

Unlocking Business Model Innovation through Advanced Manufacturing

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Executive summary

The COVID-19 pandemic has highlighted the critical role manufacturing and supply chain systems play in powering the global economy. But while most companies have been able to adapt to the unprecedented disruptions by leveraging and deploying technologies across factory sites, manufacturing and supply chain leaders need to enhance their efforts if they want to remain competitive in the current environment.

The new challenges posed by consumers and society at large require leaders to go beyond operations, productivity and efficiency improvements (Section 1). The most successful companies will be those able to leverage their investments in advanced manufacturing not only to optimize operating models, but also to unlock new business models that create and deliver new value to all stakeholders, including the companies themselves, workers, society and the environment. Three essential stages, from point solutions to end-to-end digital infrastructure and integration to new business models, are necessary for the transformation (Sections 2 and 3).

Given the complexity of the journey towards business model innovation, five key strategies most commonly used by leading players illuminate the way forward: 1) start with leadership and culture shifts; 2) forge system-wide collaborations; 3) adopt new metrics to measure success; 4) leverage core manufacturing strengths to close the gaps with digital natives; and 5) relentlessly pursue the broader purpose (Section 4).

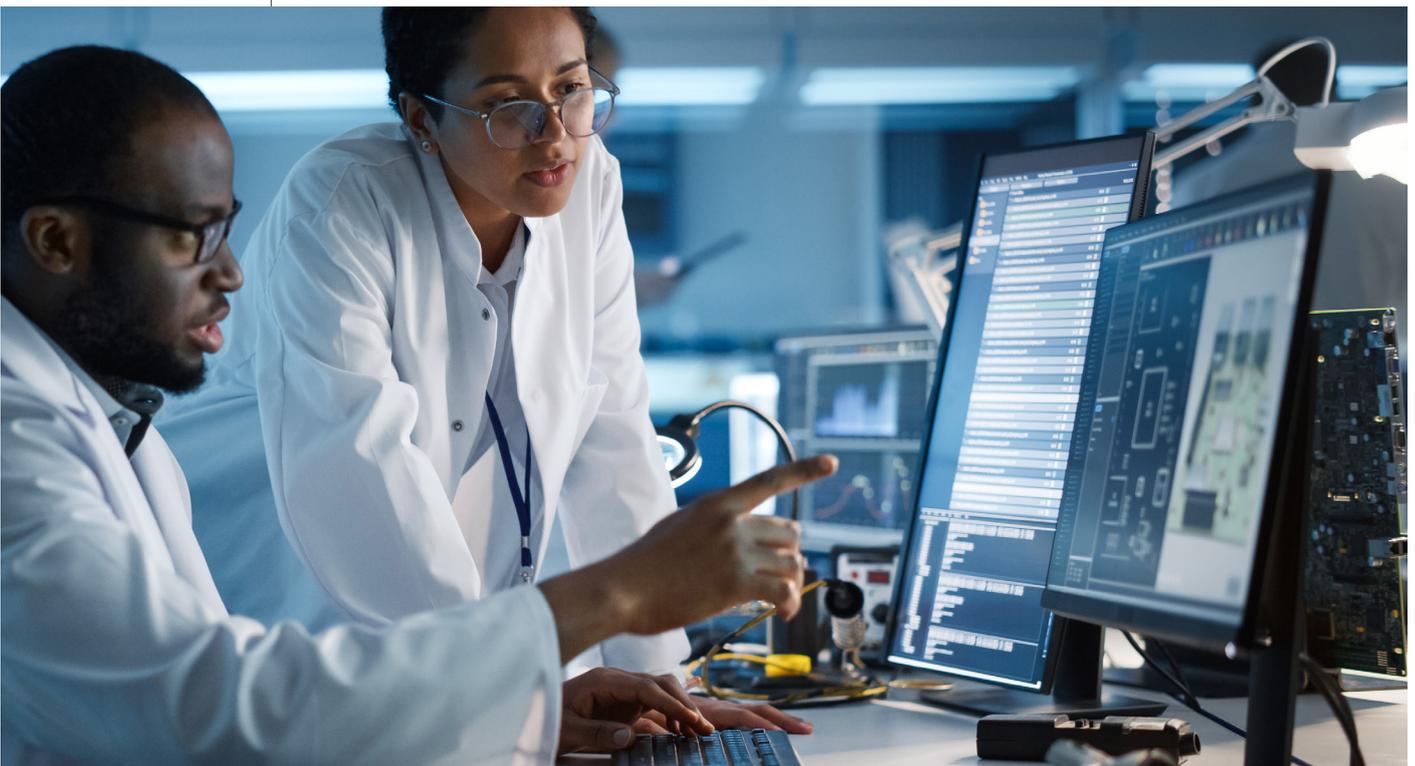
This White Paper aggregates the views of over 50 leaders from manufacturing companies, services providers and academia, and highlights successful case studies from those who have already started to unlock business model innovation by adopting advanced manufacturing. The objective of this paper is to inspire manufacturing and supply chain leaders to start or accelerate the business model innovation journey and ensure it can achieve and deliver its full potential for driving responsible industry transformation and growth.

1

It is time to think beyond manufacturing operations

The COVID-19 pandemic provided a vital reminder of the importance of supply chains and the role of advanced manufacturing. Companies in the production ecosystem had to quickly pivot and accelerate digital transformation to keep operations up and running, serve their consumers in a fast-changing environment, and support the needs of their employees and communities.

While companies have used technologies for decades to optimize production processes, the most forward-looking organizations have been taking advantage of advanced manufacturing not only to drive efficiency across their operations and supply chains, but also to bring a more innovative, sustainable and inclusive approach to value creation, benefiting customers, workers, society and the environment.



Three main trends are pushing companies to go beyond the transformation of manufacturing operations and to leverage investments in technology to reinvent their business models:

1

New customer needs and a constantly changing demand environment:

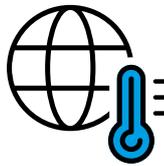
The pandemic has deeply changed how consumers select, buy and interact with products, and how they expect to be engaged by the companies producing them. Customers are now looking for frictionless purchases, transparency of product information, and personalized products, which require new levels of agility and flexibility across manufacturing and supply chains for companies to meet new needs.



2

Climate change and the imperative of a net-zero-emissions world:

Current planetary challenges have elevated the importance of manufacturing companies cutting CO2 emissions and creating circular business models where supply chains can recover or recycle the resources used to create their products.



3

Digital transformation is here to stay, and disruption will further accelerate:

To remain competitive in markets increasingly threatened by digital players and new entrants, manufacturing companies must go beyond digitalizing their operations and leveraging their investments in advanced manufacturing to transform and innovate their operating and business models.



While the case for change is clear, most companies lack clear strategies and are struggling to execute. The journey is complex, so to unpack what it takes to successfully transform operating and business models, the World Economic Forum [Global Future Council on Advanced Manufacturing and Value Chains](#) conducted in-depth interviews with over 50 leaders from manufacturing companies as well as technology and services providers. The results of this effort highlight the lessons from those who have already started to unlock business model innovation by adopting advanced manufacturing technologies.

This White Paper presents:

- Concrete examples of how leading companies are leveraging advanced manufacturing to drive business model innovation (Section 2 and the Appendix)

- Tailored guidance on key enablers and strategies, as well as guiding questions, that can help accelerate this transformation (Sections 3, 4 and 5)
- A call to action for scaling innovation across industrial players by stepping up collaboration to address systemic failures (Section 6)

The findings and lessons captured in this paper will serve as a concise reference guide for manufacturing companies to inform their strategies and go beyond the digitalization of operations by leveraging advanced manufacturing to enable new business models. Done rightly, this will give companies a new competitive edge and help accelerate responsible industry transformation and economic growth by creating and delivering new value to address the challenges of the triple bottom line for profit, people and the planet.

