

Complex Manufacturing Outlook: Emerging Trends and Opportunities

An Executive-focused Survey



This study was conducted in partnership with:
FROST & SULLIVAN

syspro

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Report Objective and Aim

Modern manufacturing is complex. Efficiently managing supply chains and production processes is key.

There are two areas that all manufacturers must manage carefully – their supply chains and manufacturing processes. The more complex the manufacturing process is, the more challenging it becomes to efficiently manage people, processes, and systems.

As modern manufacturing operations get more and more dynamic, manufacturers need to manage the flow of parts, as well as consistently assess how to keep costs low while ensuring timely production.

Around the world, manufacturers also face the challenge of finding experienced people to manage the complexities of their manufacturing environment.

In this research study conducted by Frost & Sullivan, we surveyed small and medium-sized complex manufacturers to assess the current state of technology adoption and emerging trends poised to drive innovation in complex manufacturing.



Project Aim

Syspro, a prominent global ERP provider, has partnered with Frost & Sullivan, a leading market intelligence and strategy firm, to provide an analytical overview of the state of Complex Manufacturing and 4IR technology adoption. This initiative specifically targets Complex Manufacturers across North America, Europe, Asia-Pacific, and Africa.

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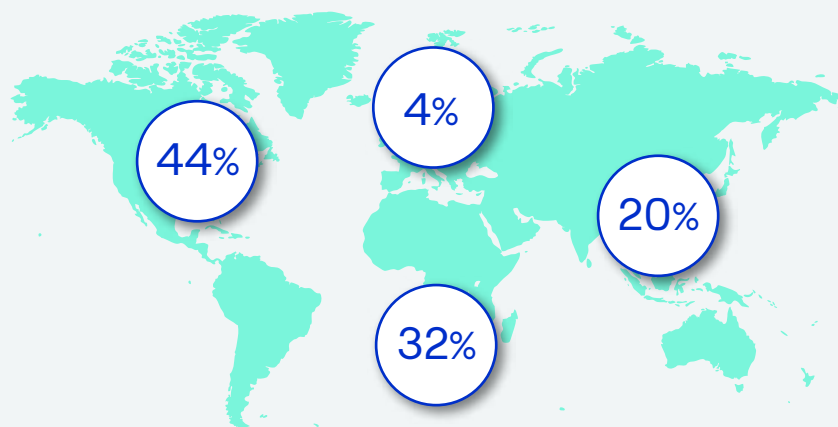
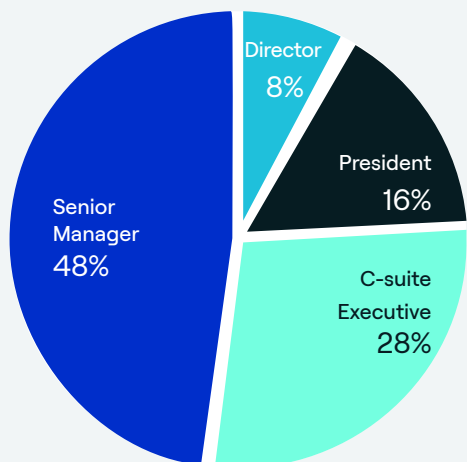
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Data Collection and Analysis Process

Frost & Sullivan's team of experienced consultants extracted over 360 data points from in-depth interviews and 290 online survey data points from executives across four regions.

Survey Demographics:

Participant Job Titles and Regional Distribution



Research Methodology

This study was conducted using a structured, iterative approach, integrating both primary and secondary research to capture insights and regional distinctions in Complex Manufacturing practices and the adoption of advanced technologies.

The primary research—serving as the core data source—involved structured discussions and detailed surveys designed specifically for senior stakeholders involved in Complex Manufacturing Operations. Frost & Sullivan's team of experienced consultants extracted over 360 data points from in-depth interviews and 290 online survey data points from executives across four regions. Our senior team, which has extensive industry knowledge and experience, carefully analyzed these insights. technology adoption and emerging trends poised to drive innovation in complex manufacturing.

