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Industry 4.0: How digitization makes the supply chain more efficient, agile, and customer-focused

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Published: September 7, 2016

Executive summary

If the vision of Industry 4.0 is to be realized, most enterprise processes must become more digitized. A critical element will be the evolution of traditional supply chains toward a connected, smart, and highly efficient supply chain ecosystem.

The supply chain today is a series of largely discrete, siloed steps taken through marketing, product development, manufacturing, and distribution, and finally into the hands of the customer. Digitization brings down those walls, and the chain becomes a completely integrated ecosystem that is fully transparent to all the players involved — from the suppliers of raw materials, components, and parts, to the transporters of those supplies and finished goods, and finally to the customers demanding fulfillment.

This network will depend on a number of key technologies: integrated planning and execution systems, logistics visibility, autonomous logistics, smart procurement and warehousing, spare parts management, and advanced analytics. The result will enable companies to react to disruptions in the supply chain, and even anticipate them, by fully modeling the network, creating “what-if” scenarios, and adjusting the supply chain in real time as conditions change.

Once built — and the components are starting to be developed today — the digital supply “network” will offer a new degree of resiliency and responsiveness enabling companies that get there first to beat the competition in the effort to provide customers with the most efficient and transparent service delivery.

The supply chain ecosystem

At most companies, products are delivered to customers through a very standardized process. Marketing analyzes customer demand and tries to predict sales for the coming period. With that information, manufacturing orders raw materials, components, and parts for the anticipated capacity. Distribution accounts for upcoming changes in the amount of product coming down the pipeline, and customers are told when to expect shipment. If all goes well, the gap between demand and supply at every point in the system is small.

This rarely happens, of course. Forecasting remains an inexact science, and the data it depends on can be inconsistent and incomplete. Too often, manufacturing operates independently from marketing, from customers, and from suppliers and other partners. Lack of transparency means that none of the links in the supply chain really understand what any other link is doing, or needs. Inevitably, it seems, the orderly flow from marketing to customer is disrupted somewhere.

Over the course of the next few years, this will all start to change. This will not be because we will have fewer disruptive weather events, flat tires, or outsourcing snafus. No, what is changing is the supply chain itself. With the advent of the digital supply chain, silos will dissolve and every link will have full visibility into the needs and challenges of the others. Supply and demand signals will originate at any point and travel immediately throughout the network. Low levels of a critical raw material, the shutdown of a major plant, a sudden increase in customer demand — all such information will be visible throughout the system, in real time. That in turn will allow all players — and most important, the customer — to plan accordingly.

Better yet, transparency will enable companies not just to react to disruptions but to anticipate them, modeling the network, creating "what-if" scenarios, and adjusting the supply chain immediately as conditions change.

The goal of the digital supply chain is ambitious: to build an altogether new kind of supply network that's both resilient and responsive.

But if companies are to make the digital supply chain — or perhaps more properly, the digital supply chain *ecosystem* — a reality, they can't just gather technologies and build capabilities. They must also find people with the right skills, and manage the shift to a culture that's willing to carry out the effort. In other words, they must transform their entire organization.

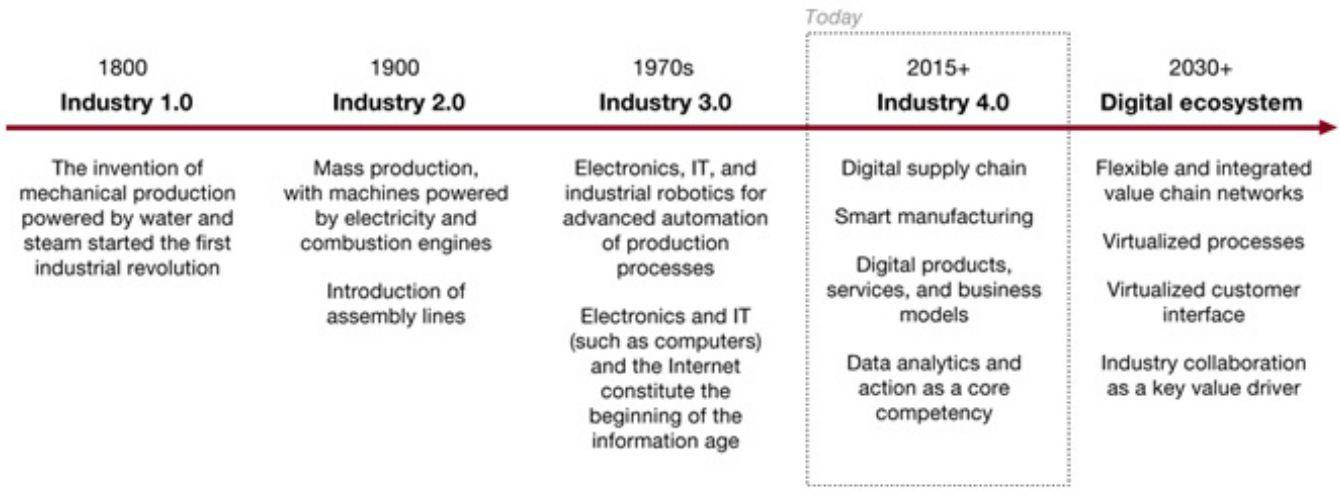
The digital supply chain, as we envision it, consists of eight key elements: integrated planning and execution, logistics visibility, Procurement 4.0, smart warehousing, efficient spare parts management, autonomous and B2C logistics, prescriptive supply chain analytics, and digital supply chain enablers. Companies that can put together these pieces into a coherent and fully transparent whole will gain huge advantages in customer service, flexibility, efficiency, and cost reduction; those that delay will be left further and further behind.

How these elements work to enable the digital supply chain, and, more important, how they work together, is the subject of this report.

The evolution of the digital supply chain

Behind the great potential of the digital supply chain (DSC) lies Industry 4.0, the fourth industrial revolution. A transformation in production and automation was brought on first by steam and water power (Industry 1.0), then by electrification (2.0), and more recently by the digital computer (3.0). Industry 4.0, digitization, is about companies orienting themselves to the customer through e-commerce, digital marketing, social media, and the customer experience. Ultimately, virtually every aspect of business will be transformed through the vertical integration of research and development, manufacturing, marketing and sales, and other internal operations, and new business models based on these advances. In effect, we are evolving toward the complete digital ecosystem (*see Exhibit 1*).

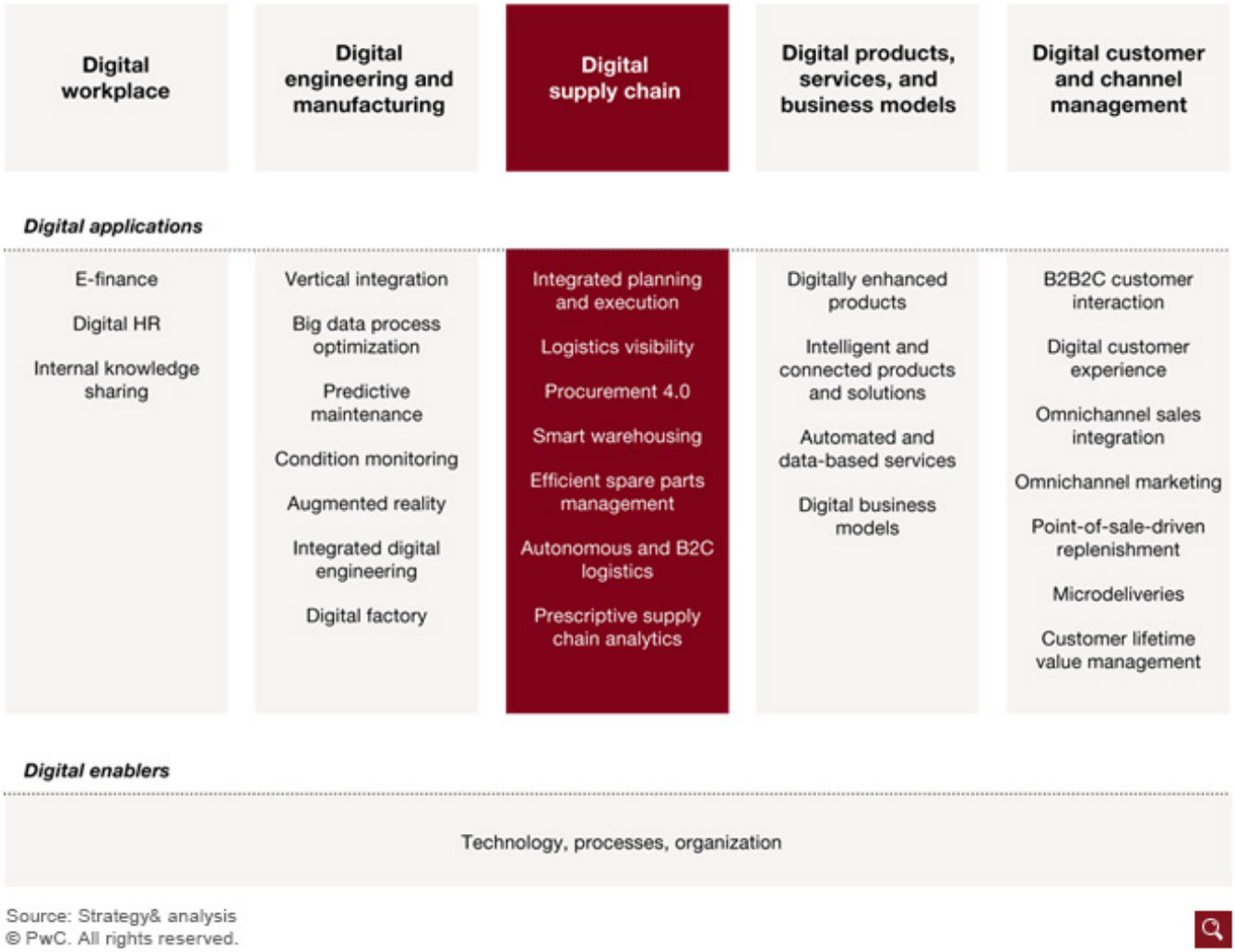
Exhibit 1: The long road to Industry 4.0, the digitization of every aspect of business



