that these systems be reliable.

That's where Advantest comes in. It provides test equipment so the semiconductor industry can ensure its products will work when they're needed, and it is a critical partner in today's electronics supply chains. Because the industrial equipment industry is subject to high levels of demand volatility and project-oriented business cycles, the environment can be challenging. There are pressures on costs too.

Advantest uses several strategies to manage these challenges. For example, its strong manufacturing network includes close collaboration with contract manufacturers for key product lines. These partnerships give the company a high level of flexibility so it can manage growth and adjust to market volatility when needed.

By digitalising its supply chain, Advantest is achieving a high level of transparency, both across functions within the company and with value chain partners. That helps Advantest make sure it has sufficient capacity to provide its customers with the right technical performance and required yield.

Much of the company's growth over the past several years has been both driven and enabled by supply chain innovation. Advantest integrates product design with supply chain management (SCM) — 'Design for SCM.' New products are designed in a systematic way, using a modular approach with common platforms, modules and components. During the design process, contract manufacturers and component suppliers are involved at an early stage. The company's supply chain function also takes a leading role in making sure that logistics requirements are integrated into the definition and design of new products, for example by taking inventory considerations for raw materials and components into account.

Organisational considerations are an important success factor for this Design for SCM approach. Advantest clearly defines and communicates roles and responsibilities for operations across the entire value chain, including their contract manufacturers, component suppliers and customers. Since Advantest designs and builds many products to order, a strong integration of R&D with the supply chain is critical.

Advantest also places a strong focus on close integration within the planning environment. The company optimises inventory planning by integrating demand and supply planning, including close connections with contract manufacturers. That helps Advantest achieve a strong level of delivery reliability, even for highly customised products.

Smart logistics flows

Smart logistics is the key savings driver and a growth lever in the connected supply chain ecosystem

Logistics — managing and executing the physical flow of goods from the point of origin to the point of consumption — is an essential part of the supply chain. 'Smart logistics' connects suppliers, manufacturers, logistics service providers and customers interactively, building on supply chain transparency and integrated planning (see Exhibit 15). Logistics execution has seen a whole range of technological innovations coming into play to improve processes and activities. Examples include automated picking, drones and autonomous guided vehicles in warehousing, or track and trace in transportation, to name just a few.

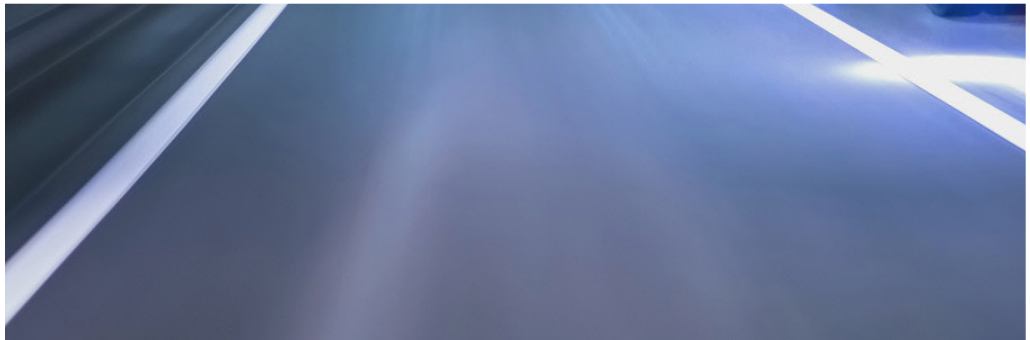
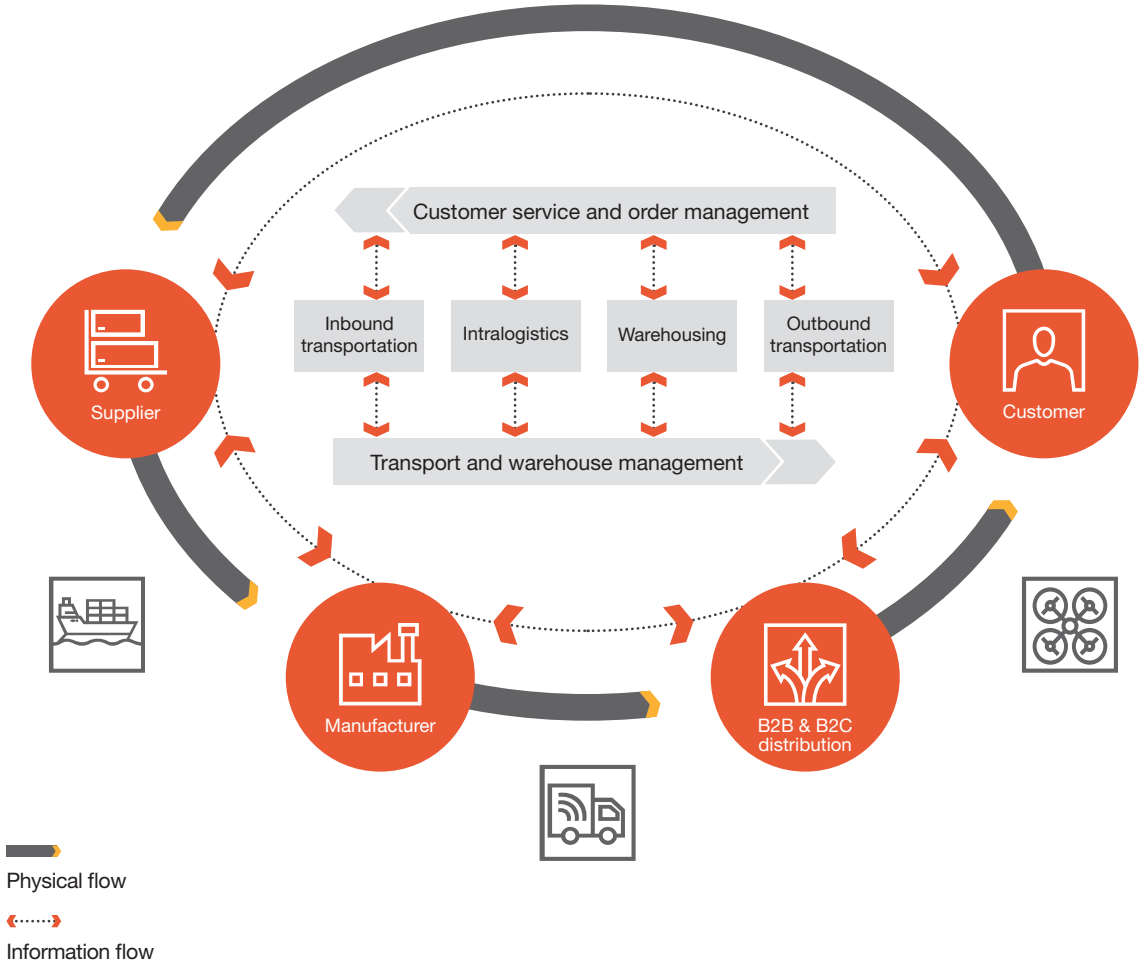


Exhibit 15: Overview of smart logistics



Although warehousing and transport management have been supported by WMS and TMS for decades, these systems have been changing and evolving. In addition to enabling real-time data visibility and improved usability, it's now possible to fully connect systems both inside and outside the organisation, enabling smart logistics.

Logistics often involves working with partners, such as freight forwarders, carriers or warehouse service providers. This makes good economic sense; manufacturing companies that regard transportation as a core competence and maintain their own fleet are rather rare. The number of partners and external transactions happening during logistics processes is very high compared to other areas in the supply chain (e.g., manufacturing). To manage and optimise logistics, it's particularly critical to ensure smooth integration across the entire ecosystem. Seamlessly linking the flow of information — customer service and order management and transport/warehouse management — with the flow of physical goods, including inbound and outbound logistics (transportation), intralogistics and warehousing, is vital. Internal integration across functions and external integration with customers, suppliers and service providers is the backbone of the smart logistics ecosystem. By fully orchestrating this network, leading companies can turn their logistics network into a strategic asset that helps them better manage diverse channel requirements, such as the faster delivery speeds expected when companies move into the B2B2C or B2C space.

Our survey respondents see smart logistics as the strongest lever for cost savings. It's typically the largest cost bucket in the connected supply chain, as it incorporates warehouse, order management and transport (inbound and outbound), which are each key cost drivers. Its importance goes beyond pure cost considerations, though. Because logistics includes outbound transportation, it closes the loop to the customer, making it particularly visible and critical for customer satisfaction. And it can also be a key contributor to new revenue streams and resulting growth, as it is a key enabler for new B2B2C and B2C business models.

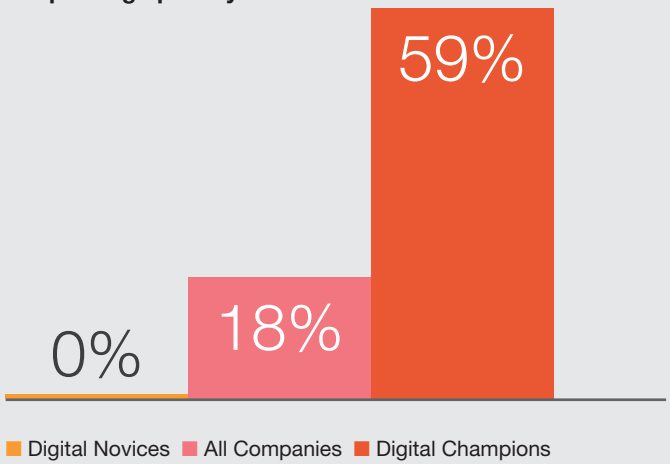
Digital Champions have recognised its importance and are putting smart logistics at the top of their agenda: 59% say it's a high or even a top priority, and 82% have already implemented it (see Exhibits 16 and 17). That's far more than across the sample overall, where only about a third of companies say they are already implementing smart logistics. Nearly half of Digital Champions told us that smart logistics is having a large or very large positive impact on their business, compared to just 19% of respondents overall and almost no Digital Novices or Digital Followers. Given that respondents report that transportation management and warehousing solutions together contribute just over half of the total cost savings gained from advanced supply chain capabilities, this is clearly a major opportunity for many companies to drive efficiency.