2

The business model innovation opportunity for manufacturing companies

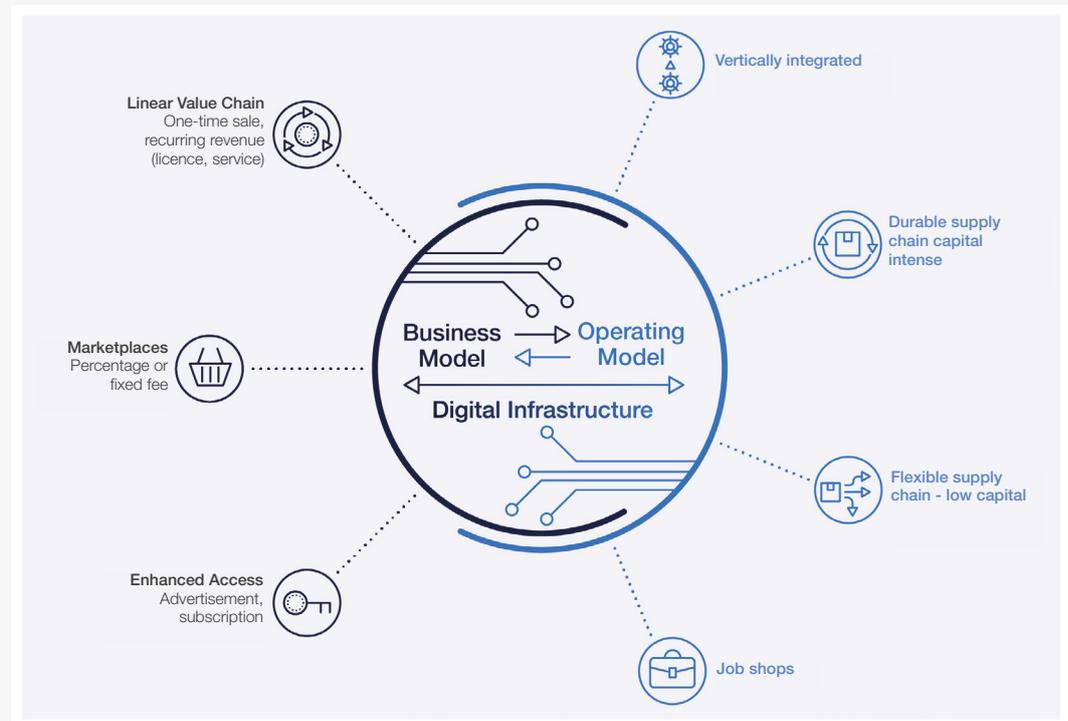
While business model innovation is not a new concept, it remains a nascent topic for many production companies. Most of them are still in the early stages of their digital transformation journeys, often focusing on step-changing the efficiency of

their manufacturing operations. To compete with digital native players and new entrants, however, a narrow focus on transforming manufacturing operations is no longer enough.



Although the terms “operating model” and “business model” are often used interchangeably, and the two are indeed tightly interconnected and mutually reinforcing, they embody very different concepts:

- The *operating model* refers to how an organization and its supply network operate to create and deliver value for customers.
- The *business model* refers to how an organization and its supply network capture the value it has created.



A more detailed explanation is available in the World Economic Forum White Paper, “[Winning the race for survival: How advanced manufacturing technologies are driving business-model innovation](#)”.

Source:
World Economic Forum

A common theme from this study is that leading companies are embracing technology to drive innovations that transform how they deliver and capture value – in other words, that transform their business models. The findings highlight four clear benefits of business model innovations:

1. Leveraging technology to address market and/or climate change disruptions
2. Anticipating and meeting customers’ new needs
3. Enabling agile, co-created innovation for new products, processes and services
4. Developing new revenue models

1. Leveraging technology to address market and/or climate change disruptions

An increasing number of manufacturing companies are starting to address system-wide failures, such as climate change or trade conflicts, through business model innovations. These include multi-sided platforms, marketplaces or ecosystems that are enabled by advanced manufacturing technologies and that allow companies to collaborate with a broader set of partners on the supply and demand sides. Thus, the companies can scale innovations faster.

For climate change, as the race to net-zero emissions becomes an imperative, companies are starting to move from linear to circular value chains to try to generate and deliver more value with the continuous recycling and reuse of the same resources. A good illustration of this is how Ralph Lauren is championing a multistakeholder collaboration to invest in solutions for true reuse, upcycling and life-cycle extension of natural fibres, which currently cannot be easily reused due to their structure. Through circular business models, the life cycle of natural-fibre products can be extended several times (see [Appendix, p. 18](#)).

Further, Procter & Gamble's Fabric & Home Care division will start producing its first paper bottle in 2022 in partnership with Paboco, a company that produces paper bottle technology. Paboco resulted from a collaborative project developed through an ecosystem of leading consumer goods companies, including Carlsberg Group, BillerudKorsnäs, The Coca-Cola Company, The Absolut Company, L'Oréal and ALPLA, with the aim of manufacturing "green fibre" bottles. It will enable a carbon footprint reduction of 90% compared to a glass bottle, and 30% compared to a polyethylene terephthalate (PET) bottle.

2. Anticipating and meeting customers' new needs

Several organizations have recognized the imperative of responding to fast-changing customer demands for customized products. They are leveraging advanced manufacturing to address this need by gaining greater insights into buying behaviours and customer choice, and innovating their business models.

Johnson & Johnson is enabling patients around the world to gain personalized and universalized access to healthcare by supplying surgeons with operating room material that meets the needs of each patient and intervention. It is also helping hospitals to optimize operations and asset management with the use of on-site 3D printing, smart cabinets and insights-as-a-service, among other solutions enabled by advanced manufacturing (see [Appendix, p. 18](#)).

3. Enabling agile, co-created innovation for new products, processes and services

By bringing buyers, sellers and enablers together, companies that use digital platforms amplify the possibilities to interact, learn and participate with all players in a given production and business ecosystem. Some companies are experimenting with marketplaces to address fragmented, non-transparent and complex value chains. They are also promoting the sharing economy to improve the use of their assets.

Marketplaces are unlocked by advanced manufacturing solutions including digital platforms, end-to-end supply chain connectivity, a robust cloud infrastructure and secure data privacy to build trust and help companies scale solutions fast. Schneider Electric recently launched the Exchange Platform, where technology providers, system integrators and end-users can collaborate and co-innovate for building digital solutions. Participants can meet remotely with experts in various locations and access online digital assets such as products, data and interfaces. They gain visibility and can create, collaborate and scale business solutions to meet customers' needs (see [Appendix, p. 18](#)).

Lanxess built an independent and neutral digital marketplace and was able to shift a traditional industry (chemicals) with a very complex value chain to a more seamless ordering process and user experience for both buyers and sellers (see [Appendix, p. 18](#)). This allowed the company to increase efficiency and transparency in the ordering process, creating value for both customers and suppliers.

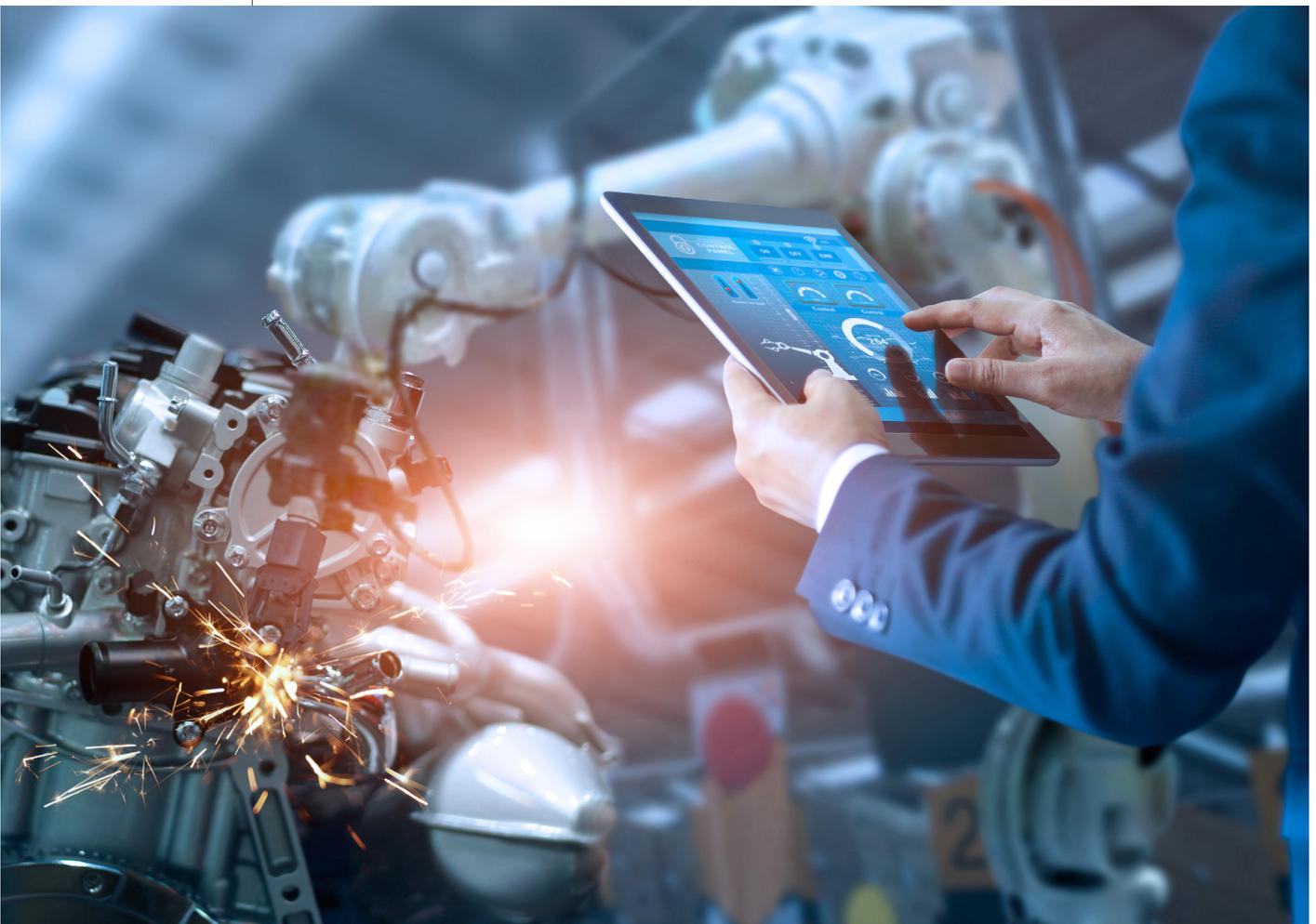
4. Developing new revenue models

Some companies have transformed the buyer-seller relationship into a partnership, which requires greater collaboration and sees performance as a shared responsibility. An example of a new revenue model is a new service from UPS, which outfits certain stores with 3D printers to provide on-demand services for manufacturers and consumers. UPS plans to use its investments in 3D printing to lay the groundwork for a network of on-demand print shops, bringing manufacturing capacity closer to consumers and thereby increasing resiliency, flexibility and reach.