Source: Strategy& analysis

This ecosystem will be based on full implementation of a wide range of digital technologies — the cloud, big data, the Internet of Things, 3D printing, augmented reality, and others. Together, they are enabling new business models, the digitization of products and services, and the digitization and integration of every link in a company's value chain: the digital workplace, product development and innovation, engineering and manufacturing, distribution, and digital sales channels and customer relationship management (*see Exhibit 2*).

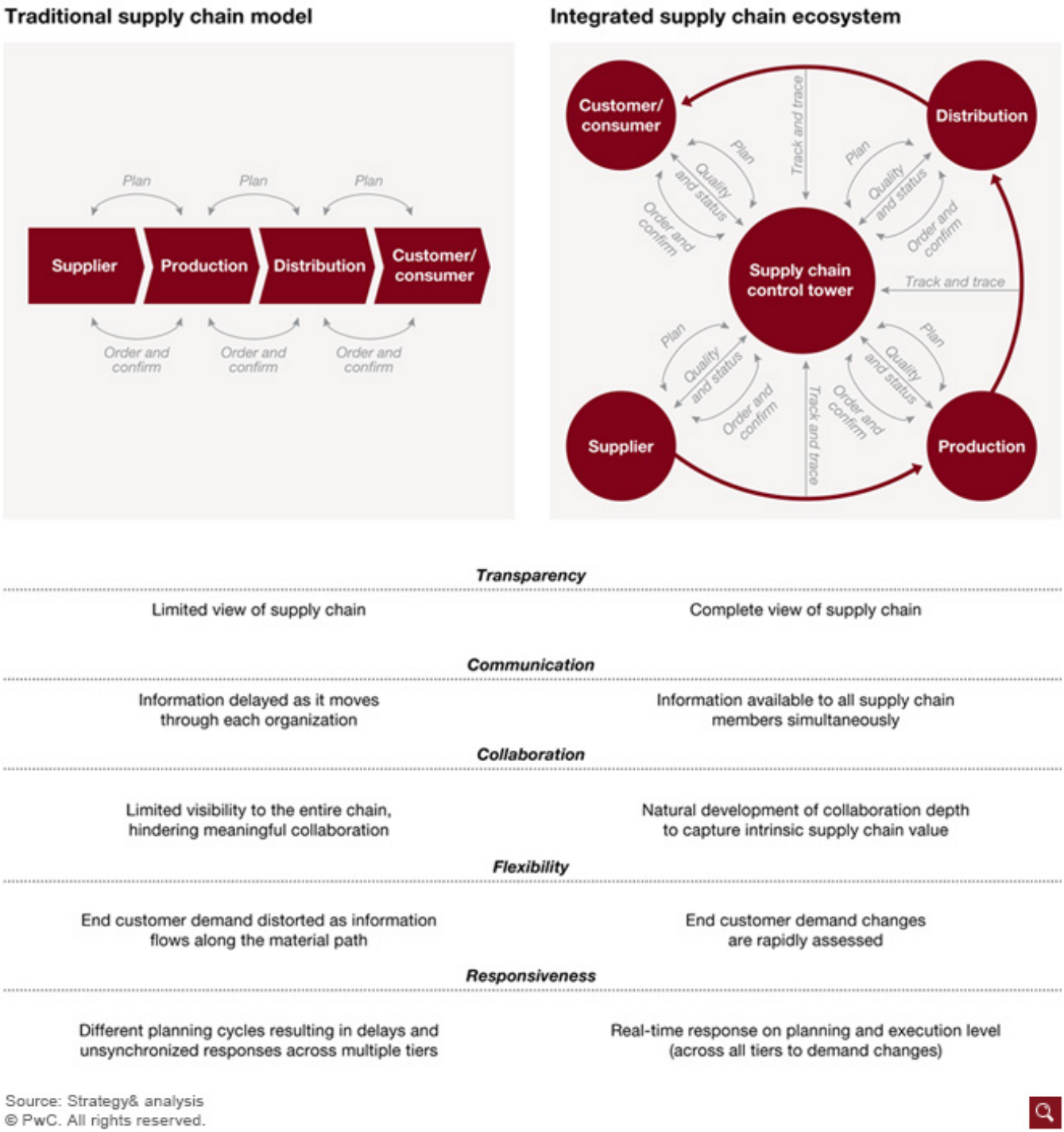
Exhibit 2: The supply chain at the center of the digital enterprise



Source: Strategy& analysis

At the heart of all this activity sits the digital supply chain, and it is key to the operations of every company that manufactures or distributes anything. Indeed, for many companies the supply chain is the business. It extends the vertical integration of all corporate functions to the horizontal dimension, knitting together relevant players — the suppliers of raw materials and parts, the production process itself, warehousers and distributors of finished products, and finally the customer — through a network of sensors and social technologies, overseen via a central control hub, and managed through an overarching data analytics engine (*see Exhibit 3*).

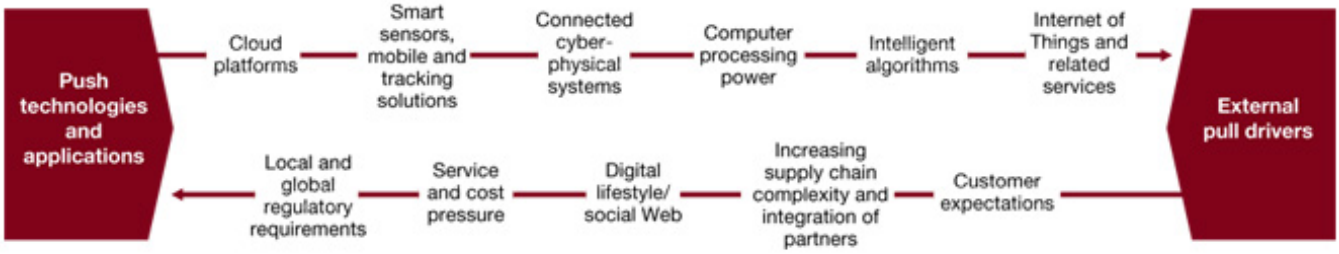
Exhibit 3: The digitally enabled supply ecosystem vs. traditional linear supply chain



Driving the transformation to the smart supply chain are two tightly intertwined trends. On one hand, new technologies like big data analytics, the cloud, and the Internet of Things are pushing into the market.

On the other, more exacting expectations on the part of consumers, employees, and business partners are pulling companies to develop more reliable and responsive supply chains (*see Exhibit 4*).

Exhibit 4: Effect of push technologies and pull demand on the digital supply chain



Source: Strategy& analysis

So the race is on. Companies across industries are already investing heavily to develop their own versions of the DSC. According to a recent PwC study on the rise of Industry 4.0, a third of the more than 2,000 respondents say their companies have started to digitize their supply chains, and fully 72 percent expect to have done so five years from now.