Digital Champions have recognised its importance and are putting smart logistics at the top of their agenda

59%

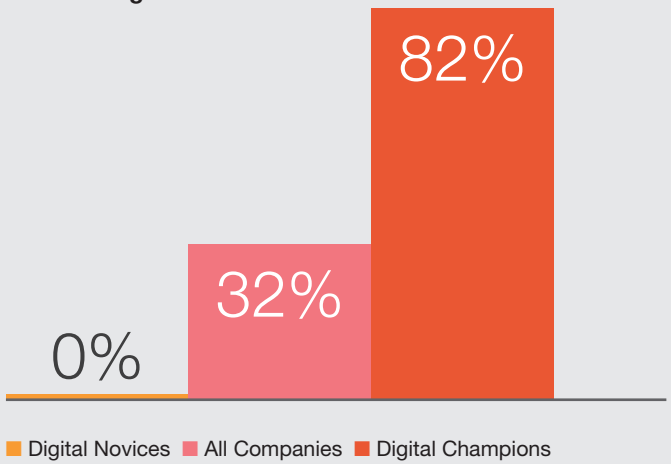
say it's a high or even a top priority and 82% have already implemented it

Exhibit 16: Companies reporting that smart logistics is a top or high priority



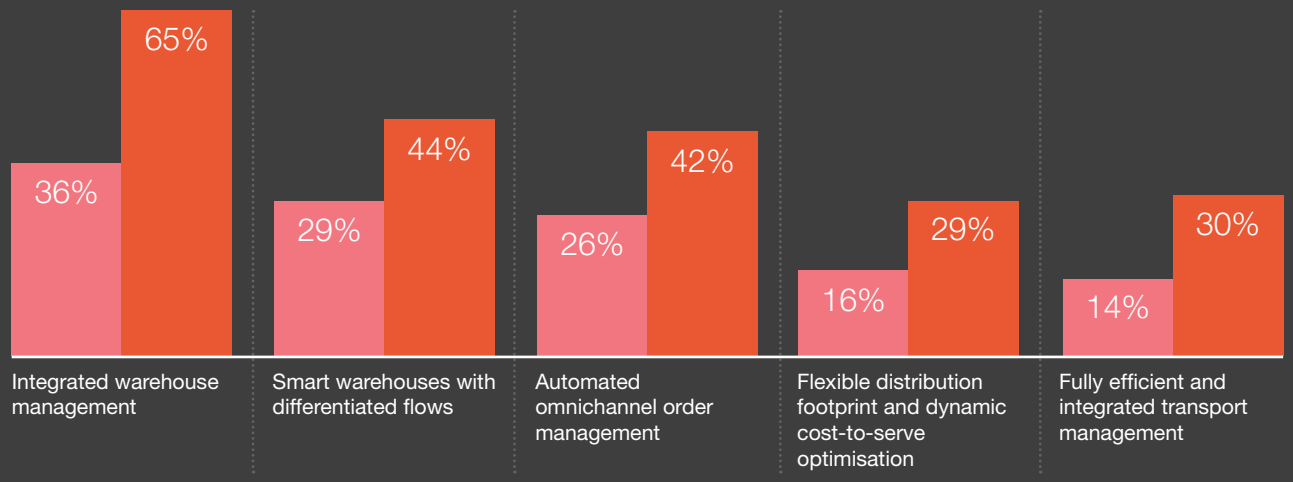
What are your priorities for implementing smart logistics? (For those reporting high or top priority) Base: 1,601 compaines

Exhibit 17: Companies reporting partial or full implementation of smart logistics



To what extent have you already implemented smart logistics? (For those reporting partial or full implementation of smart logistics) Base 1,601 companies

Exhibit 18: Integrated warehouse management tops the list of logistics capabilities



Have you implemented the following logistics capabilities? (For those reporting 'yes')
Base: 967 companies (companies implementing smart logistics)

50%

of supply chain cost savings can be attributed to smart logistics

We took a closer look at just what companies implementing smart logistics approaches are doing (see Exhibit 18). Nearly two-thirds of these Digital Champions already practice integrated warehouse management that is seamlessly linked with warehouse planning and execution processes, and even more are already using WMS. These systems are the basis for connecting warehouses with other parts of the supply chain and provide its digital backbone, automating a range of functions, including the management of labour, visibility on inventories and overall warehouse storage and handling. They are also vital to supporting other key capabilities, such as dynamic supply chain segmentation, because they enable flexible distribution, making smart logistics a critical enabler for segmentation.

Indeed, many of these Digital Champions are also taking advantage of the potential of smart warehouses with differentiated flows. In these warehouses, digital solutions are streamlining many aspects of execution. For example, rather than relying on paper lists, companies are now using smart scanners, augmented reality glasses, RFID tags, tablet and/or mobile-based apps and more to tell employees where to put or pick goods.

Direct interaction with customers through a wide range of channels is becoming increasingly important for B2B2C, B2C and B2B business models, and it opens up new revenue streams and growth potentials for companies. Automated omnichannel order management supports this interaction, making it possible for companies to dramatically enhance both customer service and integration with the rest of the supply chain. It allows companies to 'close the loop' during interactions with customers, whether these happen via phone, email, ordering platforms or directly via automated connections with enterprise resource planning (ERP) systems. As a major step in supply chain execution, order management is an important area of focus within logistics, as it triggers the transportation process to customers (similar to internal stock transfer orders for replenishment that trigger transportation between warehouses). Digital Champions are ahead in this area, with 42% of those who have implemented planning already using automated omnichannel order management.

Digital Champions are also significantly more likely to take advantage of fully efficient and integrated transport management strategies, which enable a highly sophisticated process for fulfilling transport orders (see 'Next-level transport order workflow,' page 34). This provides the basis for flexible distribution footprints that can be altered as needed to optimise cost-to-serve dynamically, for example by taking advantage of 'on-demand' warehousing, sometimes referred to as the 'Uberisation' of warehousing. A fully integrated transportation management process also improves cost efficiency and reduces order fulfilment cycle times.

Next-level transport order workflow
(points in italics involve ecosystem partners)

1. Automated creation of a transport order by the omnichannel order management system
2. Stock availability is checked, respective material blocked, and *customer receives a delivery date* (near instantaneous)
3. Transport execution process is triggered
4. Orders are consolidated with other transport orders allowing for the maximum fill rate
5. *The load is tendered on a fully connected transport marketplace to source the best rate*
6. *Transport marketplace platform stores shipment instructions and documentation of shipment status, enabling track and trace right through to the last mile to the customer*
7. *Transportation invoices are uploaded to the transport marketplace platform by the carrier*
8. *Transport marketplace platform automatically checks against the provided initial quote and matches the invoice*
9. Invoice is forwarded to the accounts payable team for settlement via a linked ERP system

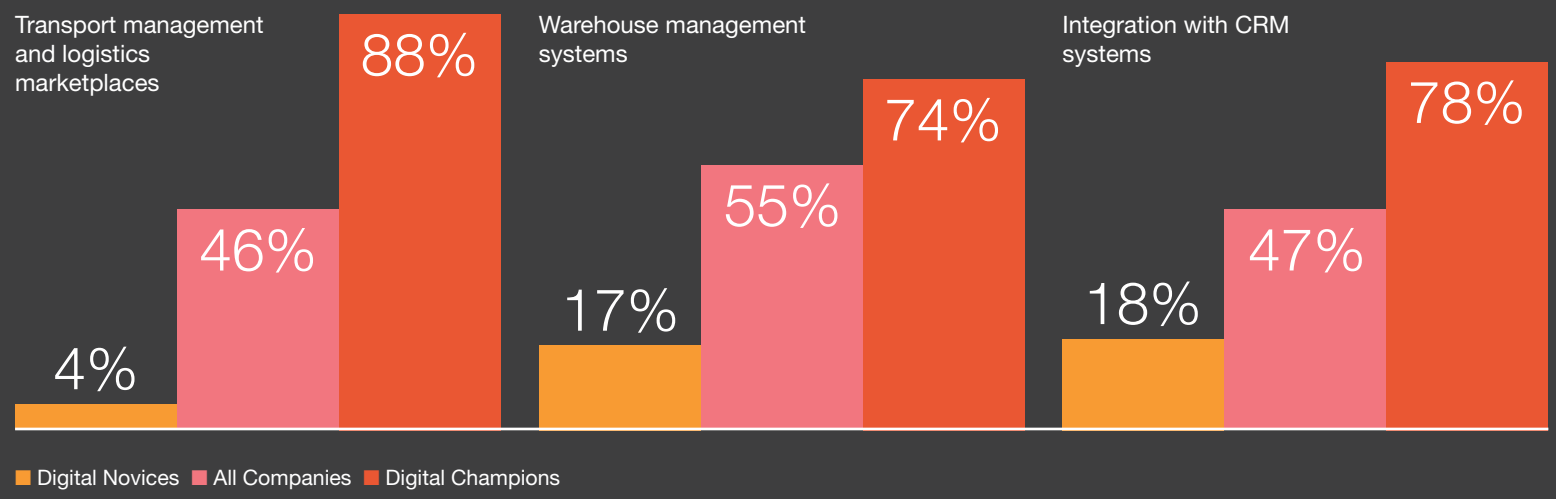
Technology viewpoint: Choices for smart logistics

To achieve smart logistics, companies are implementing several key technology solutions. Almost nine out of ten Digital Champions already use TMS and/or logistics marketplaces (see Exhibit A). That allows them to take advantage of improved planning and better pricing of logistics services. Nearly three-quarters are deploying WMS to optimise everything from inventory levels to picking to intralogistics.

Around half of companies overall are implementing WMS, TMS and/or logistics marketplaces, but Digital Novices are notably behind on both fronts, with just 17% using WMS and only 4% taking advantage of TMS and/or logistics marketplaces.

Most Digital Champions (78%) are also integrating customer relationship management (CRM) systems with other aspects of smart logistics. This can provide valuable tools for customer-facing service staff, who are proactively able to provide more accurate information on, for example, delivery times.

Exhibit A: Technology choices for smart logistics



To what extent have you implemented the following software-based supply chain technologies within your company? (For those reporting partial or full implementation) Base: 1,601 companies

Company snapshot
Nokia

Nokia creates technology that provides a backbone for the world's communication networks. It develops and delivers an end-to-end portfolio of network equipment, software, services and licensing that is available globally. Its customers include communications service providers whose combined networks support 6.1bn subscriptions, as well as enterprises in the private and public sector.