New revenue models have the potential to provide manufacturers with recurring cash inflows, offer more flexibility, engage directly with customers and make the supplier a true partner in ensuring the customer's success.

3

How to unlock business model innovation through advanced manufacturing



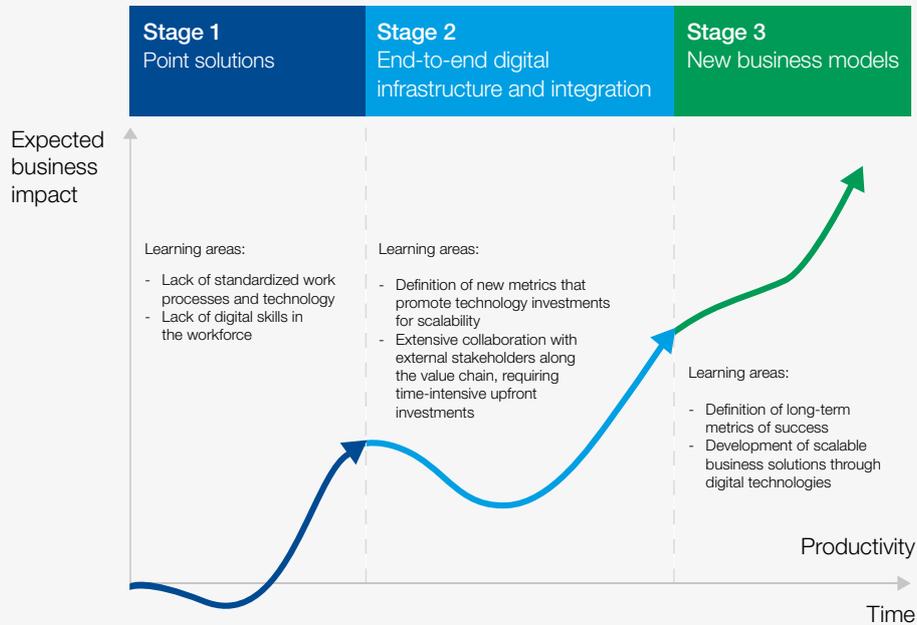
While transformation and innovation vary in pace, scope and approach, the common element from the case studies is that they all leverage advanced manufacturing to first-step-change operating models, and then enable business model innovation. They followed a journey of three main stages:

- Stage 1 – Point solutions: Advanced manufacturing boosts factory productivity

- Stage 2 – End-to-end digital infrastructure and integration: New infrastructure and strategy drive impact
- Stage 3 – New business models: Transformation at scale unlocks growth

Progress made at each stage paves the way for the following phase.

FIGURE Main stages of the journey – from point solutions to new business models



Notes: [x-axis] Productivity improvement over time: for example, labour, machine or material is measured at a whole-system level incorporating the full manufacturing value chain. The x-axis therefore spans from a single-point solution application at a particular point in the system (e.g. a machine within a factory) to the extended factory network and supply chain, through to a system-wide perspective incorporating suppliers and end users.

[y-axis] Expected business impact: in terms of margin improvement and revenue uplift, but also broader measures on sustainability/environmental, social and governance, as well as inclusivity.

The learning curves can be accelerated by leveraging the key strategies learned from leading companies and summarized in this White Paper (Section 4).

Source: World Economic Forum

Stage 1: Point solutions

Advanced manufacturing boosts factory productivity

In this first stage, companies look for ways to optimize their manufacturing operations and operating models by piloting and deploying promising point solutions in a given factory site or value chain. Point solution applications are usually created in close collaboration with a technology provider. These pilots are often focused on validating the benefits of the new solution (typically reduced operating costs and improved productivity) and testing its ease of adoption and potential to be deployed across more sites or value chains.

The business impact includes reduced operating costs and improvements in speed. The case studies from Siemens and Foxconn ([Appendix, p. 18](#)) are good examples of such point solutions, which show how advanced manufacturing, such as artificial intelligence (AI), virtual reality and predictive analytics, can fast-track throughput, support new product functionality and reduce material consumption.

While manufacturing companies are generally able to demonstrate productivity improvements through point solutions, they often face two challenges that prevent them from deploying point solutions at scale:

- A lack of work processes, data layering and technology standards across the network of factory sites and value chains, leading each site to request highly customized and expensive solutions
- A lack of digital skills in the workforce, constraining the overall roll-out timeline of new solutions based on the availability of qualified operators and new upskilling and reskilling programmes

Critically, manufacturing companies must assess their capability gaps as they move to Stage 2. Tools such as the [Smart Industry Readiness Index](#) were created in partnership with leading industry and technology companies to help manufacturers assess their level of maturity and results of the Stage 1 transformation.

Stage 2: End-to-end digital infrastructure and integration

New infrastructure and strategy drive impact

In this stage, companies aim to enable seamless end-to-end data flows and supply chain integration. For this, companies must go through a comprehensive and integrated transformation that addresses technology infrastructure and capability gaps. These include the following:

- Significant investments should be made in technology upgrades to build a solid technology infrastructure. The investments must be closely linked to the organization's business strategy.
- Strategic choices need to be made for defining clear data platform standards, implementing modern operational technology (OT) architecture, and launching new reskilling and upskilling programmes. For instance, to create clear data platform standards and integrate the diverse technologies used across all product lines (which involves discrete, batch as well as continuous processes), Johnson & Johnson has been investing for five years in building data science expertise to develop a data layering strategy closely linked to the organization's business strategy.

These infrastructure and capability investments enable organizations to:

- Roll out and scale point solutions at a low cost and reduced time across their factory network, and by integrating them across value chains
- Seamlessly connect and leverage data across the whole production ecosystem, from suppliers to customers, thus enabling breakthrough innovation and improvements in supply chain agility, cost and sustainability footprint

A good example of the benefits of such end-to-end digital integration can be found in the Schneider Electric case study ([Appendix, p. 18](#)). Its approach towards scaling and integrating solutions across networks of factory sites has helped reduce total energy consumption by 26%.

Yet, and despite the promise of significant benefits, many companies struggle to complete their move to Stage 2. Their challenges include the following:

- Technology investments are often not easily justified by short-term return-on-investment (ROI) metrics, as they normally lead to significant upfront investments in capital and human resources. Supply chain leaders struggle to make the case for the new OT infrastructure needed to scale up the deployment of solutions.

- Upfront and time-consuming investments are often required to allow for collaboration with external stakeholders along the value chain, who are critical to connecting end-users with producers and suppliers.

Those who persist and manage to make the right infrastructure investments through Stage 2, however, not only boost the efficiency and productivity of their overall operating models, but also pave the way to Stage 3, in which access to new business models is then unlocked.

Stage 3: New business models

Transformation at scale unlocks growth

The breakthrough progress made on processes and technologies during Stage 2, with the untapped data available across the wider ecosystem of supply chains, can now be leveraged to unlock business model innovation. This final stage has no prescribed journey. Indeed, not all organizations start by operating a marketplace or orchestrating ecosystems (see Section 2). Depending on their business contexts, some companies experiment with multiple opportunities in parallel, while others focus on operating model innovation by learning how to accelerate the delivery of solutions at scale that are built on the new Stage 2 infrastructure. Others work to operate within new business models orchestrated by other organizations. An example of such orchestration (see [Appendix, p. 18](#)) can be found in the discussion of RIZE's microfactories together with Microsoft's at-home manufacturing network.

As mentioned, organizations that learn to effectively use new infrastructure to improve operations and develop new business models could generate major new sources of value. That value can be created and delivered not just for companies and customers, but also for workers, society and the environment. To do so, companies must shift their attention from an internal focus (factory orientation) to an external one. This involves developing a system-wide perspective that spans factory networks, multi-actor supply chains and a wider set of business ecosystems in which they operate. Key strategies to accelerate operating and business model innovation, as emerging from the examples collected, are presented in the following section.

Value generated in unlocking new business models can be transformational and has the power to shift traditional industries at scale. To read more about the significant reductions in water consumption, waste, costs and inventory, as well as the extension of product life cycles, local production at scale and increase in revenues, refer to the case studies in the Appendix, listed in the following table.