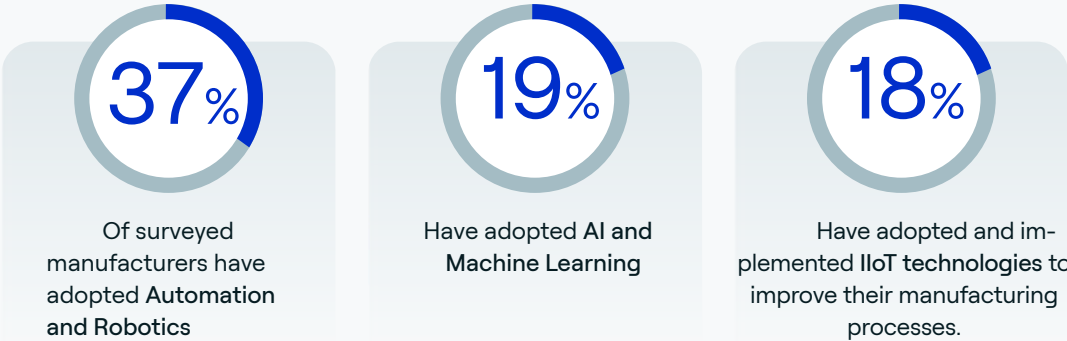


Key Takeaways

Complex manufacturers are steadily embracing smart technologies. However, high costs and resistance to change remain key barriers.

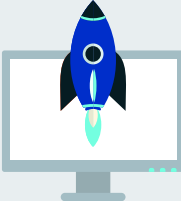
Technology Adoption Trends:

Complex manufacturers are embracing smart technologies, with six promising and emerging technology categories.



Productivity Gains from New Technologies:

Small and medium-sized manufacturers witnessed a productivity improvement of 26% to 50% by adopting emerging technologies like AI, Big Data, and Robotics.



Digital Readiness Across Different Regions:

While the USA leads in digital readiness, it struggles with slow technology adoption in small- to mid-tier manufacturing. China leads in adoption with 45% of manufacturers adopting emerging technology.



Investment in Sustainability Initiatives:

Almost 50% of the respondents mentioned investment in sustainable technologies, with North America and Europe leading in implementations.



Key Barriers and Mitigation Strategy:

High upfront costs and resistance to change are key barriers to technology adoption. Overcoming them requires executive buy-in, a clear implementation plan, and a robust support team.

Future Outlook

Smart factories are poised to lead Complex Manufacturing, with AI, automation, IIoT, digital twins, and ERP systems enhancing efficiency, real-time visibility, and workflow optimization.

As data drives these advancements, strong cybersecurity is critical to protecting against cyber threats and ensuring secure and resilient operations amid growing technological complexity.



of manufacturers note the need for cybersecurity.

Industry 5.0 is the long-term guiding force directing innovation in Complex Manufacturing

Complex Manufacturing executives must anticipate and incorporate Industry 5.0's future opportunities into their current outlook.

Industry 5.0 marks a transformative evolution in manufacturing, blending human creativity with smart technology to enable sustainable production, and will ultimately determine the direction of innovation and the development of innovative technologies in Complex Manufacturing for the foreseeable future.

Many executives prioritize Industry 4.0's immediate opportunities in shaping their short-term strategies but should also anticipate the transformative opportunities of human-machine collaboration (cobots). Early investment is a strategic imperative for manufacturers to leapfrog competitors and achieve early gains.

Unlike Industry 4.0's technology-driven approach, Industry 5.0 prioritizes cobots to enhance decision-making and problem-solving at all employee levels¹⁹.

This shift supports a value-centric model that improves efficiency, addresses social and environmental challenges, and fosters a balanced ecosystem of innovation and sustainability in manufacturing.

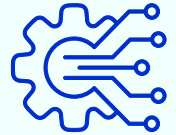


Trends Shaping the Complex Manufacturing Sector

Survey respondents identified six key trends, ranked by importance, shaping advanced technologies in Complex Manufacturing globally.