Future Eye: A conscious supply chain network

Nokia has evolved from a company primarily focussed on consumer electronics to one with a broader telecommunications and IT focus, including a strong commitment to both providing the backbone for 5G and taking advantage of the opportunities it provides. Nokia is focussing on supply chain innovation not only to improve its own manufacturing and distribution but also to enhance the experience of its customers and ultimately provide them with new solutions that have the potential to revolutionise their own supply chains.

Nokia's overall supply chain strategy, 'Future Eye,' was initiated to describe Nokia's future end-to-end value chains covering necessary processes, technology, data and organisational models. It also includes developing what it calls the 'conscious factory,' the 'conscious warehouse' and 'conscious distribution.' It's creating an end-to-end supply chain network by integrating suppliers, carriers, and customers and ensuring end-to-end process visibility and traceability. The ultimate goal: give customers a differentiated experience and build long-term loyalty. To develop and continuously enhance the Future Eye vision, close cooperation among supply chain, R&D, production and sales is key. It makes it possible to capture improvement potentials, validate customer requirements and identify new business opportunities.

The conscious factory is highly automated and efficient. Many of the company's manufacturing facilities are outsourced, while Nokia concentrates on retaining ownership of the information, data and knowledge that supports them. By adding sensors to factories and connecting manufacturing and logistics assets, Nokia is gaining visibility over activities in real-time. That in turn helps the company to optimise a range of factors, from throughput to quality. It also leads to reduced inventory costs and enhances supply chain flexibility.

Nokia's ambition goes beyond its own supply chain. The company also offers many of its conscious factory and conscious warehouse solutions as part of its 'Go Allwhere' product and service portfolio. One example is the 'factory-in-a-box' solution, an innovative, container-based portable factory line that is highly automated and includes a digital twin. It can be deployed anywhere around the world and set up in hours, opening new possibilities for flexible and fast supply chains.

Communication technology is the backbone of Nokia's conscious warehouse and makes it possible to connect the entire warehouse with smart devices. Nokia's cloud-based WMS is designed to support, manage and optimise warehouse operations. It enables track and trace by using smart devices based on GPS, Bluetooth, near-field communication and ultra-wide band tags. Nokia is also pioneering private 4G and 5G networks in factories and warehouses. An indoor positioning and asset-tracking solution being developed will allow real-time predictive warehouse optimisation.

Nokia's 'warehouse-in-a-box,' also currently under development, will allow the company to flexibly place smaller, digitally enabled warehouses closer to customers to support specific country and project needs. The result: shorter lead times and more flexibility.

Both the conscious factory and conscious warehouse will be connected to the company's conscious supply chain and engineering network. This includes conscious distribution, which allows real-time shipment monitoring and dynamic routing so Nokia can react faster to changing conditions. Conscious distribution makes use of key technologies like automated customs clearance, geolocation and geofencing, that enable real-time shipment monitoring and proactive alerts. It's also a self-optimising, dynamic network that is continuously remodelled to optimise the total cost of ownership.

Dynamic supply chain segmentation

Dynamic supply chain segmentation enhances customer centricity and continuously balances service levels

Supply chain segmentation is the design and operation of distinctly different end-to-end supply chains from suppliers to customers (see Exhibit 19). A whole range of potential attributes can define these segments, from the value of the individual customer through product, manufacturing and supply capabilities, which then determine the configuration of the specific supply chain. Companies that have developed mature capabilities in this area — including processes, talent and technologies — and are following a structured approach to optimising their supply chains are now able to optimise cost-to-serve performance.

Supply chain segmentation isn't new — we identified it as a key value driver for leading companies in our *2013 Global Supply Chain Survey* — but we are now seeing it reach a new level of sophistication and flexibility. Rather than establishing static segments, companies can use advanced AI tools to adjust and configure a higher number of supply chain segments dynamically. That includes combining a range of strategies for sourcing, manufacturing and delivery in diverse ways, opening up new possibilities to enhance both customer service and profitability.

For example, as demand for customised products increases, dynamic and AI-enabled supply chain segmentation also helps companies juggle a greater number of increasingly granular supply chain segments, each of which includes a highly diverse product portfolio — sometimes all the way down to a lot size of one.

Exhibit 19: Evolution of supply chain segmentation

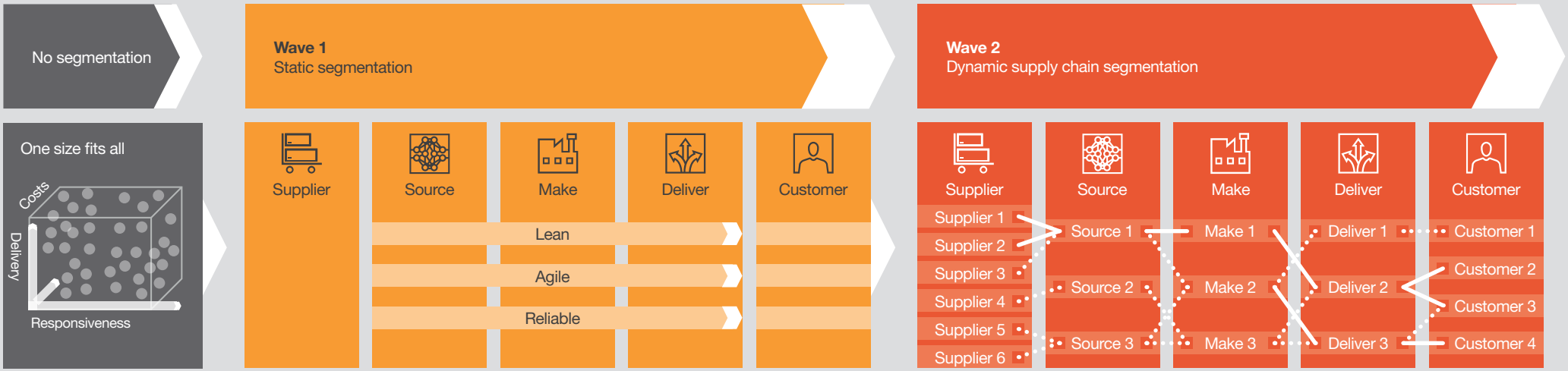
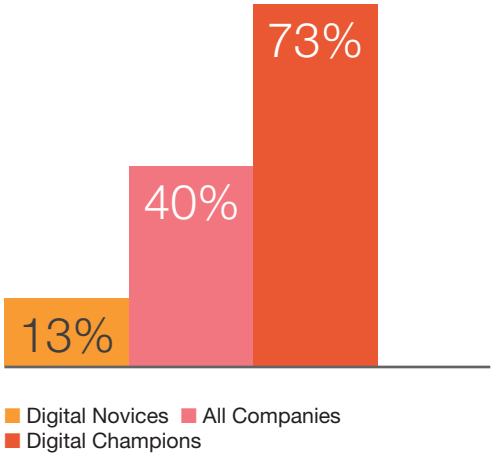
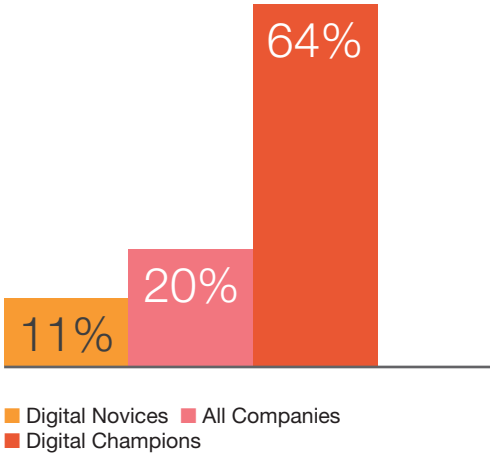


Exhibit 20: Companies reporting partial or full implementation of segmentation



To what extent have you already implemented supply chain segmentation? (For those reporting partial or full implementation)
Base: 1,601 companies

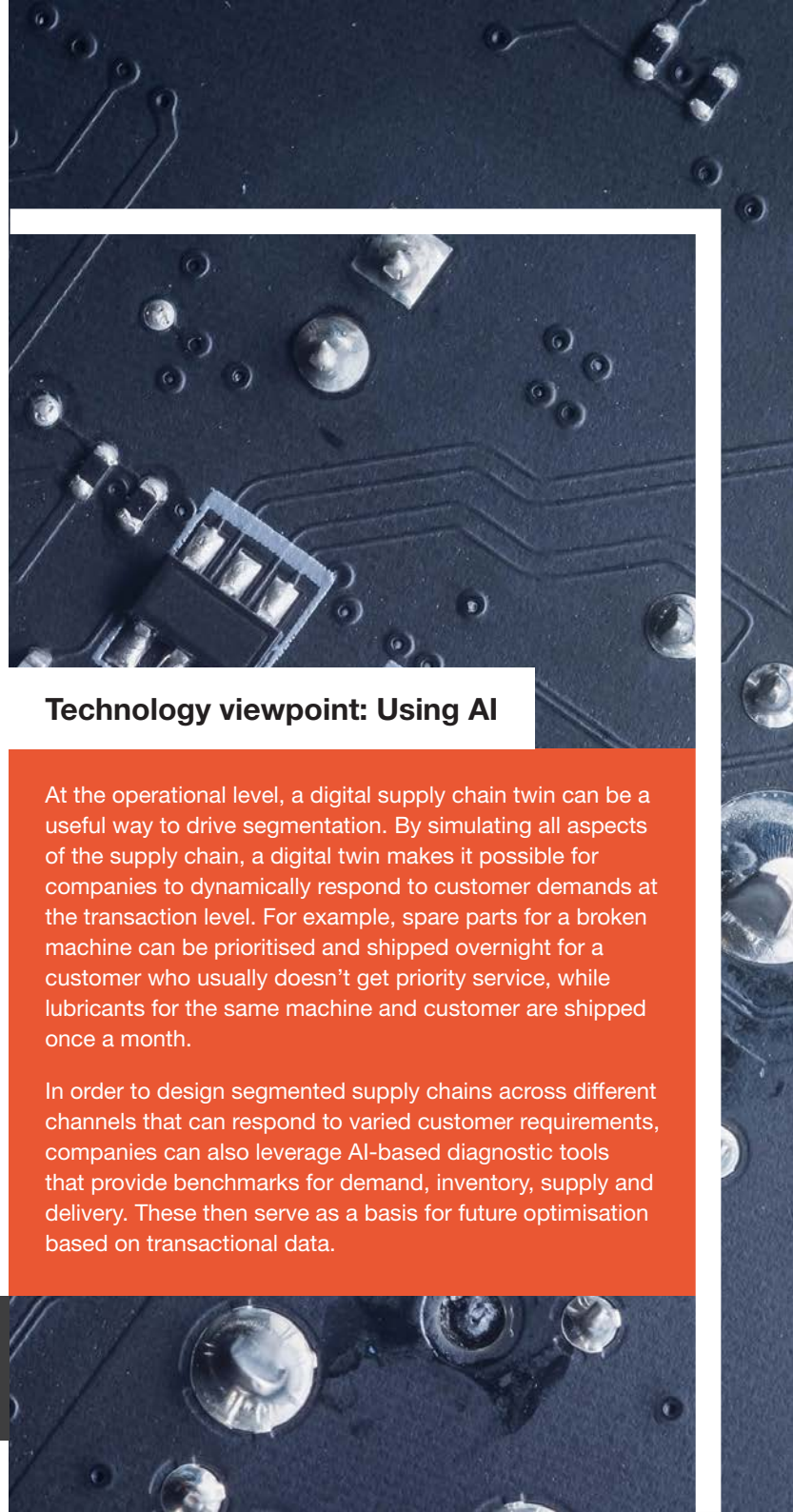
Exhibit 21: Companies reporting segmentation is having a large or very large impact