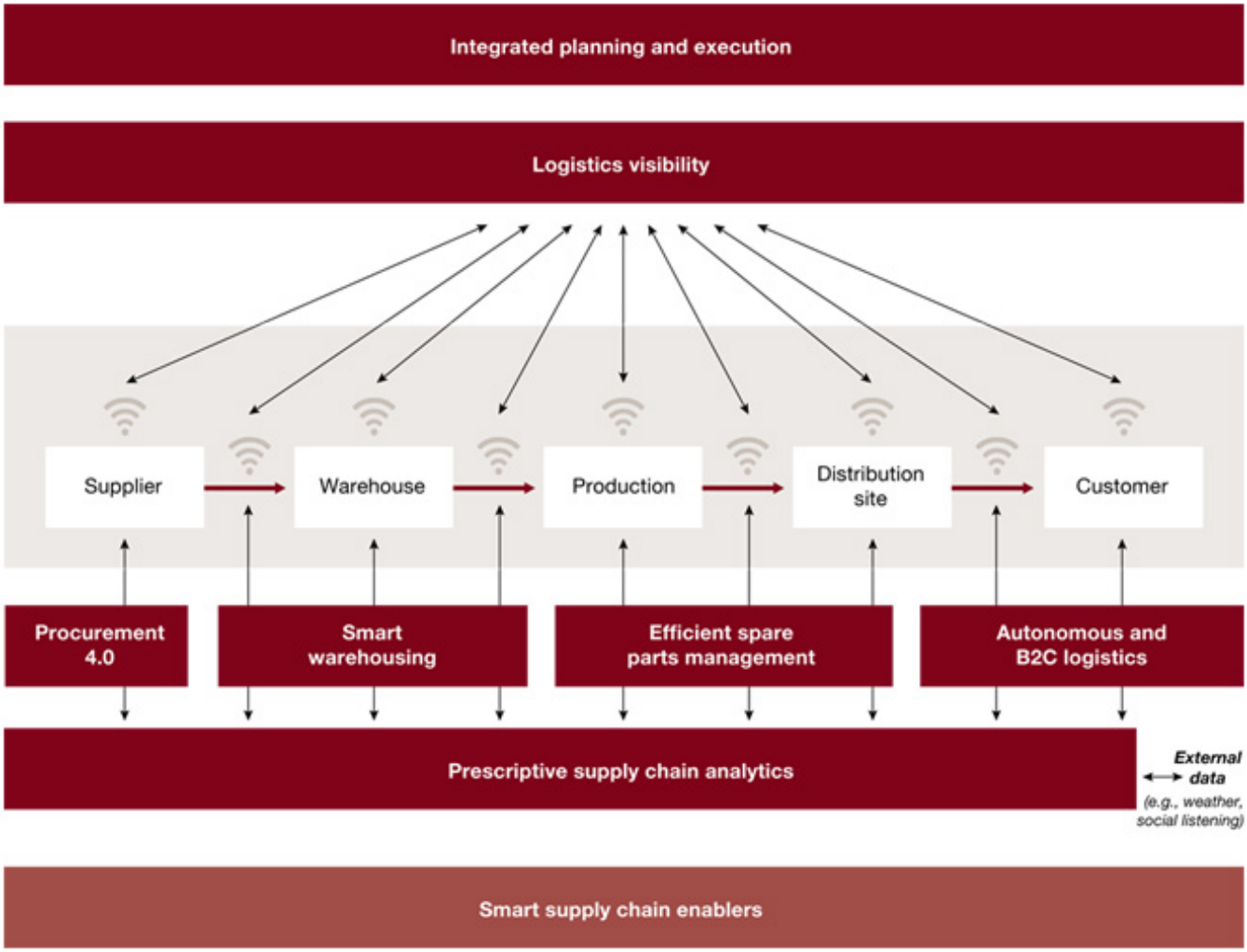
The reasons behind the investment rush are easy to see. Supply chain professionals expect digitization to bring significant economic benefits to both top and bottom lines: Companies with highly digitized supply chains and operations can expect efficiency gains of 4.1 percent annually, while boosting revenue by 2.9 percent a year.

Some industries are further along the digital supply chain continuum than others. Electronics manufacturers, for example, have learned a great deal about building and managing DSCs through their long-standing efforts to create outsourced manufacturing networks. Not so far advanced are consumer-facing companies, like retail and fast-moving consumer goods, which are still vulnerable to serious disruptions in their supply and distribution networks. Yet, these industries are already working to transform their chains, as are even more asset-intensive industries like chemicals.

Core elements and new technologies

Supply chains operate along the traditional SCOR[1] processes — plan, source, make, deliver, return, and enable. Every one of these elements is rapidly being revitalized through technological innovation. We divide up the technologies into eight key areas: integrated planning and execution, logistics visibility, Procurement 4.0, smart warehousing, efficient spare parts management, autonomous and B2C logistics, prescriptive supply chain analytics, and smart supply chain enablers (*see Exhibit 5*).

Exhibit 5: Eight key elements of the digital supply chain



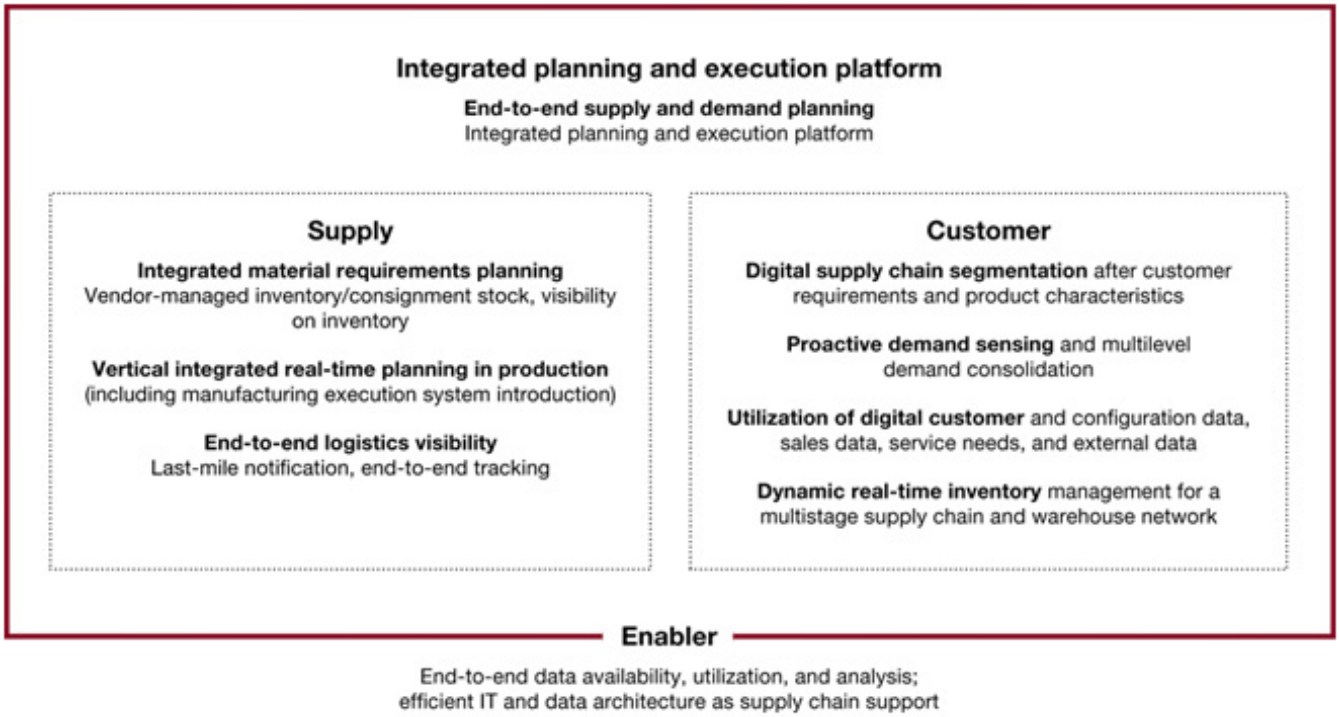
Source: Strategy& analysis

All of these elements are interrelated, and they build on one another. Consequently, a digital supply chain strategy needs to consider all of them to leverage the full benefits of digitization. Let's look more deeply at these critical elements.

Integrated planning and execution — the horizontal axis

The business goal of the digital supply chain is to deliver the right product into the customer's hands as quickly as possible — but also to do so responsively and reliably, while increasing efficiency and cutting costs through automation. This goal cannot be achieved unless the supply chain is fully integrated, seamlessly connecting suppliers, manufacturing, logistics, warehousing, and customers, and driven through a central cloud-based command center (*see Exhibit 6*).