01

Emerging Smart Technologies



02

Investing in Sustainability



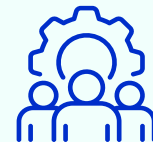
03

Evolving Government Policies



04

Workforce Development



05

Supply Chain Resilience



Trends Prioritised and Identified in the Frost & Sullivan Survey

06

Mass Customization



Trends Identified from Secondary Sources

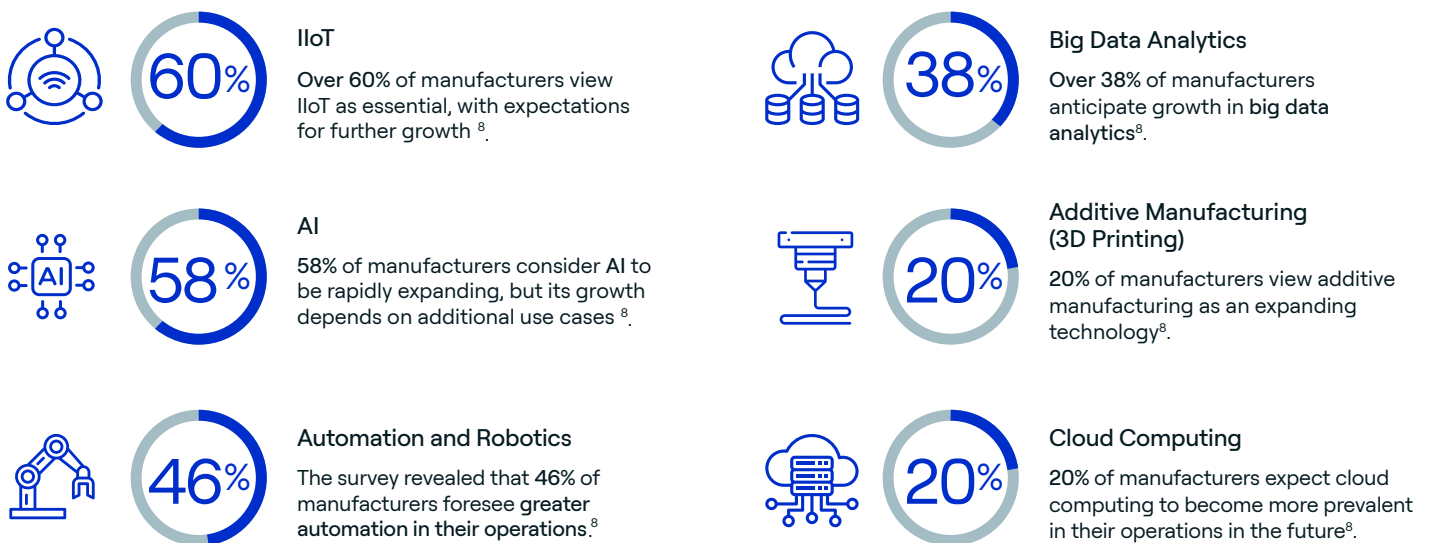
Trends Shaping the Complex Manufacturing Sector

The analysis identified six emerging technologies, with over 55% of complex manufacturers recognizing IIoT and AI as the most promising technologies.

01 Emerging Smart Technologies



The survey identified six emerging technologies shaping and impacting the sector.



Regional Distribution Of Technology Implementation

North America

The USA is a major hub for Complex Manufacturing benefiting from high digital readiness. However, it struggles with modernising legacy systems, resulting in a slower technology adoption rate that threatens its competitive edge¹¹.

Europe

Germany excels in Complex Manufacturing, prioritizing innovation and high-quality production. Smart technology aligns manufacturing practices with ESG principles, driving rapid advancements in sustainable production⁵.

South Asia

China leads in Complex Manufacturing, housing 45% of technologically advanced manufacturing firms¹², but faces sustainability challenges, with policies shifting towards greener practices.