What impact on performance are you seeing or do you expect to see from implementing supply chain segmentation? (For those reporting large or very large positive impact) Base: 1,601 companies

The companies in our survey view supply chain segmentation as one of the most important supply chain capabilities. A quarter consider it to be a high or top priority, and 40% have already implemented it at least partially (see Exhibit 20). For Digital Champions, that number jumps dramatically — nearly three-quarters (73%) have already implemented supply chain segmentation. They're also reporting significantly greater benefits. Around two-thirds (64%) say that they are seeing a large or very large positive impact, compared to 20% of companies overall (see Exhibit 21). That's in line with our experience, which suggests that companies need to have sophisticated supply chain strategies in place to effectively implement segmentation.

Supply chain segmentation is closely linked to cost-to-serve optimisation. Cost-to-serve calculates the total cost of all of the activities and costs incurred to fulfil customer demand for a product, not just in the production or transportation stages but throughout the entire supply chain journey. To get this right, it's important to allocate all costs accurately to the different activities in the supply chain and also know the cost consequences of different ways of order processing. Optimisation then happens when companies are able to adjust their way of working flexibly, in line with customer needs, and to strike the right balance between costs, margins, service levels and inventories. Half of Digital Champions see cost-to-serve optimisation as a top or high priority, and more than 60% have already implemented cost-to-serve optimisation — twice as many compared to all companies (34%).



Technology viewpoint: Using AI

At the operational level, a digital supply chain twin can be a useful way to drive segmentation. By simulating all aspects of the supply chain, a digital twin makes it possible for companies to dynamically respond to customer demands at the transaction level. For example, spare parts for a broken machine can be prioritised and shipped overnight for a customer who usually doesn't get priority service, while lubricants for the same machine and customer are shipped once a month.

In order to design segmented supply chains across different channels that can respond to varied customer requirements, companies can also leverage AI-based diagnostic tools that provide benchmarks for demand, inventory, supply and delivery. These then serve as a basis for future optimisation based on transactional data.

Company snapshot
TRUMPF

TRUMPF manufactures machine tools, laser technology and electronics for industrial applications. The family-owned company's mission is to further develop and digitally connect production technology to make it efficient, precise and future-proof.

Driving innovative business models through next-level supply chains

TRUMPF has long been an early advocate of new technologies — from its introduction of industrial lasers back in the 1970s to its current innovations in metal-based additive manufacturing (3D printing) and laser systems that enable next generation chip lithography (extreme ultraviolet). This commitment to digitalisation and innovation is also reflected in the ways the company has automated many aspects of its supply chain, including transforming the order and production process.

There are around 31m different variations of the tools that TRUMPF's customers in the metals industry order for their stamping machines when new products call for different shapes or old tools wear out. Rather than keeping so many variants in stock, TRUMPF manufactures them on demand at its Gerlingen, Germany, site.

Back in 2009, TRUMPF began allowing customers to log in and initiate the production process digitally. In 2015, the company started inscribing a unique data matrix product code on every part — similar to a 3D QR code — using TRUMPF's laser marking machines to make reordering and identification easier. And since 2017, customers have been able to photograph the code with the TRUMPF service app and place an order simply by uploading the image.

Each order triggers the company's semi-autonomous production system, which independently determines the priority of each order and automatically assigns it to the right machine with open capacity — under the surveillance of the plant employees. These enhancements have significantly improved supply chain performance. Compared with 2009, the company has reduced its throughput time from four days to just four hours, doubling capacity and at the same time increasing the service level from 40% to 97%. Orders placed by two in the afternoon are produced and shipped the same day. The goal: provide service to industrial customers for make-to-order parts comparable (or even superior) to what Amazon offers its shoppers.

TRUMPF's innovations are increasing transparency: the data matrix product code TRUMPF inscribes on each part enables end-to-end traceability. And they are driving enhanced after-service performance as well by making it possible to monitor a tool's usage remotely. When specific characteristics and unique information on tools and other parts are combined within the virtual twin of the machine, service personnel can quickly determine configurations and life cycle information to increase the availability of TRUMPF products. Further, the field data is used to monitor product quality and improve future product releases.

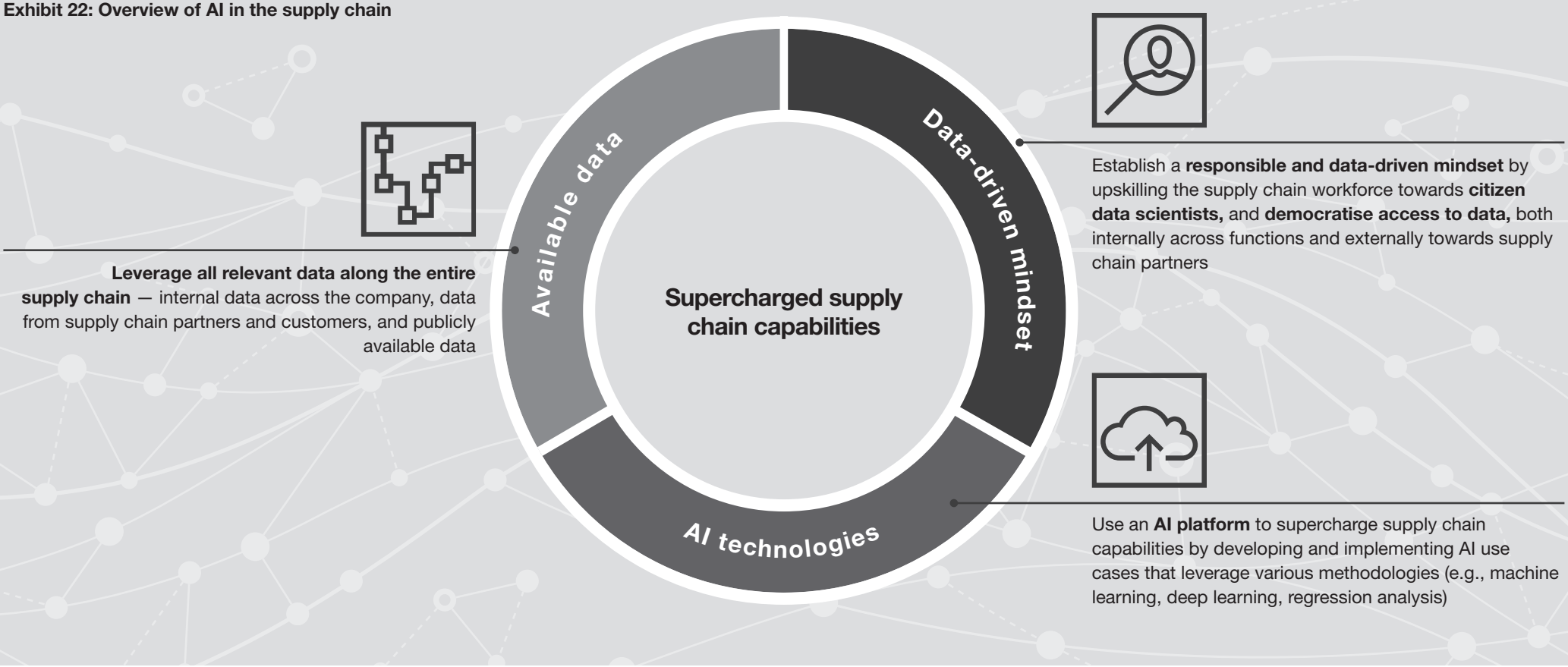
A strong commitment to digitalisation hasn't just improved the company's production processes and enhanced transparency and customer service; it has also opened up new business models and lines of business. TRUMPF now sells integrated, smart factory solutions to its customers and helps them design connected production lines, including MES systems and real-time material tracking solutions.

AI-driven supply chain management

Artificial intelligence is accelerating supply chain improvements and will become the new norm

Supply chain ecosystems are generating vast quantities of data. Although some of this data is generated internally, even more originates from suppliers, customers or service providers, such as transport carriers. Some is even drawn completely from public sources.

Exhibit 22: Overview of AI in the supply chain



When companies can effectively take advantage of these diverse data streams and share data with their supply chain partners, they can reap significant benefits. To get there, though, they need to integrate the data into a semantic supply chain data network (see Exhibit 22). This means to define the semantic — literally the meaning and relationships — of every node within the network and to store it in a machine-readable way. 'Knowledge graphs' are a way to achieve this, and with the rise of graph databases, companies are now able to store these in a natural way — as a network. For example, each supplier is clearly defined once with all its attributes and marked semantically. Based on this definition, data from different sources can be merged automatically. Inconsistencies and redundancies between the data can also be detected and resolved, which significantly improves data quality and accuracy.