TABLE | Leading companies are leveraging advanced manufacturing to drive business model innovation

Stage	Case study	Company
1	Mass production to rapid-manufacture anything	Foxconn Technology Group
1	Artificial intelligence for increased throughput	Siemens
2	Carbon footprint reduction enabled by digital twin	Henkel
2	Horizontal Fourth Industrial Revolution scaling for growth	Schneider Electric
3	Technology and on-demand manufacturing ecosystem	DXM Inc. (<i>consortia</i>)
3	Hybrid supply chain/towards Manufacturing as a Service	HP
3	End-to-end (E2E) smart healthcare and hospital solutions	Johnson & Johnson
3	Independent marketplace CheMondis	Lanxess
3	From “selling tires” to “selling mileage”	Qingdao Doublestar Tire Industrial Co.
3	Circular economy for textile production	Ralph Lauren
3	Distributed manufacturing ecosystems	RIZE (microfactories); Microsoft (at-home manufacturing)
3	Schneider Electric Exchange	Schneider Electric
3	Hyper-customization	Tsingtao Brewery

4

Five strategies to accelerate and capitalize on business model innovation

Given the complexity of the Stage 3 transformation, only a few leading organizations have been able to realize the full potential of their investments in advanced manufacturing to date. Despite the clear benefits and pressure to change, the journey towards business model innovation is often challenging and frustrating, and the literature is filled with examples of failed efforts.

If a company is experiencing roadblocks, it can be reassured that it is far from alone. In fact, challenges are the norm. The innovation chasm is real; traditional manufacturing organizations cannot circumvent it but must go through it. To accelerate their transformation, most advanced companies commonly leverage the following five key strategies:

1. Start with leadership and culture shifts
2. Forge system-wide collaborations
3. Adopt new metrics to measure success
4. Leverage core manufacturing strengths to close the gaps with companies with a digital core
5. Relentlessly pursue the broader purpose.

1. *Start with leadership and culture shifts*

– **Align the leadership team on the vision, goals and strategies:** The three stages of the transformation outlined in the previous section – point solutions, end-to-end digital infrastructure and new business models – are normally owned by different leaders who need to be aligned on the overall vision and approach. Point solutions are often owned by the manufacturing and supply chain functions; data infrastructure is typically owned and operated by information technology services; and overall investment or business model innovation is owned by business unit executives. This is why some companies, such as Schneider Electric, have chosen to appoint a digital transformation leader to ensure a consistent enterprise-level approach and to accelerate learning and reapplication across business units and functions (see the Schneider Electric case study in the [Appendix, p. 18](#)).

– **Call out the cultural changes needed:** Leaders must not only advocate, but also serve as role models, for the behavioural changes expected to support the transformation journey. For example, Hyperloop, an American transportation technology company, is enabled by an open consortium where all participants and team members have direct access to leadership at all times, enabling real-time guidance and strategy pivots.

- **Drive digital capabilities across the enterprise:** This should also occur at the executive level, as part of the challenge may lie in senior leaders operating in functional silos and thus taking a siloed view of the opportunities. To accelerate the transformation journey, leading players typically leverage a blend of centres of expertise to develop new digital skills and digital academies to ensure digital upskilling across all employees; this ensures that key competences are not isolated in one division but are present through all teams in charge of operations.

2. Forge system-wide collaborations

- **Scale the depth and breadth of collaborations:** Internal and external collaborations are essential at all stages of the transformation journey. As it progresses, the number of partners and the depth of the collaborations need to scale. During the *point solutions* stage, companies need to collaborate deeply with best-in-class solution providers while already bearing scale and integration in mind. In the *end-to-end data integration* stage, companies must collaborate with increasingly more parties internally and externally across the entire value chain. During the *business model innovation* stage, companies need to bring together new sets of partners and players to create a common value proposition, build trust, overcome not-invented-here biases, break old paradigms and shape win-win situations.
- **Engage with diverse partners in different ways:** Successful companies nurture fruitful collaborations with a diverse set of partners – fast-paced and unorthodox start-ups, large solution providers, universities, non-governmental organizations, suppliers, former competitors and end consumers. Managing numerous and often fluid relationships simultaneously requires collaboration intelligence at all levels and on all partners. Companies also need to build different formats to interact with diverse actors and allocate the sufficient internal resources and clear external communication of formats and channels.

3. Adopt new metrics to measure success

- **Use metrics suitable for each stage of the transformation:** Metrics need to evolve depending on the transformation stage (e.g. point solutions, infrastructure development, markets, platforms) and the life cycle of the initiative (launch, growth, maturity). This requires companies to go beyond ROI metrics as their transformation evolves:

Stage 1 – Point solutions: ROI metrics (e.g. payback periods, product improvement, internal rate of return) can remain central, as point solutions are related to an organization's current activities.

Stage 2 – End-to-end digital infrastructure and integration: Leaders must focus on the capabilities being created, and the full potential for both operating and business model transformation, instead of just measuring ROI against the current footprint of activities. Speed of infrastructure development provides an example of an alternative approach to track progress.

Stage 3 – New business models: The metrics needed vary depending on the type of operating and business model the firm is launching. Platform metrics are required for marketplaces and ecosystem business models; those metrics evolve as the business model matures. At the initial stages, the volume of interactions and their value must be considered. During the growth phase, monetization becomes critical, while at the maturity stage looking at *who, what and how to innovate* is essential to compete with other platforms' business models.

The introduction of such new metrics is challenging as goals, compensation and status are deeply tied to historical metrics, and changing metrics is often perceived as too difficult. Successful firms are doing the following:

- **Adopt new metrics in parallel with the existing key performance indicator (KPI) framework:** The firms anticipate the metrics and allow them to evolve until they are sufficiently accepted as the primary measure of performance.
- **Act despite the lack of complete information:** Firms will frequently have only some of the necessary data, but they can still proceed and iterate. As new data becomes available, they can be used to refine the metrics.
- **Make it safe to accept and pursue the implications of new KPIs:** As with the introduction of new KPIs, the performances recorded might change drastically. For example, when judged by production against output goals, a plant may score 99%. But when overall equipment effectiveness (OEE) is accurately measured in real time using digital technologies, the plant may well be performing at an OEE level of 50-60%. This KPI of course suggests great opportunity for improvement, but only if the company's leadership is prepared to encourage adherence to accurate reporting and to support change.

4. Leverage core manufacturing strengths to close the gaps with companies with a digital core

- **Maximize the use of competitive advantage:** Although manufacturing companies face the tough challenge of competing with an increasing number of digital native players, they can leverage their sources of competitive advantage.

- **Enhance the customer experience:** Deep product, market and consumer expertise can be used. It can focus on decreasing complexity and offering innovative, frictionless experiences, and on understanding and addressing customers' unmet and emerging needs.
 - **Leverage a broad and diverse supplier base:** This base can serve as a source of ideas for product and technology innovation (in the automotive industry, for example, 80% of an assembled car comes from suppliers' parts).
 - **Benefit from dedicated workforces:** They can adapt to new technology investments and have the critical product knowledge and resilience to operate through a changing environment.
5. *Relentlessly pursue the broader purpose*
- **Go beyond profit maximization to create new value for all stakeholders:** Leading companies in the production ecosystem are going beyond one-dimensional cost- or profit-maximizing strategies, striving to create value for all their stakeholders (e.g. shareholders, customers, workers, society, the environment).
- **Solve a real customer, societal or environmental need:** These companies maximize the use of their experience, expertise and connections not just to drive new business models but to do so while solving a real customer, societal or environmental need.
 - **Envision impact already in Stage 1 of the transformation and see it through to Stage 3:** Identifying the ultimate goal behind the transformation should be the approach followed right from the beginning and not undertaken as an afterthought. It is important to have business-savvy supply-chain leaders and to approach the transformation in close partnership with business leaders within the organization. This comes with a double benefit: externally, the chances of success increase as innovation solves a real problem; and internally, the whole organization becomes further proud and inspired to take an active part in a broader purpose-driven transformation journey, significantly boosting results and impact.

Five strategies to accelerate and capitalize on business model innovation

<p>1 Start with leadership and culture shifts</p>	<ul style="list-style-type: none"> - Align the leadership team on the vision, goals and strategies - Call out the cultural changes needed - Drive digital capabilities across the enterprise
<p>2 Forge system-wide collaborations</p>	<ul style="list-style-type: none"> - Scale the depth and breadth of collaborations - Engage with diverse partners in different ways
<p>3 Adopt new metrics to measure success</p>	<ul style="list-style-type: none"> - Use metrics suitable for each stage of the transformation - Adopt new metrics in parallel with the existing KPI framework - Act despite the lack of complete information - Make it safe to accept and pursue the implications of new KPIs
<p>4 Leverage core manufacturing strengths to close the gaps with companies with a digital core</p>	<ul style="list-style-type: none"> - Maximize use of competitive advantage - Enhance the customer experience - Leverage a broad and diverse supplier base - Benefit from dedicated workforces
<p>5 Relentlessly pursue the broader purpose</p>	<ul style="list-style-type: none"> - Go beyond profit maximization to create new value for all stakeholders - Solve a real customer, societal or environmental need - Envision impact already in Stage 1 of the transformation and see it through to Stage 3

5

Guiding questions to help stakeholders drive their transformation journey

A set of questions for CEOs, supply chain leaders and corporations to keep in mind can help them accelerate the three stages of the transformation and ensure it can deliver and achieve its full potential.