Trends Shaping the Complex Manufacturing Sector

Evolving ERP systems and the adoption of smart technologies within factory operations lay the foundations for the expansion of smart factories.

01 Emerging Smart Technologies: The Rise of Smart Factories



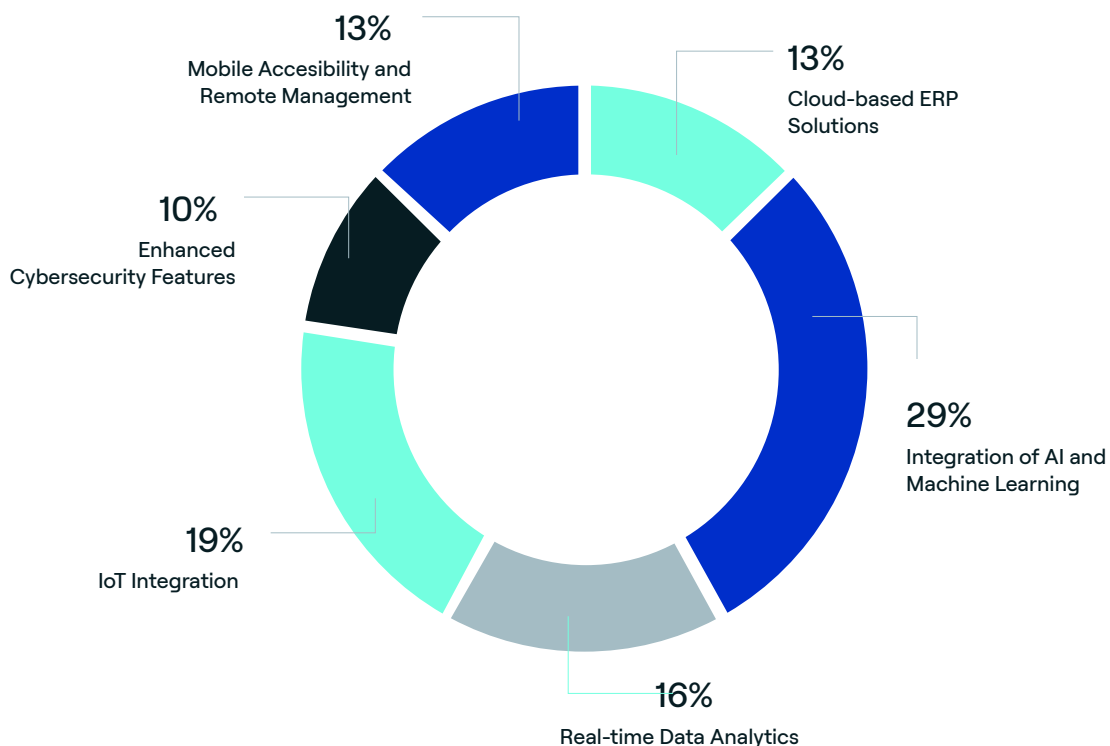
The emergence of smart technologies is leading to a rise in smart factories.

Smart factories shorten supply chains by directly sourcing inputs from suppliers, bypassing the need for overseas warehousing. Advanced technologies allow on-demand manufacturing for customized demands^{1,6}.

These factories integrate Industrial Internet of Things (IIoT), AI, digital twins, and Enterprise Resource Planning (ERP) systems to provide real-time visibility and prevent disruptions¹⁶. ERP modernization is a key priority, for manufacturers increasingly shifting to cloud-based solutions as it provides enhanced scalability and security, seamless data integration, and readiness for AI advancements².

As ERPs are rapidly replacing legacy systems for data centralization, cybersecurity becomes crucial. This is driving significant investments in protecting operations against cyberattacks⁷. Nearly 30% and 20% of respondents, respectively, observe that AI and IIoT are becoming integrated into ERPs for efficiency gains.

What are the emerging trends and recent technological advancements in ERP systems that are being adopted by the Complex Manufacturing sector?