Once this foundational semantic data network has been established, companies can use it to leverage the data along the value chain. By digging deeper, they gain significant benefits in transparency, quality and cost. Our research found that Digital Champions in particular are using AI to turbocharge selected key supply chain capabilities.

Having access to the right data is the first step to accelerating supply chain improvements. The good news: Many companies are already making use of a wide variety of different types of data to support their supply chain decisions.

This is particularly true when it comes to operations data around components and materials or manufacturing and quality data, such as equipment monitoring. Both types of data are used in decision-making in the supply chain by nearly half of companies overall (47%).

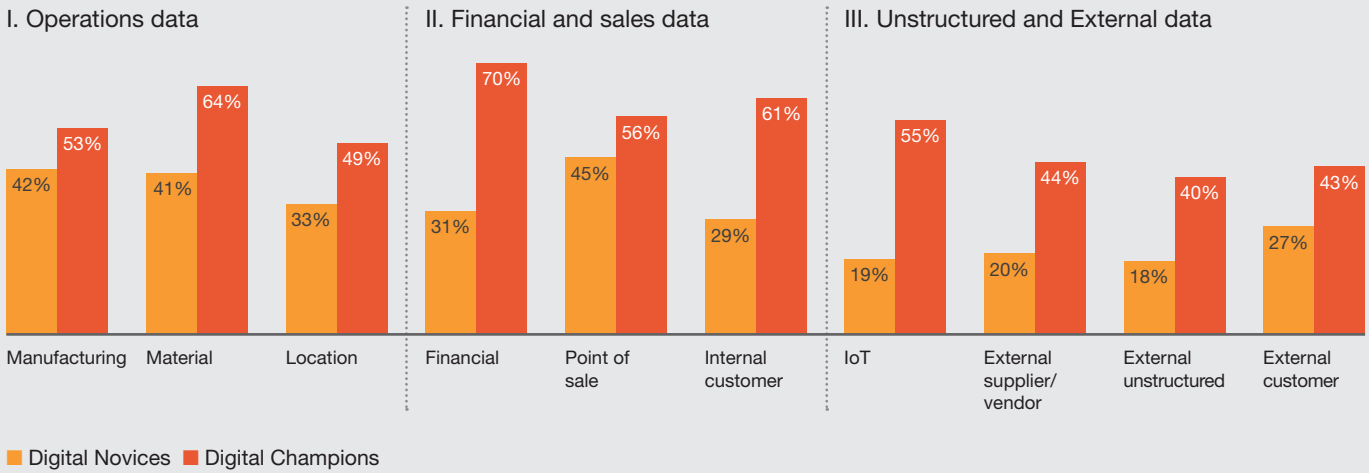
Digital Champions are making use of this type of data too, but they're also taking particularly strong advantage of financial data as a source for supply chain decisions, with 70% saying it supports decision-making. Many Digital Champions (from 40% to 55%) are making the most of various types of external data (see Exhibit 23), including external data from customers, suppliers and vendors, and unstructured external data, such as information from news feeds and social media.

Our study shows that Digital Novices are still on their way to fully leveraging the potential of financial and sales data, and that only a limited number are currently using unstructured and external data.

The potential value of data can be enhanced still further when companies apply AI methods such as machine learning or deep learning. AI can significantly enhance all of the key capabilities discussed here: closed-loop and integrated planning, transparency, smart logistics, segmentation and customer/supplier integration.

Planning that takes advantage of AI-based tools can reduce forecasting errors and increase accuracy. For example, data modelling can assist companies with over- or under-forecasting resulting in inaccurate inventories — a chronic problem in supply chains that use past data to forecast demand. By recording more forward-looking and a wider range of types of data on customer behaviour in real-time and using machine learning to analyse patterns, forecasting can become more predictive. This methodology, which is called demand sensing, also helps reduce forecasting risks while enabling forecasting on more granular levels (e.g., individual product, per hour, per store). The result: higher customer satisfaction through improved product availability at the right time and the right location.

Exhibit 23: How companies leverage different data types



To what extent does your company use the following types of data to make supply chain decisions? (For those reporting considerable or extensive use) Base: 1,601 companies

70%

of Digital Champions use financial data to make supply chain decisions

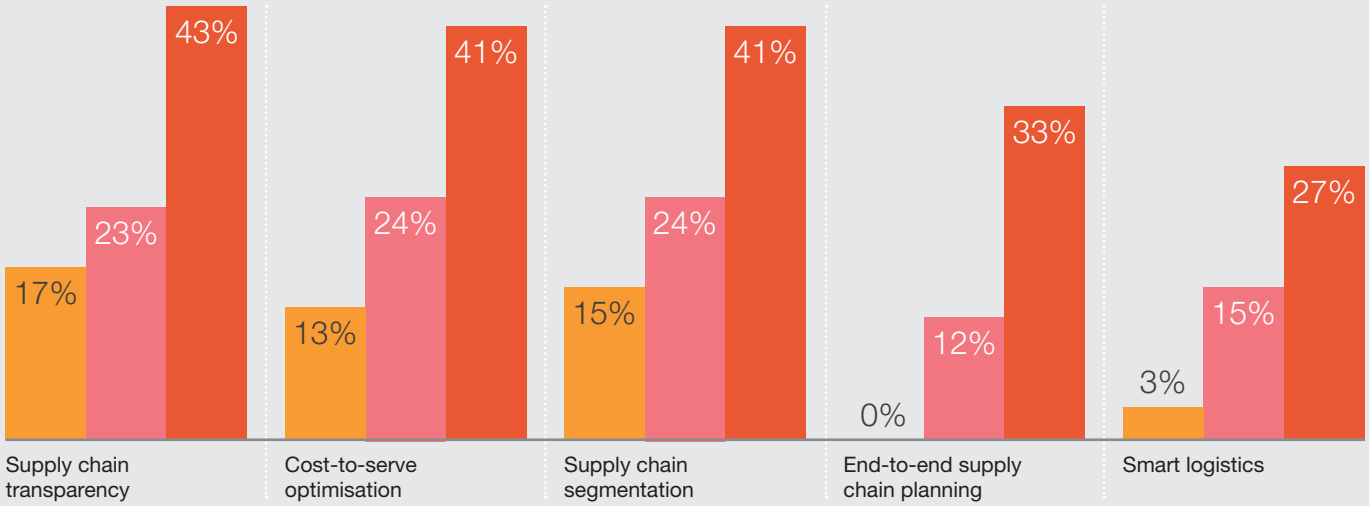
AI also increases transparency by automatically detecting patterns within the data stream, which helps reduce the noise and focus attention onto the relevant outliers where action is needed by providing proactive alerts to users. For example, AI can help to dynamically predict the estimated time of arrival (ETA) of shipments by considering all information about and around a shipment, such as real-time GPS signals of the shipment, weather, traffic and port congestion information. This helps increase the precision of the ETAs that are communicated to receivers, giving them an opportunity to adjust their operations (e.g., in a warehouse) if goods or materials will be arriving earlier or later than planned. These systems also capture real lead times for all relevant routes so that companies can use actual lead times for their planning efforts and manage their inventories more realistically.

In the case of logistics, AI is being used across a range of areas, from helping optimise the use of warehouse capacity to implementing intelligent traffic systems to speed up deliveries. One example is chatbots, where natural language processing is now being used to enhance communication between supply chain partners, for example by making it possible for a supplier to instantly check which specific part is needed for shipment, rather than needing to call a customer service representative. AI solutions also make possible new forms of customer segmentation that respond dynamically to market conditions. And by detecting anomalies and inconsistencies in supplier quality and delivery times, AI can help enhance supplier integration too.

Companies across all maturity stages see the potential of AI and have begun investing in its use to turbocharge their capabilities — indeed, 70% of all companies surveyed are using AI methods such as machine learning and deep learning in at least one area. Digital Champions are far ahead. On average, they are two to three times as likely to be harnessing AI compared to Digital Novices (see Exhibit 24).

All of this only becomes possible if companies embrace a cultural shift and establish a new data-driven mindset. By upskilling employees to citizen data scientists, companies can enable staff in various roles to use a data science toolkit. For example, a demand planner could use such tools to predict demand behaviour and to visualise it with high information density. By democratising the data for internal and external use, companies can unleash new analytical capabilities, such as demand sensing.

Exhibit 24: Champions outpace others in using AI to boost capabilities



For which capabilities are you applying AI, machine learning or deep learning? (For those reporting 'yes') Base: 1,601 companies

Technology viewpoint: Getting the most of AI — responsibly

As we have shown, AI brings enormous potential to enhance supply chain performance. But with great potential comes great risk. Are your algorithms making decisions that align with your values? Do customers trust you with their data? How is your brand affected if you can't explain how AI systems work? It's critical to anticipate problems and future-proof your systems so that you can fully realise AI's potential. It's a responsibility that will need to be taken on not just by IT specialists but by staff throughout the business. In recent research, we found that only a quarter of the businesses using or trialling AI solutions definitely prioritise a consideration of the ethical implications of an AI solution before investing in it.[4] When implementing AI, we believe companies should consider five key areas: governance; interpretability and explainability; bias and fairness; robustness and security; and ethics and regulation.

4 PwC, *A Practical Guide to Responsible Artificial Intelligence,* 2019: pwc.com/rai

Technology viewpoint: Interest in AI grows

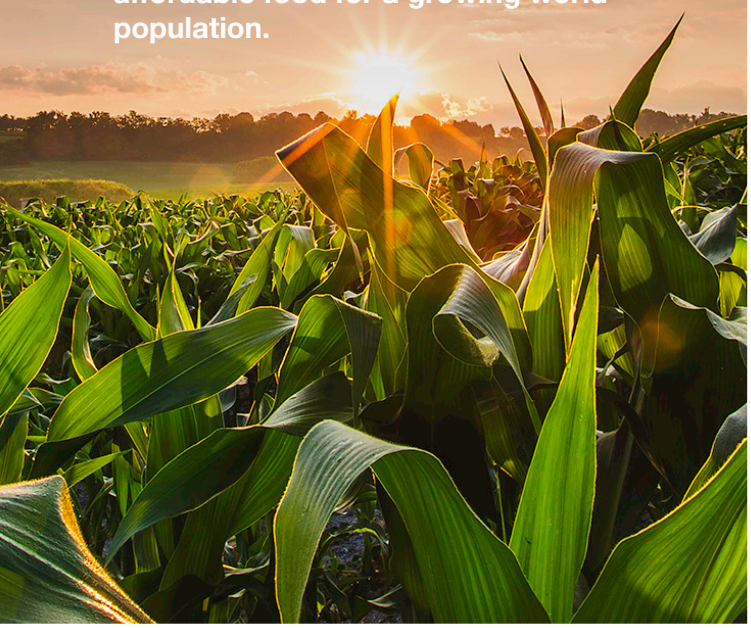
Overall, only about one in five companies (22%) have already implemented an AI and advanced analytics platform. Interest is growing, though, and 38% have begun pilots in this area, while another 22% plan to do so within the next five years. From a technology perspective, one of the key questions is whether to build an AI and advanced analytics platform on-premise or in the cloud. Even hybrid scenarios, where parts of the workloads are on-premise and parts are based on cloud solutions, are possible.