Key questions CEOs should ask their executives	Key questions supply chain executives should ask their CEOs	Key questions corporations should ask academia and institutions
<ol style="list-style-type: none"> 1. What and whose problem are we trying to solve? 2. What new strategic options does the initiative create? 3. How do we know if the transformation is working? 4. How strong is our end-to-end supply chain data backbone strategy? 5. Do we have a clear view of emerging cybersecurity threats? 6. How do we ensure that the sustainability aspect rather than the financial one is driving the new business model opportunity? 7. Are you and your teams comfortable with the language you use to communicate new business model concepts, such as “platform governance” and “network effects”? 	<ol style="list-style-type: none"> 1. Do you understand the cultural change needed? 2. Do you know which transformation behaviours we need to role model? 3. Are you aware that we need to adopt new metrics? 4. Do you know the required investments in people, processes and technology? 5. Are you willing to make investments in new infrastructure (change the organization) while also maintaining existing systems (run the organization)? 	<ol style="list-style-type: none"> 1. What new technologies are being developed in university laboratories that have the potential to drive operating or business model innovation? 2. What new trends are reshaping supply chains, and what assumptions are no longer true? 3. Where can universities and industry organizations help to solve standards challenges that might be slowing the adoption of new infrastructure technology? 4. What are some out-of-the-box operating and business models that can help address current system failures, such as resilient supply or climate change? 5. How should the new types of digital infrastructures and partnership opportunities that are emerging at speed be assessed and leveraged?

6

Conclusion: The path forward, a call to action

Using advanced manufacturing to change operations and foster new business models is a journey, often made treacherous by the challenges of the significant investments required, by the need to align across functions, both horizontally and vertically, and by the imperative to collaborate with a broad set of actors in the production and business ecosystem in which manufacturing companies operate.

CEOs and their executive teams must lead this journey, putting their weight behind the deep and abiding changes required and enabling the reallocation of resources as needed. While ensuring holistic coordination and ongoing dialogue across all functions and business units, they must also actively encourage and reward a growth mindset at all levels of the organization.

The biggest rewards await those who are able to leverage the transformation of operating and business models to help solve system failures. By collaborating across the ecosystem while

transforming their own business models and those of others – be they competitors, suppliers or customers – the most successful companies create and deliver new value to all stakeholders. Those stakeholders include the companies themselves, workers, society and the environment. Leaders in manufacturing should put system failure, such as resilient supply or climate change, at the centre of their transformation journeys.

Compared to certain other sectors (e.g. finance), manufacturing and supply chain organizations are just starting to explore new types of operating and business models. This means a window of opportunity is available to ensure the transformation can achieve and deliver its full potential. For this, the World Economic Forum [Global Future Council on Advanced Manufacturing and Value Chains](#) proposes the creation of a cross-company accelerator to bring together actors from across the manufacturing ecosystem to incubate and pilot new business models aimed at driving responsible industry transformation and growth.

Appendix: Case studies

Stage
1

Mass production to rapid-manufacture anything Foxconn Technology Group

	Enablers	Value generated
<p>Change story</p> <p>In the early stages of the COVID-19 pandemic, when the need for face masks far outstripped supply, the Foxconn facility at Mount Pleasant, Wisconsin decided to make face masks and ventilators. It used virtual reality (VR) to retrain its workers and assisted them in minimizing mistakes on the assembly line. Within days and weeks, not months, the plant was ready for production.</p> <p>The company was able to leverage VR and augmented reality (AR) to repurpose expertise and reconfigure its production lines to produce a new product from a different industrial space in a matter of days.</p> <p>Status: Pilot in the Mount Pleasant (USA) factory site Industry: Electronics Number of employees: 1'290'000</p> <p>Implementation challenges</p> <ul style="list-style-type: none"> - The lack of general and specific domain knowledge of the new product and industry sector, which makes technological development more time consuming and costly, also makes it difficult to justify near-term return on investments within a localized objective. - Addressing intellectual property protection, business secrets and proprietary data for organizations coming from a different industrial ecosystem to produce new products and enter new markets. 	<p>Advanced manufacturing enabling the transformation</p> <ul style="list-style-type: none"> - VR and AR assistance systems - Smart bin technology for assembly lines - Digital twin to characterize and monitor real-time system features across all dimensions of production and connect them to worker assistance systems <p>Enabling strategies</p> <ul style="list-style-type: none"> - The Foxconn iAI (industrial AI) Institute: a training platform launched by the company in the United States to disseminate the ideas and methodologies across factory sites and academia on the most impactful applications of technology - Well-established digital foundations and integration at the factory site - Innovation and collaboration mindset enabled by an outcome-based leadership 	<ul style="list-style-type: none"> ▲ The time to market for producing a totally new product at scale from a different sector reduced to weeks (vs months or years) ▲ Scrap material reduced by 10-20% ▲ Assembly time reduced by 10-30%, thanks to worker assistant systems (e.g. AR augmentation)

Source: World Economic Forum, "[Supply Chain Collaboration through Advanced Manufacturing Technologies](#)", White Paper, October 2019, p. 5.

Stage
1

Artificial intelligence for increased throughput Siemens

	Enablers	Value generated
<p>Change story</p> <p>The assembly and manufacturing of printed circuit boards (PCBs) are already largely automated, but Siemens' innovation lies in using artificial intelligence (AI) to predict quality issues during production, which helps to reduce costs and lead time by eliminating the need for extensive testing.</p> <p>Siemens has thus gained competitive advantage in a high-wage country (Germany) with high-volume manufacturing at its lead site of Amberg. This competitive advantage is made possible not through their assembly process or equipment selection, but by leveraging AI algorithms that learn how to interpret data collected through sensors to predict whether a PCB is fault-free or not. PCBs with thousands of devices are analysed in near real time thanks to edge computing, and only those in which the algorithms predict faults are sent through an inspection step (X-ray), eliminating time-consuming and costly testing efforts.</p> <p>Status: Pilot in the Siemens' Electronics Works Amberg, Germany factory site Industry: Electronics Number of employees: 293,000</p> <p>Implementation challenges</p> <ul style="list-style-type: none"> - Converting big data into smart data at scale is an onerous but essential task for bringing high volume and velocity streams to value. - Current IoT ecosystems, which are conventional manufacturing execution systems, are hardly capable of processing/storing the data loads. - Data transfer to other production plants is a major challenge from a cybersecurity point of view, as systems in the cloud/edge network are more susceptible to cyberattacks; thus, a holistic cybersecurity concept is needed. 	<p>Advanced manufacturing enabling the transformation</p> <ul style="list-style-type: none"> - AI - Machine learning - Advanced data analytics - Intelligence prediction system - Edge computing - Cloud - Real-time internet of things (IoT) integration <p>Enabling strategies</p> <ul style="list-style-type: none"> - Setting the vision of the company on rethinking quality assessment in production plants as one of the strongest drivers of efficiency - Leadership models where mistakes are allowed to happen and become a source of learning, creating a safe environment for testing new processes and technologies - Experimenting and piloting the AI-powered algorithm at one plant to validate its benefits and readiness for rapid deployment - Strong cooperation with research facilities and universities for model development 	<ul style="list-style-type: none"> ▲ Lower production costs (reduced need of X-ray machines that cost about €500,000 each), which allow for reduced cost pressure in high-wage countries ▲ Improved lead time (one inspection step less for non-fault boards) ▲ Better insight and quality assurance by tracing root causes in product failures (also leads to waste reduction) ▲ Reduced energy consumption as a consequence of reduced inspection process and material in use ▲ Deeper process know-how and higher process understanding

Source: Direct interview

Additional case studies can be found in [Global Lighthouse Network](#) reports.

	Enablers	Value generated
<p>Change story</p> <p>When the chemicals and consumer goods maker Henkel committed to reducing the carbon footprint at its production sites by 65% by 2025, it decided to drive the change not only internally but also within its industry. Investing in, developing and deploying advanced manufacturing technologies across peer networks, it now uses real-time data access and feedback to reset both internal and global benchmarks and targets.</p> <p>For instance, the high-energy laundry processes have been digitized, incorporated into a digital twin and scaled across the peer network. Thereafter, machine learning identifies optimal actions/methods and shares them with the operators to emulate. Expert systems identify deviations from the optimal.</p> <p>At the same time, these technologies enable carton-to-pantry traceability, and no-instruction-needed apps connect the shop floor with the digital twin, replacing paper and supporting monitoring from a distance.</p> <p>Status: Scaling to over 30 interconnected factory sites Industry: Chemical and consumer goods Number of employees: 52,950</p>	<p>Advanced manufacturing enabling the transformation</p> <ul style="list-style-type: none"> - Digital twin, which has enabled real-time data monitoring to provide new benchmarking across sites - A cloud-based replica of the facilities recreating operations and prescribing sustainability and safety actions through 250 online efficiency systems - 3,500 sensors deployed, and more than 1 million data points per day <hr/> <p>Enabling strategies</p> <p>Laundry Data Foundation – Ecosystem</p> <ul style="list-style-type: none"> - 3D replica of factory, fully connected to data stack - About 3,000 platform users; over 26,000 global accesses/day - 100% sustainability training = 8,500 "ambassadors" - 7,500 employees passed the corporate digital upskilling - Tripled size of in-house team of data scientists - 100% coverage of agile project methodology 	<ul style="list-style-type: none"> ▲ 10% reduction in CO₂ usage ▲ 16% reduction in total energy consumption ▲ 35% reduction in total waste ▲ 70% reduction of paper in shop-floor processes ▲ 4% reduction in total water usage