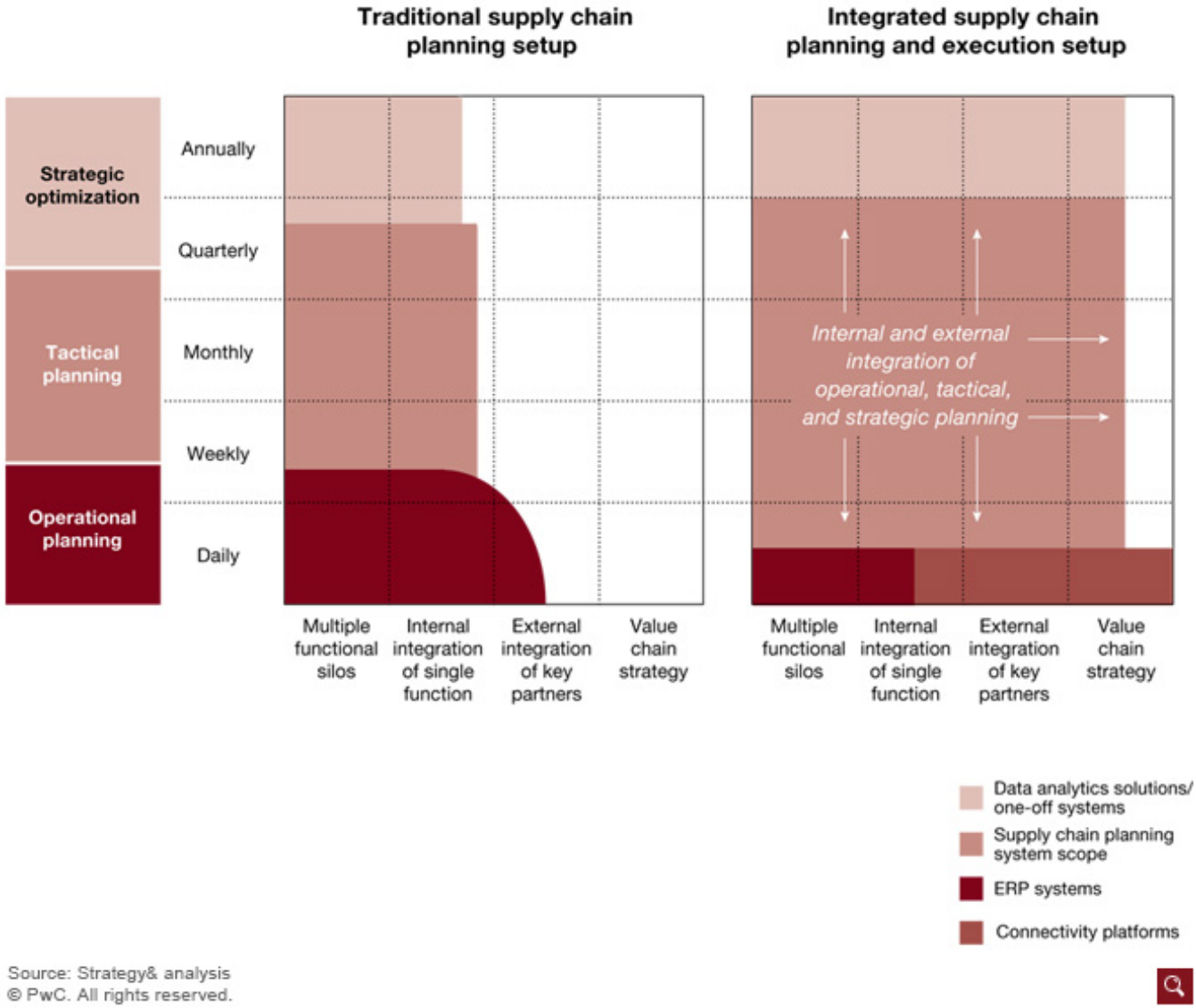
Exhibit 6: The integrated planning and execution platform in the supply chain



Source: Strategy& analysis

With this level of integration, signals that trigger events in the supply chain can emanate from anywhere in the network and alert all to issues affecting supply or demand, such as shortages of raw materials, components, finished goods, or spare parts. In a world in which customized manufacturing is fast becoming the norm, and customers are becoming ever more demanding, the fully responsive supply chain is a huge competitive advantage and fast becoming a must-have (*see Exhibit 7*).

Exhibit 7: Advanced planning systems that cover larger planning horizons



Source: Strategy& analysis

The result is full awareness and collaboration along different time horizons on strategic, tactical, and operational levels. Integration platforms have core planning capabilities that support day-to-day operations, including “what-if” scenario planning.

As an example, here’s what could happen when planners are notified in near-real-time to changes in customer demand. The planners can immediately assess impact on inventory, capacity, other customer orders, supplies of raw materials, and the like by running scenarios within the platform. Scenario outcomes can be evaluated against criteria such as impact on financial performance and delivery reliability to identify the optimal solution. This solution is then immediately shared with the customer, suppliers, manufacturing outsourcers, logistics providers, and other partners for acceptance or further refinement, if needed.

A variety of business networks and collaborative cloud-based platforms are emerging that work much like social networks to allow companies to interact with supply chain stakeholders fully and quickly. These platforms are already considerably more advanced than early trading networks, such as SAP’s Ariba, which focus on matching demand and supply for specific commodity products. Now, all players within the network can exchange information about demand, inventories, and manufacturing and logistics capacity, and provide near-real-time feedback on changes such as potential bottlenecks along the supply chain following a demand increase.

This level of integration allows — indeed, forces — players to plan collaboratively, using a single set of numbers across time to run scenarios and estimate potential trade-offs among such variables as capacity, cost, margin, delivery performance, and fill rate. The workflow can be accurately modeled to integrate all collaboration processes and ultimately to provide fast, reliable information about when finished products will be delivered to customers.

By integrating data across the entire supply chain, in real time and often without human intervention, delivery lead times can be significantly reduced and freight and inventory management optimized. The rapid exchange of information also boosts the agility of the entire chain, while enabling much closer integration with customers — always a good thing when the goal is to effectively “lock in” those customers through an efficient supply chain platform, excellent service, and a compelling customer experience.

The rapid exchange of information boosts the agility of the entire chain.

Logistics visibility — seeing the network

The key to success for any supply chain is efficient exchange of information. The traditional supply chain is fraught with friction, caused primarily by lack of complete and timely information. Potential for disruption is high; sudden shifts in demand, lack of raw materials, and natural disasters can wreak havoc on the best-laid supply chain plans. And the outsourcing of many necessary elements only makes it harder to understand the supply chain in full, fogging visibility into the transportation network and making it difficult to mitigate problems as they occur.

That's why the overarching goal of the digital supply chain is to open the supply network for all to see. B2C markets are pulling companies along to provide this level of visibility, demanding more information about shipment arrivals with real-time updates. In B2B networks, producers expect timely status information on their supply shipments, which are typically linked to production plans. Constantly updated and reliable transportation information can significantly improve the producer's customer satisfaction as well.

Gaining a high degree of transparency into the system is no easy task, requiring both technical sophistication and a fair degree of intelligent human intervention. But once it is achieved, the benefits are significant, and not limited to inventory savings and planning improvements.

Exhibit 8 illustrates the different elements of the logistics visibility framework:

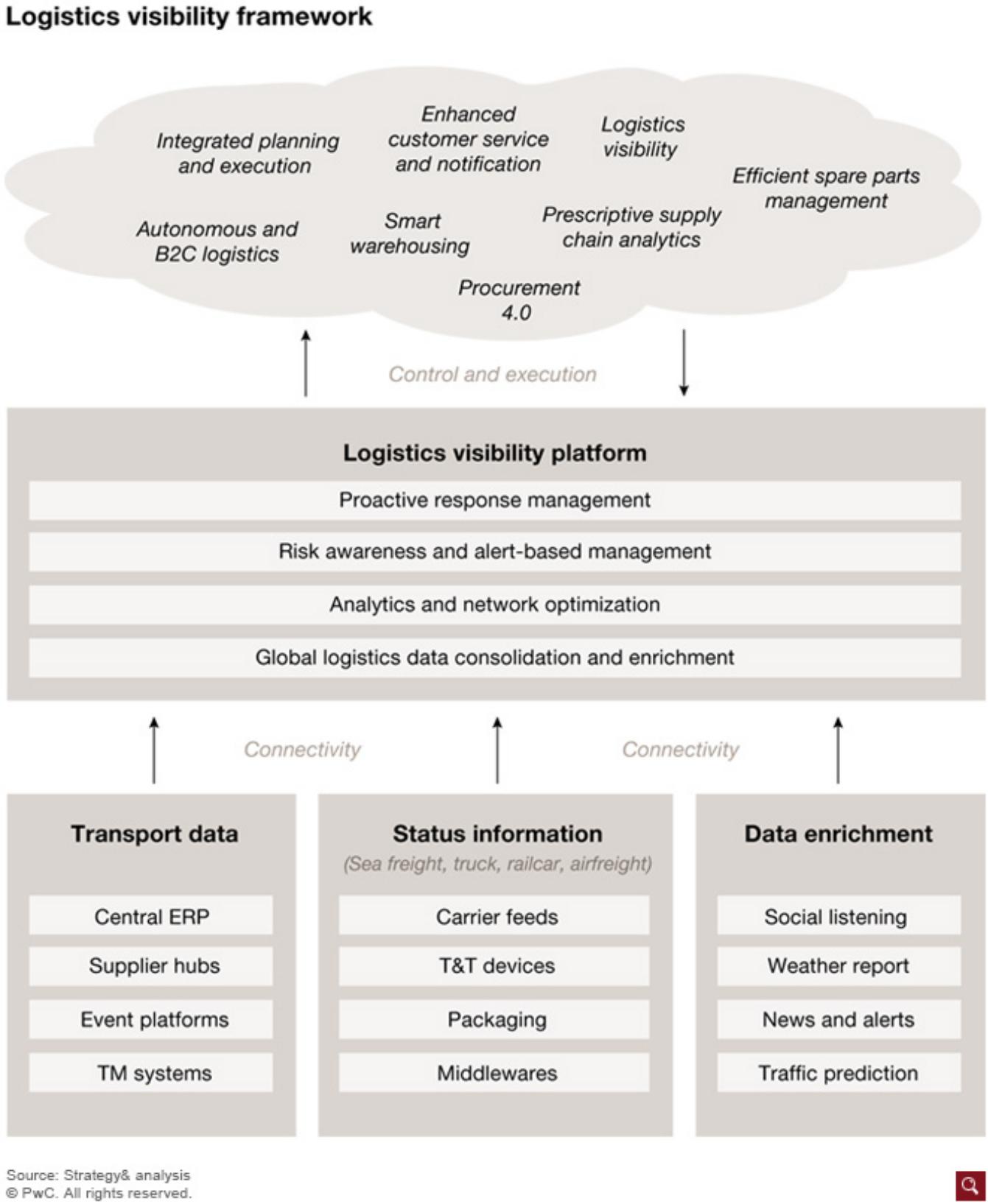
Data from internal and external sources, such as transport tracking devices and social listening, is brought into a single platform.

The data is consolidated and enriched with cross-referenced information, such as supply chain events impacting supply shipments. Relevant information is scoured from weather, traffic, and news feeds. Even social media networks are monitored — companies that paid attention to Twitter activity, for example, could have anticipated the recent workers' strike in the port of Los Angeles as early as four weeks before it happened.

This enriched information is then linked within the platform and put through additional analytics and simulation runs, allowing various levels of strategic optimization such as route network improvements and carrier performance reviews. If all this information is to be really useful, it must feed into a control center that monitors and manages logistics activities and applies advanced analytics and prescriptive algorithms to the equation.

The resulting "single source of truth" lets companies optimize their choices under different conditions, using the information to alert factories, warehouses, and customers to endangered arrival times and engage in mitigation actions. Visibility into both transport status and expected external impacts on lead time, and the ability to change plans accordingly, will be instrumental for companies looking to use their supply chains to competitive advantage, and to manage more carefully the many risks associated with supply chain activities.

Exhibit 8: A single platform drives the logistics visibility framework



Source: Strategy& analysis

Eventually, machine-learning algorithms will become smart enough to automate even this kind of human intervention, allowing managers and other stakeholders to make smarter decisions daily. These algorithms will offer mitigation advice and proven routine solutions from the past, when available. Benefits will include workload reductions and even greater increases in supply chain efficiency.

Chain visibility depends on the creation of an effective “track and trace” (T&T) system that allows players to determine the status of any given shipment of goods at any point in its travels, by any transport mode. Transport data and status information will be captured from enterprise resource planning systems as well as from carriers, either through direct connections or via third-party portals. GPS technology will enable companies to check exact shipment locations, while field sensors monitor environmental conditions such as temperature and humidity, and even provide remote theft protection. But because data is arriving from many different sources — suppliers, transporters, warehouses, distributors — quality and interoperability of the data is critical, and still a significant technological barrier that a wide range of companies are working on.

Track-and-trace technologies

The ability to track and trace movements of supplies and products through the transportation system has evolved significantly in recent years, thanks to new technologies, their increasing reach across the globe, and falling prices. Radio frequency identification (RFID) and Bluetooth technologies are being used to inventory and track movement of items indoors, such as inside factories and warehouses. 3D printers generate readable sensor tags that can be attached to cargo and capture temperature and humidity conditions. Global system for mobile communication (GSM) and satellite tracking are used in maritime transport, and ship sensors monitor engine performance. Much of this is due to increases in the battery life of small tracking devices, which can now retain power for as long as five years through intelligent algorithms that shut down the device when the sensor is idle.

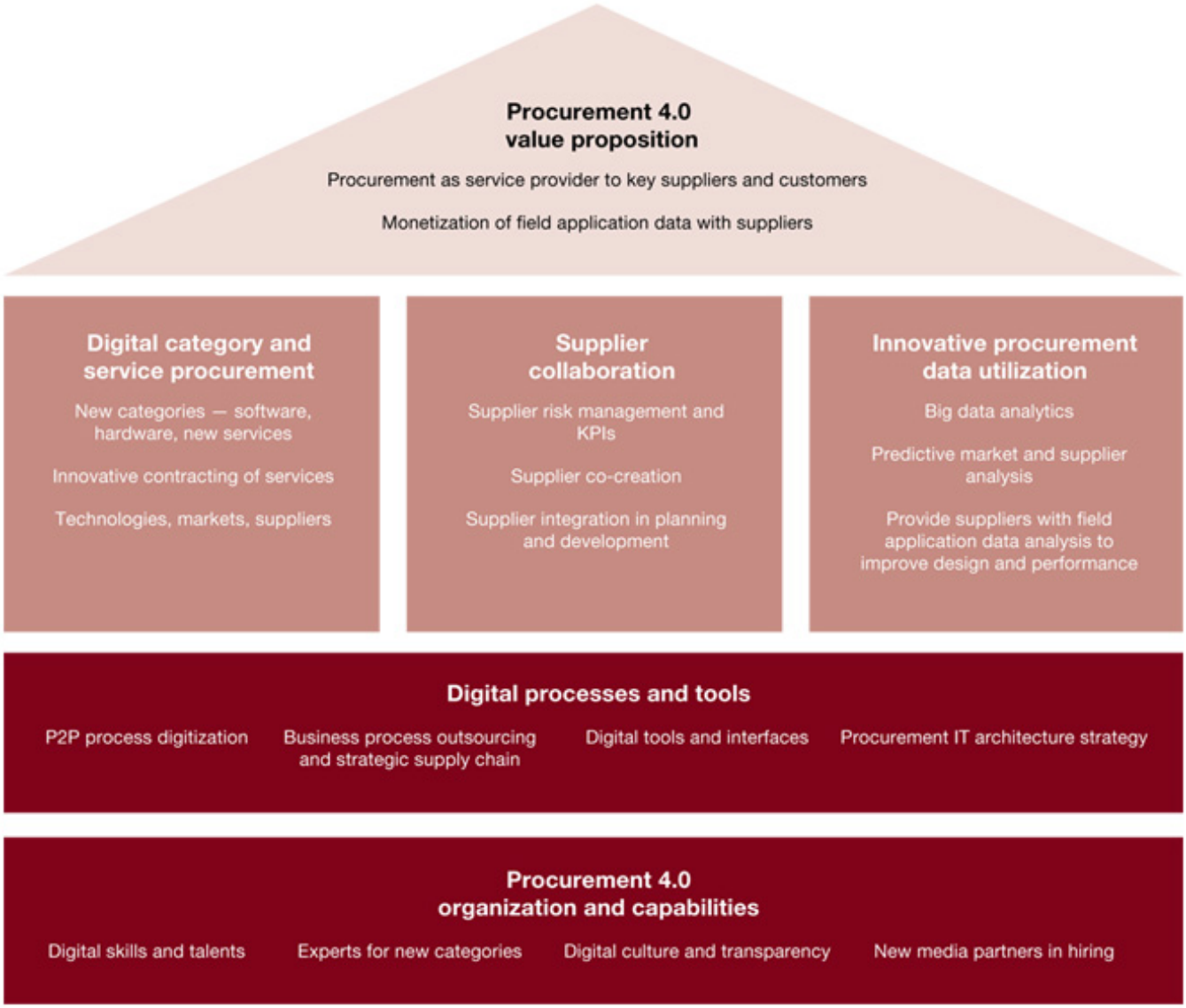
The command center for these remote-sensing activities is the control room or logistics visibility platform, akin to a traffic control tower. The great virtue of the control room is that it can provide executives and senior managers with a fully transparent view of the company's supply chain, and thus support the many decisions that have to be made to keep the flow of parts and products going.