Digital Champions seem to already have answered some of those questions. Their greater commitment to AI is reflected in a significantly higher level of implementation — 63% have already implemented an AI and advanced-analytics platform, and another 24% are piloting such software.

Company snapshot

Bayer Crop Science Division

Crop Science is a division of Bayer AG, a global life science company with a more than 150-year history and core competencies in the areas of healthcare and agriculture. The company's products and services in seeds, crop protection, digital farming and nonagricultural pest control are designed to shape agriculture to sustainably grow healthy, safe and affordable food for a growing world population.



Using data and AI to drive a connected supply chain and better customer experience

The Crop Science division uses digital technologies within its supply chain as key enablers for its customers' business transformation. While in the past supply chain optimisation focussed largely on cost improvements, Bayer's approach is increasingly driven by the ambition to improve the customer experience. Savvy use of data analytics and AI are an integral part of that strategy.

Bayer's use of digital tools is designed to empower its people to deliver better solutions and services. The organisation makes it happen by connecting four supply chain pillars — plan, source, make and deliver — to provide a consistent customer experience. Connected ordering and e-commerce tools are driving excellence in planning and demand sensing, and provide a 360-degree view of the end-to-end supply chain. The goal is to provide access to all information generated along the entire supply chain, supporting every employee to effectively and proactively solve problems in a customer-centric way.

The Crop Science division has also begun to develop a range of advanced data analytics and AI tools to help employees in many different roles make more informed, objective and fast decisions. Instead of relying on experience or gut instinct, employees now have access to data-driven tools that provide recommendations to support decision-making. Machine learning and AI, for example, help the company proactively sense demand — a must in a very volatile business with long lead times in production.

Agricultural challenges — specifically producing more with less in line with the company's sustainability commitments — require new capabilities for supply chain management (for example, the ability to integrate real-time climate and field data along the whole supply chain, all the way down to the farmer). In response to the trend towards outcome-based business models, respective data models are also becoming more predictive and/or prescriptive rather than reactive.

Bayer wants to empower every employee to make use of data analytics. To get there, the company has focussed on promoting a digital mindset, which includes openness, a curiosity about new ways of working and collaborating, and trust in the accuracy of the data and appropriateness of the algorithms. As new digital tools have been developed, the enterprise has ensured that data availability and quality are validated by the appropriate decision-maker and that the right people are involved from the outset. As a result, employees are increasingly not only using existing tools, they are proactively requesting new solutions.

Bayer understands that the digital transformation is a journey and cannot be achieved all at once. As part of developing its digital mindset, the company is actively reaching out beyond its internal organisation. The vision is a robust innovation ecosystem in which the company co-creates with external partners, such as startups and universities, to constantly drive new supply chain solutions and set new standards for outstanding customer experience and operational efficiency.

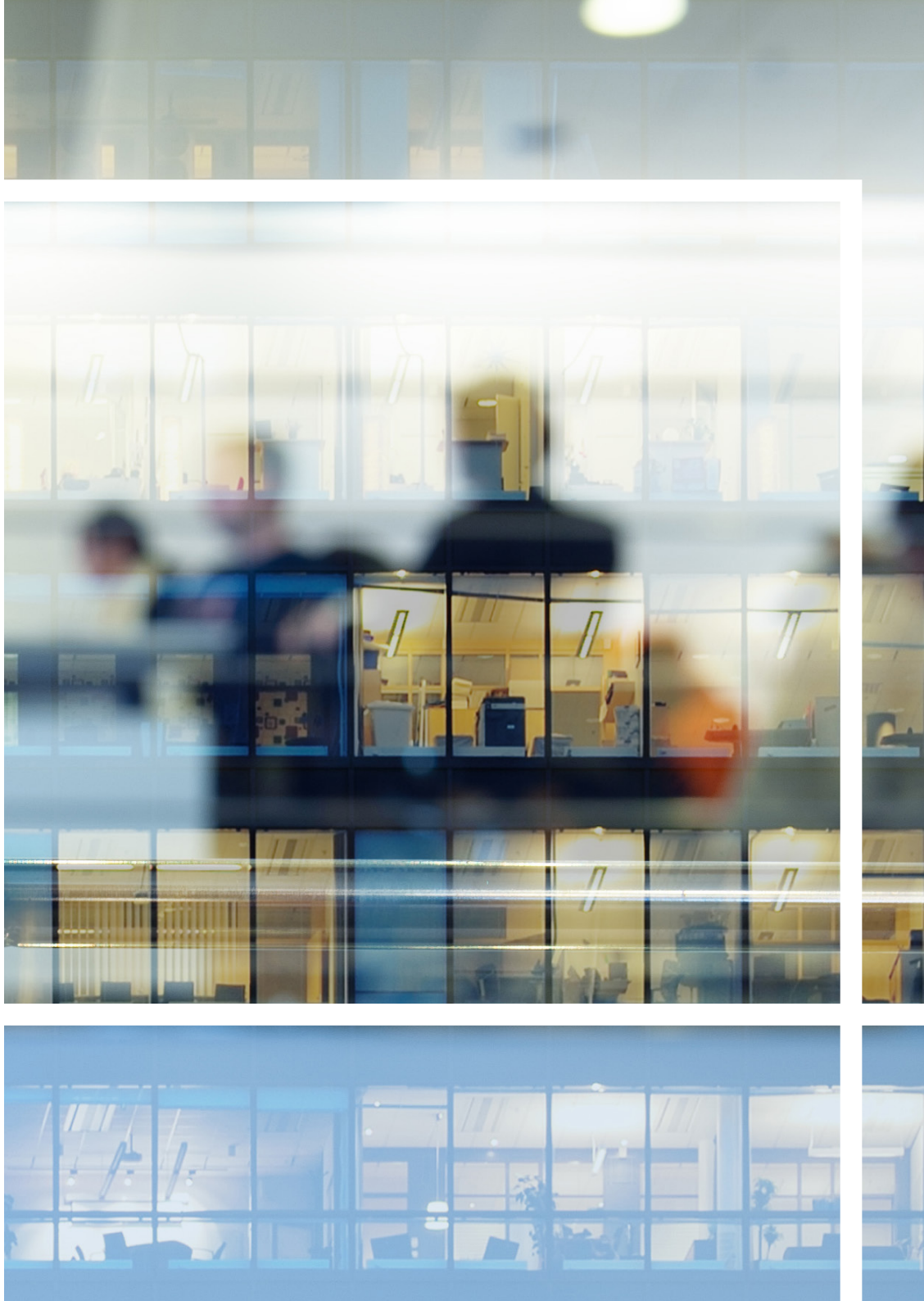
Operating model development

Mastering tomorrow's supply chain challenges through the next-level supply chain organisation and capabilities

In this report, we have emphasised the importance of advanced supply chain capabilities. Now it's time to consider what companies need to do to implement them. That includes making the organisational changes needed to master the diverse challenges they are facing as they manage their supply chains.

Top three supply chain challenges for companies overall:

- Managing profitability
- Improving volume flexibility
- Increasing supply chain visibility and traceability



When we asked companies to tell us which three hurdles were most pressing, their answers were wide-ranging, with 'managing profitability' at the top of the list. That's not surprising given the challenging environments in which most companies are operating, with supply chain costs increasing, an economic downturn looking likely, and customers becoming ever more cost-conscious and demanding extra services.

The second-biggest challenge reported by survey respondents was 'improving volume flexibility.' Companies want to be able to quickly scale supply according to very volatile, and increasingly differentiated, customer demand. To achieve that, companies need to become masters of supply chain orchestration, which allows them to quickly make changes while operating an asset-light footprint.

Next on their list was 'increasing supply chain visibility and traceability' — a prerequisite for managing inventory levels, improving sustainability and managing overall costs — along with 'managing supply chain security and risks.'

Digital Champions have already made significant progress towards connected supply chain ecosystems. While they still face several obstacles, these differ significantly from those of companies with lower supply chain maturity. 'Circularity and sustainability' has moved up the Champions' agenda to become their most significant hurdle. Given their greater use of a range of supply chain technologies and data, it's not surprising that technological maturity and the reliability of master data is a key concern. And their high level of implementation means they are now scaling across the enterprise rather than remaining at pilot level — with all the challenges that brings.

When it comes to specific priorities for organisational development, a few key strategies can help companies on their transformational journey towards a connected and autonomous supply chain ecosystem (see Exhibit 25). These centre around two key areas: driving advanced capabilities and innovating the organisation setup.