Source: World Economic Forum, "Global Lighthouse Network: Reimagining Operations for Growth", White Paper, March 2021

	Enablers	Value generated
<p>Change story</p> <p>The company experimented with advanced manufacturing solutions, such as information technology (IT)/operational technology (OT) platforms, in five lighthouse sites. In the next phase, it scaled them to more than 80 interconnected sites, integrating the solutions with its existing technology. The organization-wide transformation has been deployed at every level, from infrastructure and technology to operating modes and upskilling, with every employee engaged in driving the transformation journey. The end-to-end transformation at scale has led to substantial energy savings, a massive increase in labour productivity and a boost in on-time delivery to customers.</p> <p>Key functional-level case studies have been conducted, including digital/analytics energy management, digital maintenance and scrap reduction, automation and augmented operator, digital performance management, end-to-end planning and scheduling.</p> <p>Status: Scaling through 80+ interconnected smart factory sites Industry: Industrial automation Number of employees: 130,000</p> <p>Implementation challenges</p> <ul style="list-style-type: none"> - The first true product life-cycle management in the apparel industry, from requirements to sales and consumer feelings - Massive-scale orders planned and dispatched by cloud-enabled production network 	<p>Role of manufacturing & supply chain</p> <ul style="list-style-type: none"> - Supporting suppliers with the Schneider Supplier Portal, a cloud-based portal used with IT/OT that integrates suppliers and assists them in on-time delivery, production planning and the reduction of non-value-added activities (enabling 20% efficiency gains); the portal also allows customers to visualize the status of the order and trace each step of the process. <hr/> <p>Advanced manufacturing enabling the transformation</p> <ul style="list-style-type: none"> - Standard IT/OT platforms for faster horizontal deployment <hr/> <p>Enabling strategies</p> <ul style="list-style-type: none"> - Digital transformation office with co-located internal and external talent, paired with an agile way of working to deliver: <ul style="list-style-type: none"> - The prioritization and development of case studies across the network operating model - A transformation roadmap - Top-down global digital strategy (tailored, sustainable, connected) - Digital academy for capability building and development - Compelling change story to engage shop floor to top floor 	<ul style="list-style-type: none"> ▲ 10-26% reduction in total energy consumption ▲ 40-78% reduction in CO₂ usage ▲ 75% increase in labour productivity ▲ 40% reduction in scrap cost ▲ 25-40% increase in customer on-time, in-full delivery

Source: Direct interview

	Enablers	Value generated
<p>Change story</p>	<p>Advanced manufacturing enabling the transformation</p>	<p>▲ Manufacturing and/or finishing of goods closer to consumers, making the supply chain local</p>
<p>Five large players from apparel and manufacturing are coming together to create a new way of collaborating openly. The underlying platform and collaboration concept allows the partners to go from design to delivery of new products to customers in under 48 hours. This fast process from request to delivered products has only been possible through collaboration. DXM now seeks to provide an open platform for all apparel and footwear companies to use and change how products are produced (consumer centric and small batches) and how they are produced (distributed, by a local ecosystem), enabled by advanced manufacturing and digital tools. The business model involves a subscription model for all partners.</p>	<ul style="list-style-type: none"> - Data exchange platforms, marketplaces and open collaboration platforms - Artificial intelligence, machine learning - Internet of things, edge computing - 3D visualization and printing - Cloud - Digital ID 	<p>▲ New degree of personalization speed through building local production and a large ecosystem</p> <p>▲ Elimination of the 20%+ overproduction of garments the industry currently experiences</p>
<p>Status: Roll out Industry: Apparel, footwear, accessories</p>	<p>Enabling strategies</p>	<p>▲ Reduction of raw materials by up to 30%</p>
<p>Implementation challenges</p>	<ul style="list-style-type: none"> - Bringing together four best-in-class manufacturers and one iconic brand with multiple dynamic technology partners - Open and accessible platform for all companies (big or small); driven by a subscription model and per-unit revenue stream based on a local, sustainable unit of one and small-batch manufacturing process, therefore eliminating waste and excess - Alliance of different actors to create the microfactory for connecting to a local production and for educational purposes - Ecosystem approach with competitors in the same room - Creation of the same vision and following it across all co-founding members and consortium partners 	<p>▲ Significant reduction of carbon emission waste on freight by 20%</p>
<p>Key lessons on strengths and threats for manufacturers</p>		<p>▲ Creation of more than 400 local jobs</p>
<ul style="list-style-type: none"> - Customer needs to adapt to new model of purchasing - Pace of funding (from participating organizations and external parties) for this completely novel approach that will dictate the speed of implementation <ul style="list-style-type: none"> - Understand that capabilities to transform are innate in manufacturing, where parties are constantly learning and improving; manufacturing engineers like to build, and are thinkers and doers - Anticipate and react early to potential disruptions - Beware of the lack of a mindset to change, as well as the fear of failure for both companies and individuals - Build workforce; train and upskill 		

Source: Direct interview

	Enablers	Value generated
<p>Change story</p>	<p>Advanced manufacturing enabling the transformation</p>	<p>▲ \$14.5 million cost reductions during a pilot, representing approximately 10% savings</p>
<p>HP implemented hybrid supply chains to drive resiliency and efficiency, and to reduce the time to market by integrating novel cyberphysical technologies into production processes and supply chains for just-in-time order fulfillment. This approach, which includes the combination of rapid prototyping through 3D printers, design thinking and platforms for digital distribution of the designs, can change what and how products can be designed and manufactured. This can allow organizations to venture into completely new fields of production within days (e.g. HP was able to move from prototyping to international production of face masks in six days).</p>	<ul style="list-style-type: none"> - 3D printing - Conventional moulds - Design thinking - Sophisticated supply chain software - Advanced analytics 	<p>▲ More equal distribution of manufacturing capacities around the world</p>
<p>In a different example with HP printer products, the implementation of hybrid supply-chain capabilities, used for temporary bridging during production scale, for bridging temporary solutions during supply-chain disruptions, or for full end-of-life support of the product, has led to 10% overall savings across the entire end-to-end product life cycle.</p>	<p>Enabling strategies</p>	<p>▲ Locally resilient supply chains (2- to 10-times faster planning cycle)</p>
<p>In both examples, the centralized low-cost, high-volume supply chain in one country is complemented by an agile distributed manufacturing model that leverages 3D printing to produce parts locally, which is what defines hybrid supply chains.</p>	<ul style="list-style-type: none"> - Integrating more deeply with suppliers - Building and scaling technological capabilities - Possessing the skills and culture of rapid prototyping with customers - Applying new metrics (end-to-end product life-cycle costs) - Using data analytics for real-time decision-making - Developing a "resiliency supply chain model" with academia - Obtaining government support for the investment of local redundancy of the supply chain 	
<p>Status: Roll out Industry: Information technology Number of employees: 53,000</p>		
<p>Implementation challenges</p>		
<ul style="list-style-type: none"> - Dealing with lack of best practices for calculating product life-cycle costs - Making complex trade-off decisions - Working with nascent-stage sophisticated supply chain management software 		