Trends Shaping the Complex Manufacturing Sector

Approximately 50% of complex manufacturers are investing in sustainable technologies, with 26% seeing a marked reduction in their carbon footprint and waste when utilizing select technologies.

02 Investing in Sustainability



Around 50% of the surveyed respondents revealed investments in sustainability initiatives to reduce their environmental impact. However, over 38% of the respondents prioritize sustainability for waste and cost reduction⁸.

The application and implementation of advanced technologies offer notable advantages for reducing carbon footprints and waste:

- IoT sensors use early detection to prevent breakdowns and reduce energy use, emissions, and downtime¹².
- AI enables better resource management and identifying consumption patterns. AI-driven predictive maintenance extends equipment life and conserves resources.
- Additive manufacturing reduces material waste and supports on-demand production, lowering inventory and transport emissions.
- Digital twins allow virtual simulation of production, optimizing resource allocation and reducing waste¹².



In our industry, we are using advanced technologies to enhance production methods and improve waste management, which has significantly reduced wastage.

Owner, Food Manufacturer, Asia-Pacific



What technological advancements are you witnessing due to sustainability and environmental considerations?



26%

Carbon Footprint Reducing Technologies



19%

Energy Efficiency Improvements



16%

Waste Reduction Technologies



16%

Integration of Renewable Energy Sources



13%

Water Conservation Innovations



10%

Pollution Control Technologies



Our company aims to reduce its environmental footprint by reusing components from decommissioned equipment in operational machinery. However, this process is still nascent.

Director, Mooring Equipment Manufacturer, Asia-Pacific



Trends Shaping the Complex Manufacturing Sector

The impact of government policies and supporting investments varies significantly across regions. In North America and Europe, government policies are heavily supporting smart technology investment.