Exhibit 25: Building blocks for transformation towards a connected and autonomous ecosystem

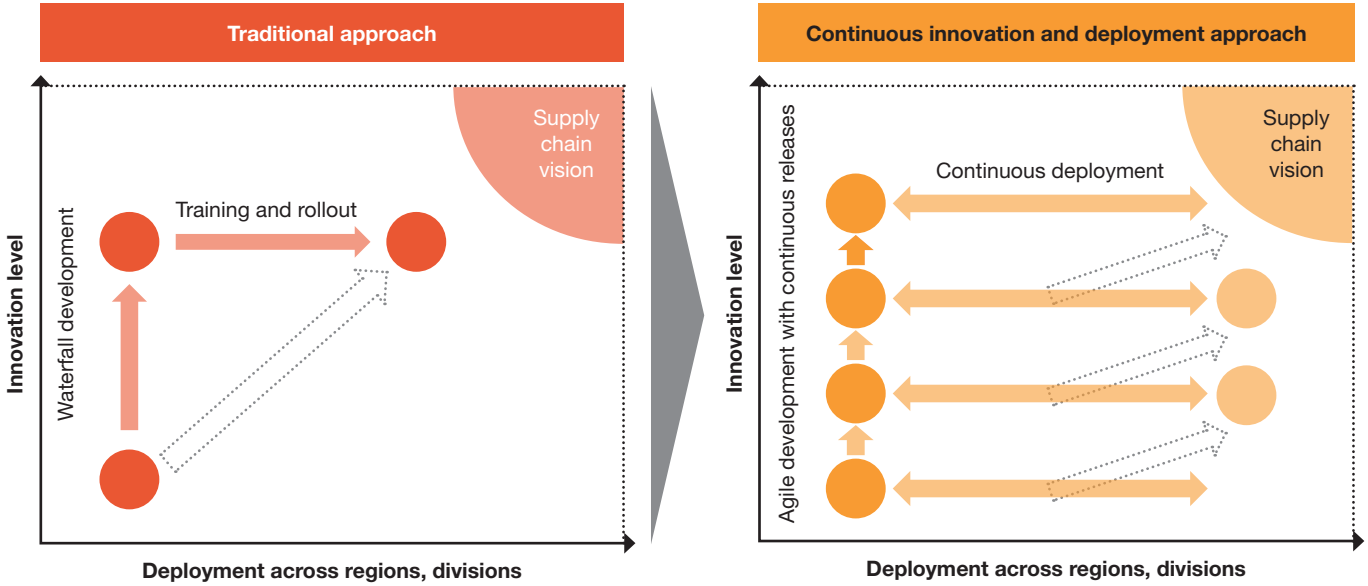
Digital Champions' biggest supply chain challenge is

circularity and sustainability

The limits of the possible are expanding, with technologies becoming more sophisticated. But at the same time, for many companies, market environments are becoming ever-more challenging. Coping with constant change will require developing an organisation that is able to continuously evolve and improve. One important way to speed up implementation of advanced supply chain capabilities is to establish a culture of continuous innovation and cross-functional collaboration while always keeping the end-to-end value chain in mind. Begin with the needs of the end customer, but also consider factories, warehouses and back-end technologies. We have observed several key principles that successful companies are using to help them get there.

Making innovation happen often means paying particular attention to changing elements of the company culture and ways of working, such as encouraging employees to develop their own ideas and work together across functions. In our experience, small, agile and cross-functional team structures can be extremely effective in gaining speed and effectiveness. By developing supply chain communities, companies can focus on solving their most pressing problems quickly. Digital Champions in particular rate cross-functional community and stakeholder management as a top priority for their supply chain organisational development, although it is viewed as important by companies across the board.

Exhibit 26: Innovation through continuous development and deployment approach



This setup is often coupled with the establishment of centres of excellence, which maintain a strong link to local teams to ensure best practices or continuous improvements are leveraged, and supply chain innovations and improvements can be effectively realised. CoEs often focus on industrialising the deployment and scaling of new solutions to the wider organisation. They actively support requests from the organisation and push out new solutions.

In our view, companies can achieve progress most quickly when they develop a continuous development and deployment model (see Exhibit 26). That means defining which capabilities need improvement and then working to enhance these in parallel in a staged process. This often includes running several pilots, which are progressively expanded across divisions or geographic regions. To do this, many companies find it helpful to use agile development

Digital Champions' top organisational priority is

attracting digital talent

methods, which help develop new ideas into 'minimum viable products' that can be used to drive new supply chain solutions. User-centric design approaches are gaining significant traction too. By building up a number of capabilities in this way, companies can benefit from lessons learned, identify synergies across projects and correct course quickly when needed.

This transformation needs to be people-driven. By maximising talent, executives can build a tech-enabled workforce that meets future business needs and keeps pace with looming uncertainties. Upskilling is critical — it's attractive to potential candidates, builds enthusiasm and confidence among the existing workforce, and develops future leaders who are key in transitioning to a digital supply chain. It involves training employees to get the most out of digital enablers and fostering an environment of citizen-led innovation that is smartly directed towards business-led imperatives.

Enhancing training capabilities to upskill and digitally transform the supply chain workforce is seen as a priority by companies across the sample, although Digital Novices are lagging somewhat behind. Digital Champions often go one step further and recruit external supply chain experts: their first organisational priority is attracting digital talent, such as data scientists needed to interpret advanced analytics or AI specialists who can devise new ways to utilise and interpret unstructured data.

Another important element to driving advanced supply chain capabilities is establishing the right technology backbone, which can bring processes, IT and advanced analytics together with the rest of the business and make them real enablers for innovation. The first step is integrating the IT function with the supply chain. Digital Novices and Digital Followers are still putting most of their attention here. That makes sense, as it's important to get the basics down before moving forward. We believe that an important part of a strong IT foundation is developing a state-of-the art supply chain IT architecture. In our view, this is most effective when it is based on cloud platforms with an application programming interface (API) and microservice-centric architecture, employs open standards, and ensures scalability. Microservice-centric architecture is based on developing small and autonomous components that interact with each other through defined interfaces. Many Digital Champions have already mastered this, so their priorities have shifted to the next stage: embedding advanced analytics into their supply chain functions. This makes possible their diverse uses of AI.

The final piece of the puzzle is collaboration with external partners in a wider ecosystem. For companies overall, actively managing the supply chain partner and innovation network (including collaboration with startups) is a top organisational priority — although again, Digital Novices are somewhat behind. We've already shown how valuable integrating suppliers and customers can be in areas like planning and logistics. By working with a broader ecosystem that includes startups alongside these traditional partners, companies can also draw on the advantages of stable organisational structures while benefitting from collaborations that help speed up innovation and enhance organisational agility.

The only way to operate and thrive in this new normal is for supply chains to become more connected, smarter and faster — today more than ever before.

Company snapshot
IKEA

IKEA offers well-designed, functional and affordable high-quality home furnishings made with care for people and the environment. There are several companies with different owners working under the IKEA brand, all sharing the same vision: 'To create a better everyday life for the many people.'

Connecting local and global supply chain experts from across functions to drive innovation

IKEA has a strong tradition of supply chain excellence — its pioneering 'flat pack' approach to shipping furniture is legendary. In recent years, IKEA has become increasingly global, and customer behaviour has changed radically. To respond to these changes, relying on existing solutions isn't enough, so driving innovation in its supply chain is a priority.

IKEA is making sure that these innovative strategies are embraced globally and aligned cross-functionally, with a common agenda and shared focus areas. To achieve that, IKEA has built a modern way of working, in which teams of experts collaborate across functional areas and geographies to drive innovation through six key development areas. These six development networks (DNs) covering the supply chain — from production logistics and packaging to fulfilment of services — define innovation priorities.

Strong governance ensures three key elements are present:

- A combined development plan that summarises the status quo and articulates a clear vision for the future
- A comprehensive road map detailing priority initiatives, avoiding repetition and leveraging synergies across the DNs
- Clear leadership, including two heads for each DN and their executive-management sponsors, who together agree on priorities and define ambition levels in specific areas.

IKEA uses its DNs to share knowledge and insights from across various IKEA organisations. By taking this networked approach, IKEA is able to both foster new ideas from the many people across the IKEA ecosystem and ensure that the ideas can be implemented effectively. For example, there are not many solutions on the market for robot picking of heavy products — a real need for IKEA's operations, which must cope with a high number of heavy and oddly sized products. Working together with external partners, IKEA is developing robotic picking solutions for better ergonomics and higher efficiency in the customer fulfilment process.

IKEA's culture and future vision play an important role in driving innovation efforts. Employees are challenged to think differently and be cost conscious in everything they do. So, for example, a strong focus on packaging, material choice and utilisation at the design phase contributes to an effective and efficient supply chain that generates less waste, helping the company to create affordable and sustainable products. As part of this commitment, IKEA aims to decarbonise transportation. This can only be done through innovative solutions and close cooperation with partners. IKEA has teamed up with CMA CGM, the Port of Rotterdam and an initiative called the GoodShipping Program to pilot the use of biofuels on container ships sailing from Rotterdam.

IKEA has also embarked on a transformational journey to become a circular enterprise. The company believes that customer expectations in this area will continue to grow and sees a competitive advantage through an integrated value chain. That means building entirely new capabilities — and potentially new business models. Tomorrow's IKEA may be able to reuse materials and resell or rent products. IKEA believes its networked structure and ability to work with external partners will give it a head start on addressing infrastructure challenges and other complexities that may emerge. That, in turn, could drive truly disruptive innovation — tomorrow's flat pack.

About the survey

This PwC report is based on quantitative research consisting of interviews conducted between October 2019 and January 2020 with 1,601 senior executives from companies in 33 territories across EMEA, the Americas and APAC. Global survey results were weighted by territory GDP to provide a balanced view (see Exhibit 27).