Procurement 4.0 — sourcing on demand

Digitizing procurement will radically change the tools and talents required, add new categories to be sourced, and transform the value proposition of the procurement function.

Efficient integration and management of suppliers of raw materials and parts is a critical building block in the digital supply chain ecosystem. The digitization of many traditional aspects of procurement is already under way, as companies use a variety of big data tools and techniques to connect more closely with suppliers, aid the planning process, improve sourcing, actively manage supplier risk, and boost collaboration. The result is lower costs and faster delivery throughout the supply chain as it becomes increasingly automated (*see Exhibit 9*).

Exhibit 9: Digitizing the procurement function



Source: Strategy& analysis

But the truly digital supply chain will have several other key consequences for the procurement function as well. First, the overall shift to Industry 4.0 will require companies whose supply chain needs have been limited to physical goods to become equally adept at buying digital supplies and services — software maintenance contracts, developers (who is going to program all those GPS devices you will be deploying?), and digital procurement platforms. The millions of sensors and other electronic components needed to run the digital supply chain itself are another obvious procurement need. It's the vastly greater need for all kinds of software, however, that will really transform the procurement function.

On one level, this will involve buying the software needed to run the digital supply chain itself. This will likely turn out to be a relatively straightforward exercise; there are certainly plenty of vendors willing to work with companies to develop and supply it. The real challenge, however, will come as software and services become a more and more important feature of the products that every company makes. Already, the software embedded in these products, from electronics to cars to industrial machinery, is more valuable than the physical materials that go into them — and is already providing the competitive advantage that companies need to win in the future.

Smart warehousing — robots at work

The next link in the digital supply chain is the warehouse, and it promises to become a strategic tool in how companies operate and generate value for their customers. Here, the aim is to improve efficiency and safety through the automation of virtually every ordinary warehousing activity. Indeed, the Industry 4.0 warehouse will look nothing like our current labor-intensive buildings.

The warehouse promises to become a strategic tool in how companies operate and generate value for their customers.

The transformation of the warehouse of the future begins with inbound logistics. Trucks on the way to the warehouse will communicate their

position and arrival time to the intelligent warehouse management system, which will choose and prepare a docking slot, optimizing just-in-time and just-in-sequence delivery. RFID sensors will reveal what's been delivered, and send the track-and-trace data horizontally across the entire supply chain. The management system will automatically allot storage space for the delivery, and assign the appropriate autonomous equipment to move the goods to the right locations.

Inside the warehouse, the management software will constantly update inventory in real time, through the use of sensors embedded in the goods and the warehouse itself. Ultimately, the system will deploy flying drones to aid in taking inventory, regularly assessing the whereabouts of goods through sensor data, and mapping the entire facility.

In addition to enhanced inbound logistics, autonomous transportation, and optimized logistics processes, innovative technologies will transform such mundane jobs as picking goods to fulfill an order. Already, companies are experimenting with wearables and augmented reality systems to aid in this expensive, labor-intensive process, which is often still carried out using paper and prone to human error.

DHL recently conducted tests on an augmented reality system at a warehouse in the Netherlands owned by Ricoh, the Japanese imaging and electronics company. Equipped with smart glasses containing software from Ubimax, employees navigated through the warehouse along optimized routes via the glasses' graphics display, enabling them to find the right quantity of the right item much more efficiently, and with reduced training time. Over the three weeks of the test, 10 order pickers succeeded in fulfilling 9,000 separate orders by picking more than 20,000 items. The resulting productivity improvements and reduction in errors increased the overall picking efficiency by 25 percent.

Once the proper products are picked, they will be packaged for shipment by robots that can handle a broad range of product sizes while taking into consideration data on the product and the customer's packaging requirements. Software will also control the internal warehouse environment, including setting the proper temperature, light, and humidity according to predefined requirements. By shutting off the lights and heat in areas where all the work is being done by robots and autonomous vehicles, for example, energy consumption can be reduced significantly.

Efficient spare parts management — with 3D printing

The warehousing link in the supply chain is expensive, labor-intensive, and fraught with potential error. Digitization will certainly eliminate much of its inefficiency and integrate the process into the entire supply chain. Meanwhile, 3D printing is poised to transform this critical link in the chain even further.

Consider the problem of spare parts. At many warehouses, more than half of all orders shipped are one-time requests for spare parts, and the demand for them is highly erratic, almost impossible to predict. That's why companies typically maintain huge inventories of parts, many of which must be kept for 30 years or more if customers are to keep operating older machines.

Already, digitization is revolutionizing the warehousing and distribution of spare parts. Sophisticated analytics software allows demand for spare parts to be forecast much more precisely, through solutions such as predictive maintenance of industrial vehicles and machines. That in turn allows companies to optimize spare parts storage and distribution, as a great deal more information can be integrated, such as social listening and traffic and weather data, on which demand and distribution depend.

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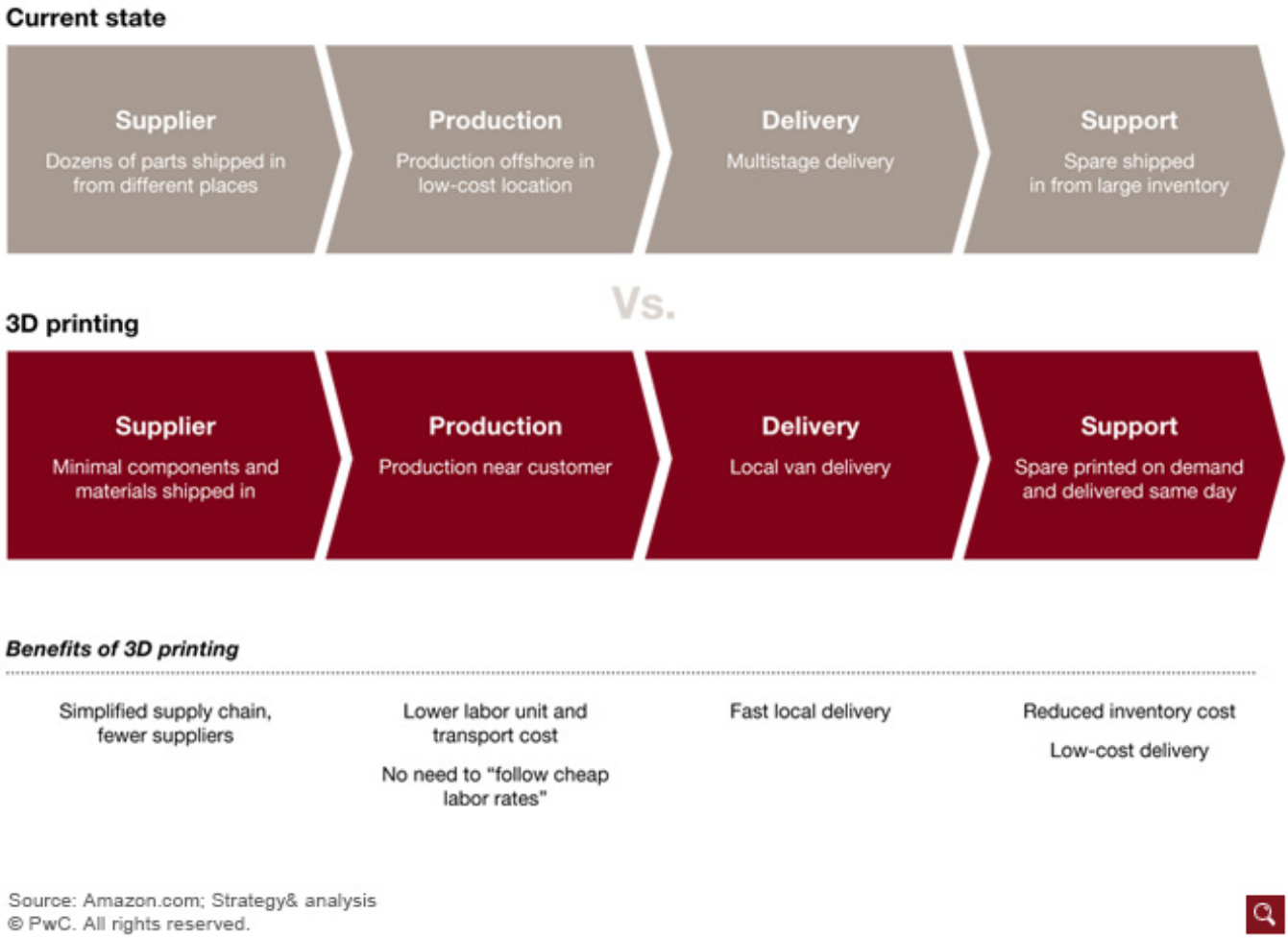
Then add 3D printing to the mix: Spare parts can be manufactured as needed at facilities maintained locally — even on-site, if demand is high enough or critical enough. All that's needed are the printers, software, a blueprint with the right specifications for each part, and the materials needed to produce it. The specifications for any part, including parts from machines too old to have the specs on file, can be created using 3D laser scanners and automatically translated into code readable by printers (*see Exhibit 10*).