03

Evolving Government Policies

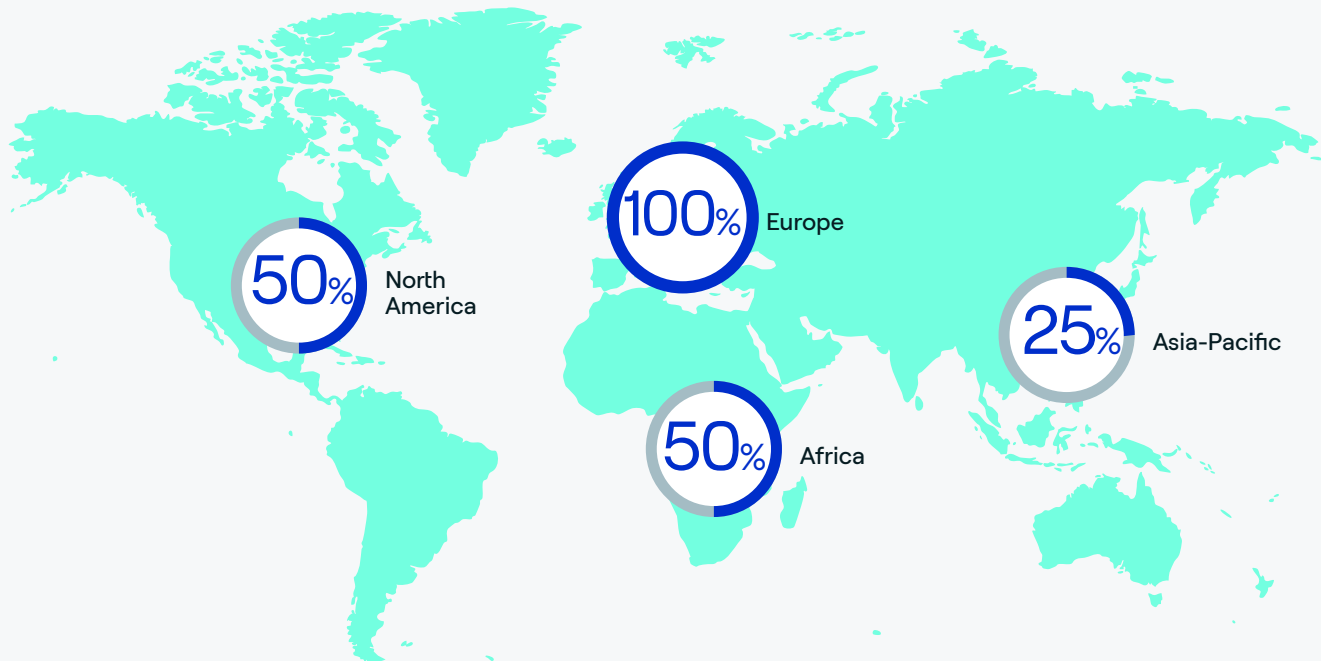


To ensure advancement in the manufacturing sector, governments worldwide are implementing policies to incentivize investment, upgrade infrastructure, and develop skilled workforces⁸.

Government policies have significantly impacted European innovation, with all respondents reporting positive effects. In contrast, North America and Africa showed weaker influences, with only 50% of respondents noting government impact, and Asia-Pacific seeing the least, at 25%.

The USA and Europe prioritize localization and green technologies due to competition and geopolitical tensions with China^{4,8}.

Has government policy influenced investment and innovation in Complex Manufacturing? Respondent agreement, by region



“

Government policies are boosting investment in advanced technologies, with European Union (EU) grants and subsidies fueling innovation.

Senior Manager, Industrial Machinery Manufacturer, Europe

”

Trends Shaping the Complex Manufacturing Sector

Developing talent for human-robot collaboration is vital, while reshoring and supplier diversification strengthen supply chain resilience.

04 Workforce Development



Human-robot collaboration is crucial in Complex Manufacturing⁸. Consequently, manufacturers are investing in Augmented Reality (AR) and Virtual Reality (VR) training, smart workstations, and mobile training apps and are paying for scholarships in Smart and Advanced Technologies in Manufacturing-related degrees to build talent^{7,8,19}. AR will empower workers with disabilities to perform tasks on par with their able-bodied colleagues – unlocking an untapped workforce¹⁹. Hybrid work models and ongoing training are keeping employees up to date with evolving technologies⁷.

“ AR is a very exciting technology with transformative potential, particularly for individuals with disabilities, that will redefine approaches to training and workplace operations.

President, Software Company, Asia-Pacific



05 Supply Chain Re-evaluation



Survey participants cited that geopolitical tensions and climate change are straining supply chains, leading to long lead times, limited flexibility, and rising labor costs^{8,9,18,19}. To build resilience, complex manufacturers are reshoring operations, diversifying suppliers, and shifting to 'Just-in-Case' and Products-as-a-Service models^{8,19}.

Analysis of Supply Chain Response Strategies:

Understanding the benefits^{8,9,19}



Reshoring⁹:

- Shortens the supply chain
- Lowers transportation and logistical costs



Changing to 'Just-in-Case'¹⁹:

- Increases flexibility to ever-changing demand
- Lowers wasting raw materials



Products-as-a-Service⁸:

- Subscriptions are a constant source of revenues instead of once-off
- Can increase customer loyalty which means returning business

Trends Shaping the Complex Manufacturing Sector

Complex Manufacturing is shifting towards mass customization, with data analytics underpinning and enabling this transition.