Exhibit 27: More than 33 territories across the globe participated in this year's study

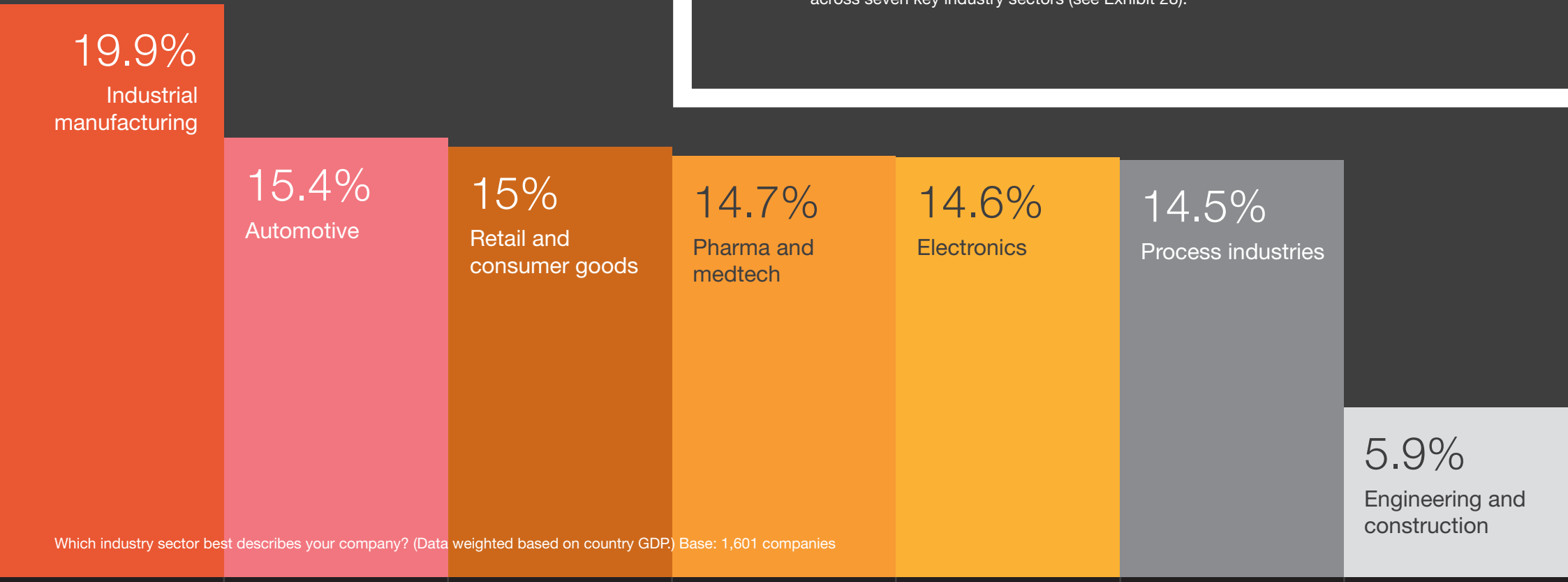
Please confirm the territory in which you are located. Base: 1,601 companies

- Australia
- Austria
- Bangladesh
- Belgium
- Brazil
- Canada
- China
- Denmark
- Finland
- France
- Germany
- India
- Indonesia
- Italy
- Japan
- Mexico
- Middle East*
- Netherlands
- Poland
- Portugal
- Singapore
- South Africa
- Spain
- Sweden
- Switzerland
- Turkey
- UK
- US

* Multiple territories included

The majority of quantitative survey participants were senior executives with top-level responsibility in their company for operations and supply chain. Companies were surveyed across seven key industry sectors (see Exhibit 28).

Exhibit 28: Industry overview



Which industry sector best describes your company? (Data weighted based on country GDP.) Base: 1,601 companies

Following a similar methodology to that used in our *Global Digital Operations Study 2018*, we developed an index that ranks companies by supply chain maturity (see Exhibit 29). Based on their scores, we grouped the companies into one of four categories: Digital Champions, Digital Innovators, Digital Followers and Digital Novices. These terms in this report refer specifically to the interviewed companies' level of supply chain maturity.

To measure where particular companies fit in these groupings, we allocated a total of 100 points to different levels of digital capabilities and advances — a maximum of 25 points for the implementation of advanced supply chain capabilities, 10 points for the use of AI to accelerate these supply chain capabilities, 25 points for the implementation of software-based supply chain technologies, 15 points for overall performance impacts, and 25 points for demonstrated revenue (10) and cost (15) impacts. The index is cumulative, so the more integrated a business and the more broadly it implements advanced supply chain capabilities, the higher the index value.

PwC also supplemented this research with in-depth interviews with executives from companies that are leading the way in particular aspects of the supply chain. Those interviews led to the company profiles included in this report.

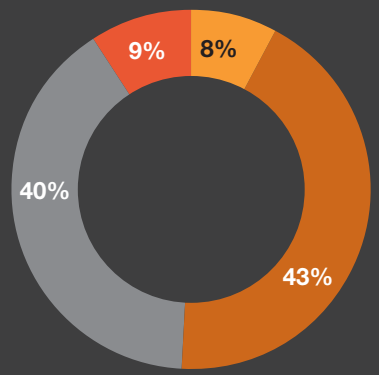
Exhibit 29: Digital supply chain maturity index

Point range

- 75–100 Digital Champions
- 50–74 Digital Innovators
- 25–49 Digital Followers
- 0–24 Digital Novices

Supply chain maturity levels

- Digital Champions
- Digital Innovators
- Digital Followers
- Digital Novices



Contacts

Authors

Stefan Schrauf
PwC Germany
+49-151-461-23326
stefan.schrauf@pwc.com

Reinhard Geissbauer
PwC Germany
+49-170-939-1263
reinhard.geissbauer@pwc.com

Judith Schneider
PwC Germany
+49-151-461-23322
judith.schneider@pwc.com

Mark Hermans
PwC US
+1-571-215-5314
mark.hermans@pwc.com

Global Industrial Manufacturing and Automotive Industry Leader

Anil Khurana
+1-734-773-8902
anil.x.khurana@pwc.com

PwC Australia

Peter Burns
+61-2-8266-4726
peter.burns@pwc.com

Varya Davidson
+61-478-303-103
varya.davidson@pwc.com

PwC Austria

Agatha Kalandra
+43-1-501-88-2965
agatha.kalandra@pwc.com

Wolfgang Lang
+43-664-2258-868
wolfgang.lang@pwc.com

PwC Belgium

Peter Vermeire
+32-9-268-8064
peter.vermeire@pwc.com

PwC Brazil

Rodrigo Damiano
+55-11-3674-2701
rodrigo.damiano@pwc.com

PwC Canada

Lino Casalino
+1-416-815-5263
lino.casalino@pwc.com

Louis Enaux
+1-514-205-5368
louis.r.enaux@pwc.com

PwC China

Grace Tang
+86-10-6533-2999
grace.tang@cn.pwc.com

PwC Denmark

Jesper Vedsø
+45-3945-9144
jesper.vedso@pwc.com

PwC Finland

Markus Kärki
+358-40-7218-102
markus.karki@pwc.com

Pekka Pesonen
+358-400-2609-67
pekka.v.pesonen@pwc.com

PwC France

Isabelle Carradine Pinto
+33-01-5657-8896
isabelle.carradine@pwc.com

Vincent Espie
+33-621-196-580
vincent.espie@pwc.com

PwC Germany

Stefan Schrauf
+49-151-461-23326
stefan.schrauf@pwc.com

Reinhard Geissbauer
+49-170-939-1263
reinhard.geissbauer@pwc.com

Reinhard Vocke
+49-172-202-2336
reinhard.vocke@strategyand.de.pwc.com

Judith Schneider
+49-151-461-23322
judith.schneider@pwc.com

PwC India

Sudipta Ghosh
+91-22-6669-1311
sudipta.ghosh@pwc.com

PwC Italy

Gabriele Caragnano
+39-02-6672-0445
gabriele.caragnano@it.pwc.com

PwC Japan

Shinsuke Suzuki
+81-080-4653-6060
shinsuke.suzuki@pwc.com

Daimi Tanaka
+81-80-7540-5245
daimi.dt.tanaka@pwc.com

PwC Mexico

Carlos Zegarra Urioste
+52-55-5263-2386
carlos.zegarra@pwc.com

PwC Middle East

Bashar El-Jawhari
+966-11-2110-400
bashar.el-jawhari@pwc.com

Anil Pandey
+971-4436-3000
anil.pandey@pwc.com

PwC Netherlands

Jaap-Willem Bijsterbosch
+31-88-7922-904
jaap-willem.bijsterbosch@pwc.com

Veronique Roos
+31-88-7926-546
veronique.roos@pwc.com

PwC Poland

Mariusz Dziurdzia
+48-502-184-117
mariusz.dziurdzia@pwc.com

PwC Portugal

Claudia Rocha
+351-918-621-261
claudia.rocha@pwc.com

Antonio Rodrigues
+351-917-614-868
antonio.rodrigues@pwc.com

PwC South Africa

Pieter Theron
+27-83-447-2394
pieter.l.theron@pwc.com

PwC South East Asia

Marc Philipp
+65-6236-4008
marc.philipp@pwc.com

PwC Spain

Joaquín Blanco Diez
+34-679-428-621
joaquin.blanco.diez@pwc.com

PwC Sweden

Tobias Kihlén
+46-725-84-98-43
tobias.kihlen@pwc.com

Martin Waldén
+46-761-0068-37
martin.walden@pwc.com

PwC Switzerland

Christoph Wellinger
+41-58-792-1299
christoph.wellinger@pwc.com

PwC Turkey

Tolga Baloglu
+90-533-455-4816
tolga.baloglu@pwc.com

Mehmet Kurtoglu
+90-530-461-1193
mehmet.kurtoglu@pwc.com

PwC UK

Mark Couttie
+44-78-2432-8012
mark.couttie@pwc.com

Michael Hawdon
+44-75-9561-0077
michael.hawdon@pwc.com

PwC US

Mark Hermans
+1-571-215-5314
mark.hermans@pwc.com

Brian Houck
+1-773-960-4148
brian.m.houck@pwc.com

Anil Khurana
+1-734-773-8902
anil.x.khurana@pwc.com

Todd Knapp
+1-917-375-3987
todd.m.knapp@pwc.com

Steve Pillsbury
+1-312-298-2257
steve.pillsbury@pwc.com

Acknowledgements

We would like to thank the following executives who shared their connected supply chain experiences with us for this report.

Advantest Corp.

Richard Junger
VP of Operations

Andreas Bayha
Senior Director Supply Chain

Bayer Crop Science Division

David Betge
VP of Supply Chain Design and Excellence

Prasad Juvekar
Head of Supply Chain Digital Transformation and Innovation

Stefan Troester
Head of Supply Chain Simulation and Analytics

Continental AG

Jan Axt
Head of Automotive Supply Chain Management and Strategy and Innovation

IKEA Supply AG

Claudio Marconi
Head of Supply Chain Development

Olof Orstadius
Logistics Developer

Nokia Corp.

Christian Schewtschenko
Head of Supply Chain and Procurement Strategy

TRUMPF GmbH & Co. KG

Philipp Berttram
Head of Corporate Operations (production, logistics, quality)

© 2020 PwC. All rights reserved. PwC refers to the PwC network and/or one or more of its member firms, each of which is a separate legal entity.
Please see www.pwc.com/structure for further details.