Exhibit 10: 3D printing is transforming the spare parts value chain



The benefits include dramatic reductions in spare parts inventories and associated costs. Just as important, customers can count on much greater uptime for critical equipment, as problems are anticipated and spare parts arrive much more quickly. Indeed, the capacity to add predictive maintenance services to industrial equipment, and the ability to deliver parts in a timely fashion, is instrumental to the shift to Industry 4.0.

Autonomous and B2C logistics — robotic transport

Few elements are likely to influence the general perception of the digital supply chain as much as the rise of autonomous logistics. The notion of driverless cars already turns heads. Fleet management will deploy all manner of driverless vehicles and other robotic innovations that will play an increasing role in moving goods around the world.

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The most common use of autonomous vehicles in logistics will be driverless trucks. Like their car brethren, self-driving trucks will depend on mapping software and short-range radar to assess the vehicle's surroundings. Wireless connections to other vehicles and to the road itself will provide additional information that will speed up traffic flow and reduce roadway congestion and accidents.

The possibility of autonomous truck convoys — a modern-day wagon train with multiple trucks in a line — will reduce the need for human drivers and allow the trucks to drive more closely together. Internal sensors will help fleet operators assess damage to cargo and determine maintenance requirements.

The virtues of such vehicles are obvious — faster and more reliable delivery times, lower labor costs, the elimination of human error, and reduced emissions thanks to more efficient operations, routing, and convoying of trucks.

Last year, the U.S. state of Nevada licensed two of Daimler's Freightliner Inspiration Trucks for use on public highways. Equipped with radar, advanced cruise control, and mapping software, the trucks, in autonomous mode, free their drivers to concentrate on more value-adding logistical tasks such as routing and route logging, making the job more attractive, safer, and less monotonous.

Another step in process automation is last-mile delivery — getting products into the hands of the customer. Because it is labor-intensive and demands a great deal of customer interaction, it is often a major accelerator of costs in the logistics chain. Many ideas for

lowering costs and providing greater customer value are being discussed, including Uber-like apps to employ nonprofessional drivers to deliver packages, self-driving delivery robots moving at pedestrian speeds that distribute packages along flexible routes — monitored by human operators, of course — and, most famously (thanks to a concept video produced by Amazon), using drones to drop packages from the sky onto customers' front porches.

Within production facilities themselves, autonomous on-site vehicles are becoming the norm, moving raw materials, parts, and components around without human interference, and choosing the best route despite constantly changing conditions. Tightly integrated with the company's ERP system, these vehicles will eventually be able to determine on their own which supplies need replenishing anywhere in the production process, pick up loads from storage, drop them off where needed, and collect returnable packaging. Contactless sensors and laser safety bumpers on these vehicles will significantly improve on-site employee safety.

Systems from companies such as Germany's Still even allow their vehicles to operate as a team, coordinating with one another as well as their human overseers to determine the best routes and most efficient use of the team's assets in a dynamically changing environment.

Prescriptive supply chain analytics — decision support for managers

The goal of the digital supply chain is to fully integrate and make visible every aspect of the movement of goods. The key to this critical element of Industry 4.0 is big data analytics. Already, companies have the tools to describe much of the current state of their supply chains — where the goods are, where the demand for specific items is currently coming from, and when items are likely to be delivered. And companies are learning to *predict* critical elements of the chain. Demand through the chain can be better anticipated thanks to more sophisticated signals from the market, which translates to demand for production capacity, storage and logistics needs, and changes in raw materials requirements.

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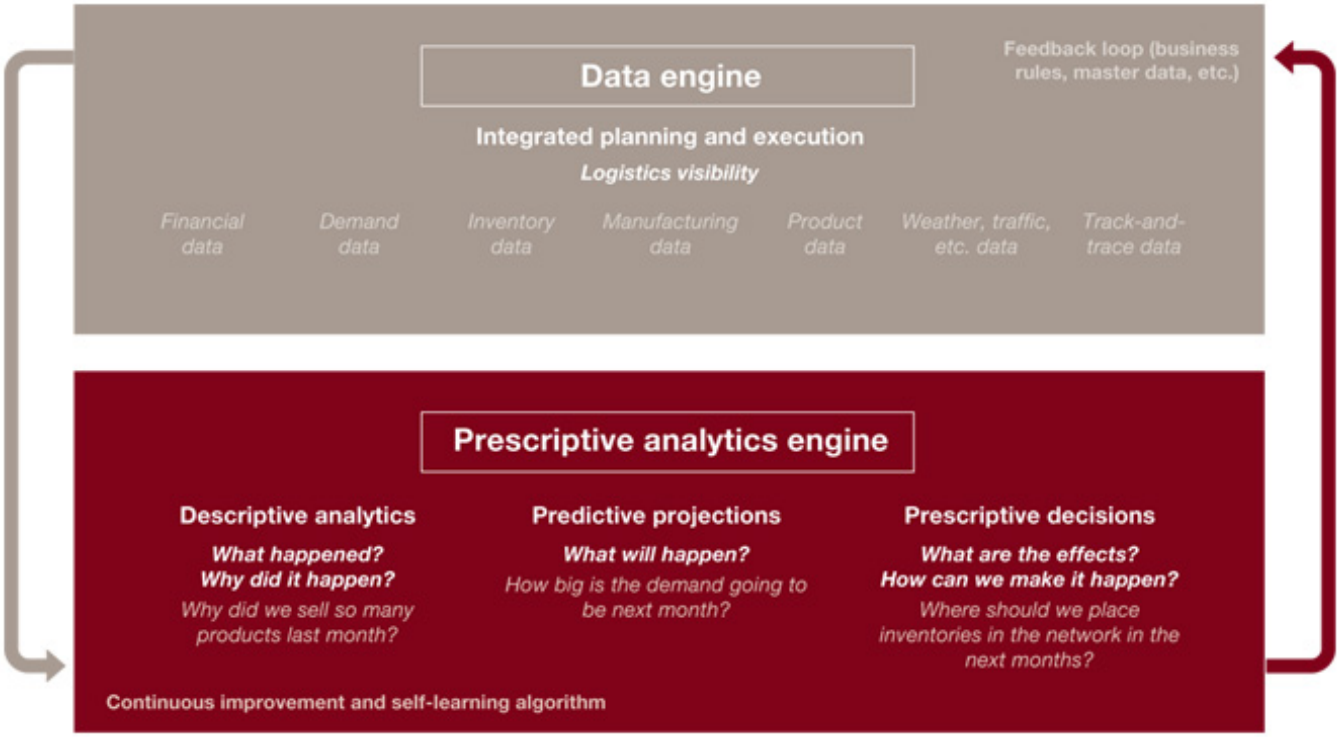
The next stage in the development of supply chain analytics will be the most important: the ability to *prescribe* how the supply chain should operate. The goal isn't simply to optimize demand planning; or the supply chain's distribution facilities, routes, and mobile assets; or the management of inventory and spare parts. Instead, the key lies in the ability to optimize for any number of factors across the entire chain, depending on circumstances, and then be able to actively modify the chain accordingly.

Prescriptive analytics systems provide decision support to supply chain managers and can even act autonomously on simple decisions. To improve the quality and efficiency of such decisions, companies will be able to include external information such as economic indicators and employ self-learning algorithms to aid in automating the decision-making process (*see Exhibit 11*).

Exhibit 11: Prescriptive analytics from big data and complex algorithms



Source: Strategy& analysis

What, the planner might ask, would be the best way to optimize the supply chain to minimize costs, setting aside other considerations such as on-time delivery? Or the best way to speed up delivery time, no matter what the effect on cost might be? Could the supply chain be optimized for maximum revenue instead, by providing the best service to customers?

Given enough data, the analytics engine would produce a minimum-cost scenario showing not just how much money could potentially be saved but also how to achieve this goal. This scenario could be adjusted to account for other factors. How might a potential disruption such as a natural disaster affect the supply chain when run to minimize costs? How risky would such a scenario be? How should those risks be minimized? How much would minimizing the risks cost? If Toyota had known the risks inherent in its optimized just-in-time system for delivering parts to factories, it may have been able to avoid production shutdowns around the world when supplies were cut off by the 2011 earthquake and tsunami in Japan.