Source: Direct interview

	Enablers	Value generated
<p>Change story</p> <p>Johnson & Johnson (J&J) is developing capability platforms to develop new business models to address some of the enduring challenges in the hospital and healthcare sector. It allows for patients around the world to gain personalized and universal access to healthcare, for surgeons to be supplied with material for the operating room that meet the individual needs of patients, and for hospitals to optimize operations and asset management through new insights, services and advanced manufacturing models.</p> <p>These new capability platforms include end-to-end smart solutions, with key features such as visibility via connected assets, patient-to-clinician modelling, triage and clinical event simulation, on-site/point-of-care manufacturing orchestration, and optimization of the hospital work flows and operating room features. A fully integrated, digitally connected and agile supply chain supports dynamic customer needs and generates new business model opportunities through on-site 3D printing, smart cabinets, insights as a service and other solutions.</p> <p>Different capability platforms are being tested in parallel and integrated together to create an ecosystem and value creation network across the organization, its suppliers, consumers and the broader group of stakeholders in healthcare.</p> <p>Status: Roll out Industry: Healthcare Number of employees: 127,000</p>	<p>Role of manufacturing & supply chain</p> <ul style="list-style-type: none"> – Drive and connect the supply chain innovation capability platforms to enable the new business models – Drive and enable strong collaboration between supply chain, commercial teams and research and development (R&D) teams – Shape the solution and the system; co-create with the customer and understand the customer pain points – Shape the solution in co-creation mode with customers through multiple minimum viable products – Recognize that commercial is more important now for scaling in cross-functional teams; commercial needs to develop the new business model (e.g. pricing) – Drive and enable strong collaboration between supply chain, commercial teams and R&D teams <p>Advanced manufacturing enabling the transformation</p> <ul style="list-style-type: none"> – Autonomous and agile order fulfilment for always-on delivery, enabled by smart track and trace and multi-modal delivery and logistics networks (e.g. fully autonomous suture order and inventory management solution) – Integrated flexible, modular and mobile manufacturing/ supply systems, augmented by cloud robotics and Equipment-as-a-Service for (re)configurable supply networks (supply-chain-in-a-box) – “Interface of Things”: AI-enabled vision, X-recognition/ identification systems and extended reality for real-time and smart cyberphysical connectivity between humans, machines and materials, enabling an agile resilient supply chain – Satellite 3D printing <p>Foundational:</p> <ul style="list-style-type: none"> – Internet of things (IoT) + digital twin + data science – Data used from external partners – Sensors – Integrated IoT – Digital engine/common data layer 	<ul style="list-style-type: none"> ▲ Over \$500 million in cost savings and \$500 million in capital expenditures over three to five years after project deployment ▲ Personalized products and localization ▲ Enhanced supply chain responsiveness and agility ▲ Dynamic, configurable and flexible supply systems with increased resilience ▲ Service-level improvements (overall equipment effectiveness) of 15-30% ▲ Reduction in inventory by 15-20% ▲ Shorter transportation and more efficient logistics by 60% ▲ Possible new revenue models ▲ Hospital management and improved service for the patients ▲ New insights for hospitals
<p>Implementation challenges</p> <ul style="list-style-type: none"> – Connecting data and data cleaning – Striking the right balance of ownership and governance in headquarters-subsidiary relationships – Ensuring internal (long-term) funding – Managing people and building capabilities – Structuring the common data layer 		
<p>Key lessons on strengths and threats for manufacturers</p> <ul style="list-style-type: none"> – Take advantage of data from 45,000+ customers, 105,000+ global affiliates, 2000+ suppliers, 110 external manufacturing sites and 17 internal manufacturing sites – Learn to start from the customer and business need, which should drive the digital transformation agenda; truly understand the customer and move digitization from there – Shift from an internal to an external focus – Have very strong operational excellence DNA – fact-based, executional, tracking and operational management – and apply it in a new way on digital innovation – Integrate this with a customer-driven approach – Run innovation like operations 	<p>Enabling strategies</p> <ul style="list-style-type: none"> – Integrating multiple (capability) platforms to build new business models that exploit system development – Drawing on access to rich J&J internal end-to-end data and intelligence – Collaborating broadly and partnering in the ecosystem with global innovation hubs, labs and incubators – Using a step-by-step approach to create the fully digitized network – Upskilling the workforce of the future, i.e. J&J’s Supply Chain Academy) – Building the digital operating model 	

Source: Direct interview

Change story

The chemicals sector typically has a fragmented, non-transparent and complex value chain. Numerous companies participate in some or all steps of the process, complicating the development of new products and solutions as well as relationships with customers.

In 2018, Lanxess, a traditional industry player, launched CheMondis, an independent business-to-business (B2B) platform for manufacturers and dealers, with the aim to try an entirely new business model for the chemical industry and to rethink traditional sales and marketing. Using cloud-based infrastructure, data analytics and artificial intelligence (AI)-enabled technology, CheMondis brings together chemicals expertise with technological know-how, enabling participation, collaboration and innovation. It supports B2B chemicals transactions across spot and contract markets, collects and uses real-time market data to streamline and expedite the ordering process, and provides the industry with a software platform addressing all kinds of chemical products so as to increase deal-making efficiency. More than one in five EU-based chemical companies have signed up on the platform, which currently boasts over 50,000 products with more than 5,000 verified companies participating.

Status: Roll out
Industry: Chemicals
Number of employees: 14,800

Enablers

Advanced manufacturing enabling the transformation

- Cloud-based infrastructure that can support rapid scaling and on-demand capabilities (e.g. analytics)
- Data analytics and machine learning to collect, track and monitor data and to drive new insights and solutions
- AI-enabled technology backbone across front- and back-end activities

Enabling strategies

- A focus on enhancing a personalized, easy and seamless user experience; also, investing proactively to understand the evolving stakeholder needs; and providing relevant solutions through seamless integration of complementary services and features (e.g. credit, reviews)
- Security and data privacy at the core of operations
- Orchestrating an ecosystem of key partners through consistent acquisition, onboarding and retention strategies to drive scale and efficiency of the marketplace
- Operating the marketplace as an independent operating model to encourage participation and innovation and to allow it to thrive outside of the company's policy limitations

Value generated

- ▲ A shift in a traditional industry with a very complex value chain to a more seamless ordering process and user experience for buyers and sellers
- ▲ Gross merchandise volume of about **\$1 billion** as of 2020
- ▲ About **22%** of the EU's **22,500** chemical companies signed up for its marketplace

Source: World Economic Forum, "Next-Generation Business Models: A Guide to Digital Marketplaces", June 2021

From "selling tires" to "selling mileage" Qingdao Doublestar Tire Industrial Co.

Change story

Faced with declining sales and new market forces, Doublestar invested heavily in Fourth Industrial Revolution solutions in its Qingdao plant. In 2019, Doublestar enabled an end-to-end production operating model, realizing closed-loop production from the point a customer places an order to the delivery of after-sales service.

Building on this foundation, Doublestar has unlocked a completely novel business model of customized tires and tire-as-a-service, instead of selling tires. Doublestar has upgraded its after-sales service to rent tires to customers. Internet of thing (IoT) terminals collect real-time data on mileage, temperature, pressure and vibration, and transmit them to a "tire cloud" platform. Customers are charged by mileage and are offered continuous insights and support, including pre-maintenance services.

Status: Roll out
Industry: Tire and automotive
Number of employees: 256

Enablers

Advanced manufacturing enabling the transformation

- Tire implant technology
- 5G transmission technology
- Intelligent cloud computing technology

Enabling strategies

- Setting up of a MakerNet platform, Chinatirenet, to interact with global users and through which global users and experts can participate in interaction and design
- Building of a network of partners; setting up of an ecosystem commanded by users, driven by data and operated by software
- One-stop full life-cycle service platform for car use and maintenance
- A CEO leading the Industry 4.0 transformation, who set up a digital transformation office responsible for promoting and following the transformation and upgrading of enterprises, and who established an intelligence division and project department to promote the construction of Industry 4.0
- Collaboration with a diverse set of solution and service providers and universities, as well as with large international companies including Siemens, ABB and Hyundai
- Improvement of employee skills through the internal training centre, including the cultivation of information technology and operational technology talents supported by long-term cooperation with Shanghai Fudan University

Value generated

- ▲ **10-20%** reduction in tire cost
- ▲ **70%** reduction in tire failure rate thanks to real-time early warning system
- ▲ **1-3%** reduction in users' fuel consumption
- ▲ **10%** extended tire service life
- ▲ Filling the big data gap of tire use

Source: Direct interview

Change story

To enhance the environmental sustainability of its fashion products, Ralph Lauren is championing a new circular business model – undertaking a fundamental redesign of the physical product to enable recycling, reuse and remanufacturing. Breakthrough material and process technologies, such as fibre welding, advances in dyes and dyeing, and fundamental investments in the digital technology stack, have enabled circularity and unlocked open collaboration ecosystems.

Status: Pilot
Industry: Fashion, textile industry
Number of employees: 20,300

Implementation challenges

- Identifying the right technology for product market fit and scaling, and scaling quickly
- Investing in digital technologies, as legacy players across the value chain have less mastery, resources and scale to drive highly flexible digital platform investments with the same return on investment as digital native players
- Connecting data flows end to end across the entire value chain to make information accessible to all stakeholders (both internal and external)

Key lessons on strengths and threats for manufacturers

- Engage with suppliers and leverage the supply chain as a unique source of product and technological innovation
- Leverage the knowledge of consumer needs and understanding of key tension points
- Measure success with uneven metrics if compared with digital native companies

Source: Direct interview

Enablers

Role of manufacturing & supply chain

- Lead the transformation from the executive level, with manufacturing/ supply chain playing a leading role (product, supply chain, merchandising and sustainability are all under the accountability of the same executive)

Advanced manufacturing enabling the transformation

Physical enablers:

- Advanced materials that allow for the reuse of fibre through multiple life cycles while retaining the structural integrity of the product (investments and collaboration with [Natural Fiber Welding](#))
- New ink/dye technologies that help to remove colorants from materials for true recyclability

Digital enablers:

- Back end: Supply chain and information technology architecture
- Front end: New digital sales tools

Enabling strategies

- Being a champion and ecosystem partner (as opposed to owning or controlling) to enable the development of breakthrough technologies
- Collaborating with a consortium, and involving start-ups and other brands and competitors
- Focusing on the end-customer value behind the transformation
- Approaching the transformation at the enterprise level and in parallel across at least three vectors: the (physical) product, the enabling digital technologies and the business team
- Setting clear expectations that this will be a journey and embracing a minimum-viable-product approach to drive proof of concept, incubation and scaling of new breakthrough technologies

Value generated

- ▲ Product life cycle extended several times for natural fibre products (material to go from one to three life cycles)
- ▲ Less variability in the market price of textiles, as material can remain in the value chain for longer periods of time (e.g. cotton prices increasing more than **25%** in 2021, which could have been remediated if another source of raw material had been available, such as from discarded clothing)
- ▲ Up to **50%** less water consumption during the production process
- ▲ Elimination of **10-25%** of textile waste normally produced to create the end product

Change story

Several cases started piloting variations of distributed manufacturing and could disrupt the current forms of manufacturing.