Ultimately, prescriptive analytics will be able to offer scenarios at a very fine level of detail, describing how shifting to a new supplier might affect product quality, or even whether the introduction of a new kind of autonomous vehicle would increase safety on the warehouse floor.

This degree of detail will depend entirely on the ability of companies to use data to knit together all the key elements of the supply chain into an integrated whole. The next logical step will be to automate standard activities within the supply chain based on the recommended actions, and to focus resources on orchestrating the entire chain and managing exceptions to standard processes.

Ultimately, prescriptive analytics will be able to offer scenarios at a very fine level of detail.

Smart supply chain enablers — success factors

Companies setting out to build the smart supply chain face a difficult task, one that will likely prove impossible unless they develop a clear strategy that is fully responsive to the opportunities on offer in a fully digital environment. It must be based not just on the company's current operations and business model but also on new business models available once digitization has been implemented, such as creating direct sales channels and leapfrogging levels in the value chain.

Once the strategy is determined, companies must put into place several key capabilities needed to carry it out, in addition to the supply chain applications discussed above. These key capabilities include the following:

Processes. Establish the new end-to-end processes connecting suppliers and customers that digitization makes possible, such as how to collaborate on cloud-based platforms.

Organization and skills. Generate an end-to-end understanding of the mechanics of the value chain. That means switching from a firefighter mentality, solving each problem as it pops up, to becoming a supply chain "orchestrator" — seeing, managing, and optimizing the entire chain. Achieving this will also require a shift to an open, fast-learning digital culture that promotes

communication across different media, programs, and user groups. Develop the talent and expertise needed to build the technology and carry out the new supply chain operations.

Performance management. Develop a set of straightforward business rules covering the management of the supply chain, and the key performance indicators needed to measure outcomes.

Partnering. Focus on boosting your ability to partner with other companies, as the fully integrated supply chain cannot be built without collaborating with a wide variety of suppliers, distributors, and technology providers.

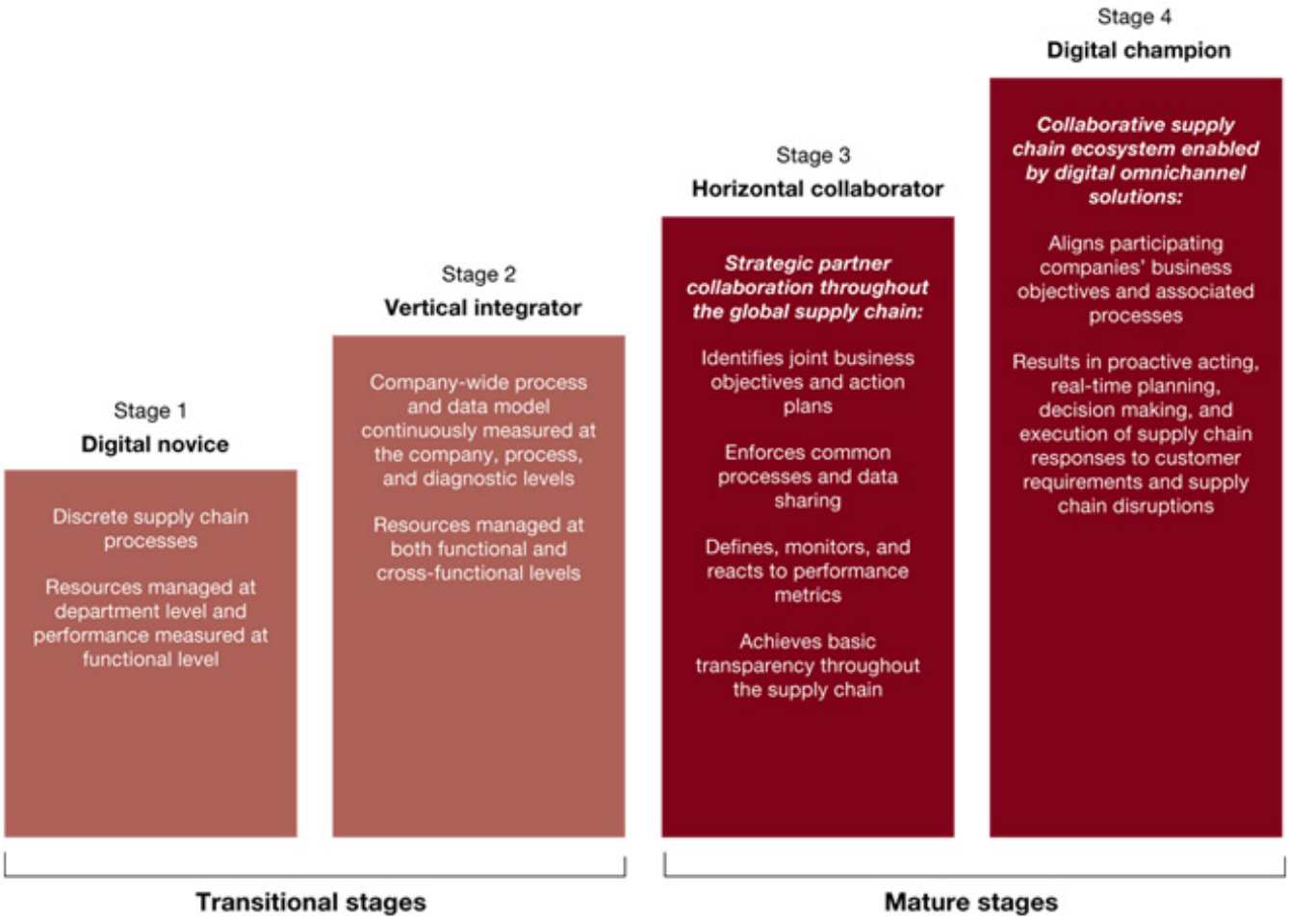
Technology. Devise a road map for the many technologies, old and new, that will underpin the digital supply chain, including the information integration layer, database and analytics capabilities, and the cloud.

Supply chain maturity

Few companies have reached anything close to complete maturity in their efforts to put together the fully digital supply chain. To develop a supply chain strategy and organize their ensuing efforts in a coherent fashion, it is critical that companies understand their starting position. The process leads through four stages of maturity (*see Exhibit 12*):

1. **Digital novice.** These companies have yet to embark on the journey. Their supply chain processes remain discrete, carried out by individual departments and business units.
2. **Vertical integrator.** Companies at this stage have managed to integrate their supply chain processes internally, across departments and functions.
3. **Horizontal collaborator.** Here, companies have learned to work with their supply chain partners to set business goals, define and carry out common processes, and achieve a fair degree of transparency into the chain.
4. **Digital champion.** These companies have achieved the highest level of collaboration with partners and transparency into operations, while developing mutually beneficial processes and analytical techniques for optimizing the entire supply chain.

Exhibit 12: The four stages of supply chain maturity



Source: Strategy& analysis

The digital supply chain road map

The key to becoming a digital champion and reaping the full benefits of DSC lies in developing an orderly process for implementing and integrating the many technologies and capabilities required. In our experience, companies need to take five primary steps:

1. **Understand your starting position:** Review your current maturity along the four stages of the maturity model and identify areas for improvement.
2. **Define your strategy:** Determine your target maturity level and the supply chain vision that best supports your business strategy.
3. **Develop the appropriate road map:** Settle on the necessary implementation steps and work them into a detailed road map.
4. **Deploy small pilots with end-to-end scope:** Many applications that make up the digital supply chain represent a radical change for most organizations, so companies should first carry out smaller pilots that showcase benefits and help develop the right capabilities. These “lighthouse” projects should aim at testing the end-to-end flow for a specific supply chain, rather than implementing a limited set of technologies on a broader scale.
5. **Segmented rollout and capability development:** After a successful pilot, the rollout should start with those supply chains where expected benefit is highest. This could involve key customers, key regions, or some other supply chain segmentation criterion. The capabilities required will need to evolve along with the rollout.

Conclusion

Supply chains are extremely complex organisms, and no company has yet succeeded in building one that’s truly digital. Indeed, many of the applications required are not yet widely used. But this will change radically over the next five to 10 years, with different industries implementing DSC at varying speeds. Companies that get there first will gain a difficult-to-challenge advantage in the race to Industry 4.0, and will be able to set, or at least influence, technical standards for their particular industry. The advantage will by no means be limited to the greater efficiencies. The real goal will be the many new business models and revenue streams the digital supply chain will open up.

Endnote

1. The Supply Chain Operations Reference model (SCOR) is the world’s leading supply chain framework, linking business processes, performance metrics, practices, and people skills into a unified structure. It was developed in the 1990s by a number of industrial companies and by the management consulting firm PRTM, now part of the PwC network.

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