RIZE, a next-generation additive manufacturing company, is creating an alliance of actors (including Festo, Synopsys, Dassault Systèmes and Virginia Tech) to provide microfactories for connecting to local industry and educational institutions. The microfactories incorporate digital infrastructure, including 3D printing and artificial intelligence (AI)-driven software applications. Sustainable materials are used for production. Creating the microfactories allowed for locating manufacturing in underserved communities and creating adaptive workplaces, i.e. working from home or an office.

Microsoft (at-home manufacturing network) provides the technology platforms for a business model where manufacturing firms have the option of extending their manufacturing process boundaries by having access to a skilled workforce who are capable of performing as “at-home network” subcontractors and micro-entrepreneurs.

Status: Pilots
Industry: Several

Implementation challenges

- Orchestrating multiple stakeholders, such as original equipment manufacturers, micro-entrepreneurs, technology providers, logistics providers and suppliers, with a unified technology platform
- Defining a “Manufacturing resource as a Service” model for micro-entrepreneurs to get equipment and executing on the model
- Managing reliability, transparency, flexibility and quality for all
- Dealing with the lack of significant attention for policy and funding support for advanced manufacturing (AM), and that AM is not just a replacement of a traditional technology

Key lessons on strengths and threats for manufacturers

- Be aware that industry externals are aiming to disrupt current best practices and industry logics native companies

Source: Direct interview

Enablers

Advanced manufacturing enabling the transformation

- Manufacturing assets of the shared economy
- Data exchange platforms + marketplaces + open collaboration platforms
- AI/machine learning
- Internet of things and edge computing
- 3D visualization and printing
- Cloud
- Digital ID

Enabling strategies

- Open and accessible platform for all companies, big or small
- Skills to work from home with technology augmentation
- Provision of manufacturing resource as a service (new business model)
- Creation of and following the same vision across all co-founding members and consortium partners

Value generated

- ▲ Manufacturing closer to consumers, making the supply chain local
- ▲ Personalization and local production; access to a large ecosystem
- ▲ Creation of new (local) jobs
- ▲ Cost optimization
- ▲ Compression of the time to market by **10-25%**
- ▲ Lower cost of tooling by **10-90%**
- ▲ Raw material reduction of up to **60%**
- ▲ Local production of product to save time and money, and increase sustainability
- ▲ Total cost of ownership to save money and drive earnings before interest and taxes

Change story

Schneider Electric offers solutions for energy management and industrial automation to homes, commercial buildings, data centres and industries, among others. Realizing it could not fulfil the entire long tail of offerings by itself, the company invited partners of all sizes onto a platform where they could collaborate and co-innovate to build and offer digital solutions and, in return, strengthen Schneider Electric's own value proposition.

The open platform, Schneider Electric Exchange (SEE), builds on capabilities, such as connectivity to connect players across the ecosystem and at different levels of digital business, including technology providers, system integrators and end users. Participants come together remotely and access online digital assets, such as products, data and application programming interfaces (APIs), harnessing their individual expertise and collective intelligence for faster co-creation of solutions and richer learning.

This new platform-based business model now offers a wider range of services and helps all ecosystem players innovate solutions faster while reducing costs and increasing volumes.

Status: Roll out

Industry: Industrial automation

Number of employees: 130,000

Implementation challenges

- Data regulation (e.g. non-localization of data)
- Portability of business data; interoperability across sectors
- Protection of privacy with silos between personal and non-personal data

Key lessons on strengths and threats for manufacturers

- Embrace the DNA of traditional products (legacy hardware) and add the value of digital
- Be aware that legacy manufacturers typically must build off legacy technology and brownfield sites and are thus more selective when considering investments in technology that bring incremental value to the product
- Leverage legacy depth of expertise (e.g. cybersecurity is more challenging at the operational technology level)
- Create dedicated organizations to drive the transformation and in turn, help the company develop a meta skill of "how to transform"

Enablers**Role of manufacturing & supply chain**

- Make each product connectable, trackable and registered in the SE Exchange portal
- Work closely with Schneider Digital, headed by a chief data officer setting digital architecture and standards across business units

Advanced manufacturing enabling the transformation

- Connectivity of each product
- An open business/digital platform and marketplace creating a digital ecosystem
- Standard APIs, datasets, etc.
- Foundations: Cybersecurity and operational technology security

Enabling strategies

- Direct and indirect stakeholder engagement to understand their needs and create a culture of inclusiveness by enabling all players to connect, learn and participate
- C-level support to drive alignment on the marketplace proposition and execution
- Ensuring the organization culture is genuinely customer-focused
- Decreasing the complexity for customers and making their digital experience easy
- Recognizing and embracing the power of an ecosystem
- Switching from an old, siloed technology approach to real community-centric problem-solving model for customers
- Strong access management and full control of data sharing with the customers who own the data, with trust being the most important principle of the platform implementation
- Passion for sustainability, enabling collaboration and interactions across ecosystems

Value generated

- ▲ Long-tail (breadth of services) value proposition for customers
- ▲ Matchmaking across a global network of over **50,000** experts, **250** small to medium-sized enterprises (SMEs) and **500** services
- ▲ Allowing anyone who can connect to the platform to generate business. This new way of collaborating opens up new ways of working for small and medium businesses and start-ups in remote locations
- ▲ Working remotely on a common digital platform with experts and peers in various locations, which allows collaboration and co-innovation to create digital applications that are having a real impact on the sustainability sphere

Source: Direct interview; Schneider Electric, "[Schneider Electric Exchange](#)"

For more details on marketplaces, see World Economic Forum, "[Next-Generation Business Models: A Guide to Digital Marketplaces](#)", June 2021

	Enablers	Value generated
<p>Change story</p> <p>Beer consumers demand greater personalization, and the premium segment of the industry is burgeoning. Tsingtao Brewery created the industry's first online customization platform, which enables small batches of customized products and packaging to be rapidly produced for both business-to-business and business-to-consumer (B2C) sales channels.</p> <p>To realize this platform-based business model coupled with the necessary advanced manufacturing capabilities, Tsingtao had to first fully disrupt itself by transforming its 118-year-old facilities through advanced manufacturing to create an all-new, end-to-end digital value chain spanning research and development, production and sales. The hyper-customized business model is based on tailored product development – a detailed “fingerprint” for each product is created to inform product development based on demand. A flexible production model, coupled with automatic quality management, allows for rapid and flexible production, even for small batches. Best-in-class supply chain analytics reduce distribution inefficiencies and shorten lead times. More accurate demand forecasting reduces product change and increases overall equipment effectiveness.</p> <p>This mass customization and B2C online ordering has cut the minimum order size by 99.5%. By improving its ability to know and respond to customer preferences, Tsingtao has experienced genuine growth and improved consumer preference for its brand.</p> <p>Status: Roll out Industry: Food and drink Number of employees: 35,000</p>	<p>Advanced manufacturing enabling the transformation</p> <p>Intelligent flexible production line supporting customized production</p> <ul style="list-style-type: none"> – Cloud communication: production system connected with sales system; recognizes the customized order simultaneously – Flexible sorting: based on machine vision system, customized production is implemented on a 60,000 cans/hour high-speed production line to simultaneously produce 20 varieties <p>AI-based forecasting and planning system</p> <ul style="list-style-type: none"> – Demand forecasting: based on historical data and factors such as “promotions” and “weather”; apply “neural network”, among others, to predict sales – Information traceability: production, logistics, sales; customers view product information and monitor product freshness, among others, via radio frequency identification <p>Enabling strategies</p> <ul style="list-style-type: none"> – Cooperation with Jiangnan University and Ocean University of China in the application of digital decoding technology – Creation of the Industrial Internet Academy to improve employee skills and training of 167 digital professionals – The century-old plant built into a digital and transparent plant/museum that receives 1.5 million visitors annually – Digital transformation culture communicated to employees at all levels of the company (e.g. a person one year from retirement learned how to operate a smart warehouse) 	<ul style="list-style-type: none"> ▲ Customization and customer experience: special edition design and online DIY plus augmented reality/3D model preview, and more than 200 customized products ▲ 14% revenue increase while overall volume increased by only 2% in the same period, thanks to product mix change towards customized beers (from 0% to 31% of total volume) with an average 53% higher selling price ▲ 28% profit increase thanks to same product mix change (+25% profit per kilolitre) ▲ 55% decrease in order lead time for customized products ▲ 50% improvement in new product development lead time ▲ 33% reduction of the grain loss rate in the brewing process ▲ 19% reduction in electricity consumption per unit of product ▲ 5% reduction in water consumption per unit ▲ 11% reduction in coal consumption per unit

Source: World Economic Forum, “[Global Lighthouse Network: Reimagining Operations for Growth](#)”, White Paper, March 2021

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