06 Mass Customization

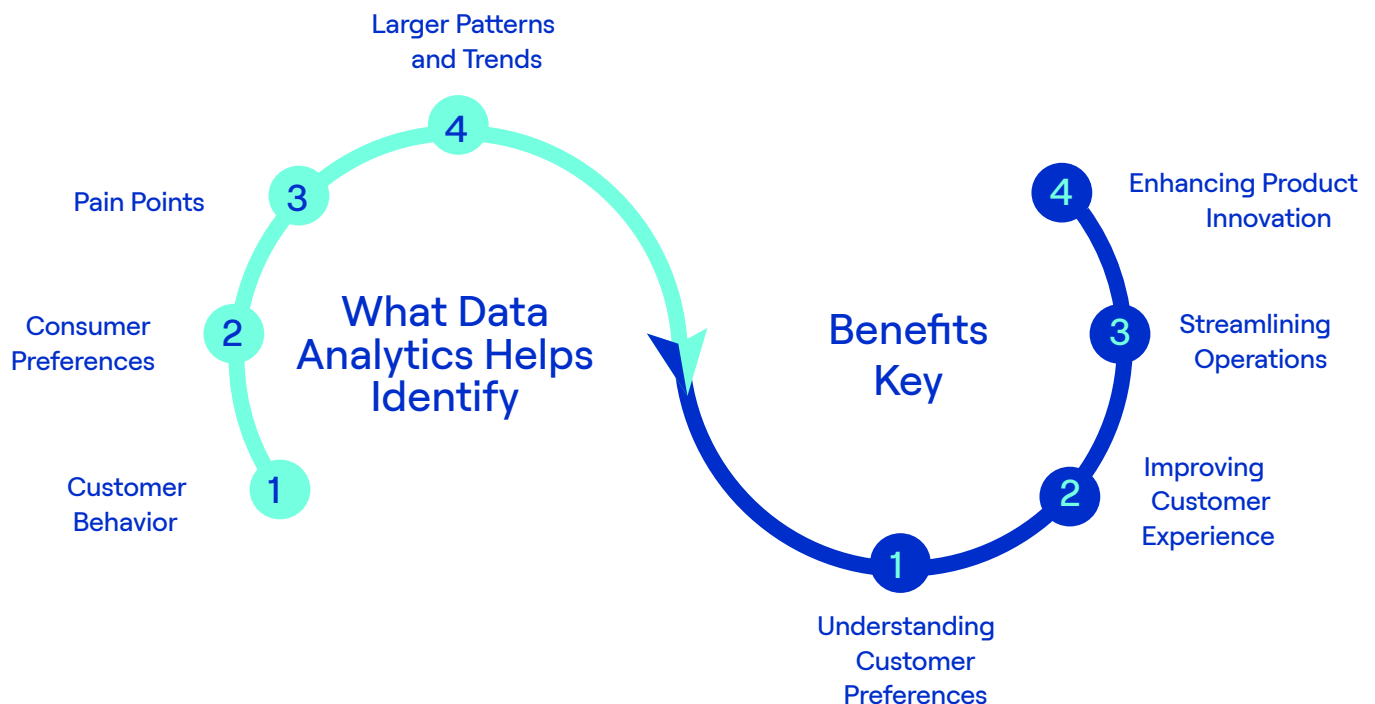


Complex Manufacturing is shifting to large-scale customization, combining mass production efficiency with product flexibility¹⁶. Personalization is replacing the one-size-fits-all strategy in business-to-customer (B2C) and business-to-business (B2B) interactions, supported by advanced technologies that enable real-time adjustments¹⁶. In B2C interactions, end-users can now directly request manufacturers to tailor products to meet their unique needs¹⁶.

Data analytics is core to mass customization, enabling manufacturers to identify customer behaviors, preferences, pain points, and broader trends⁶. These insights support product tailoring, improving operations, and cost reductions⁶. AI further enhances this process by predicting customer preferences¹⁶.

The Significance of Data Analytics in Mass Customization:

Understanding what data analytics identifies and the associated benefits⁶



Adoption of Technologies in Complex Manufacturing

More than 50% of complex manufacturers are still in the early to intermediate stages of implementing advanced technology.

The study revealed that some sectors rapidly integrate innovative technologies to boost efficiency, quality, and competitiveness⁸. While others lag due to limited resources, outdated infrastructure, and unclear digital strategies⁸. Technology adoption is relatively slow with the survey indicating that many manufacturers are still in the early stages, with most companies piloting or partially implementing technologies. None of the survey participants have fully implemented these technologies⁸.

“

Our company regularly explores advanced technologies as options to enhance our operations and maintain a competitive edge. Our current focus is on piloting AI.
Senior Manager, Electrical Components Manufacturer, Africa

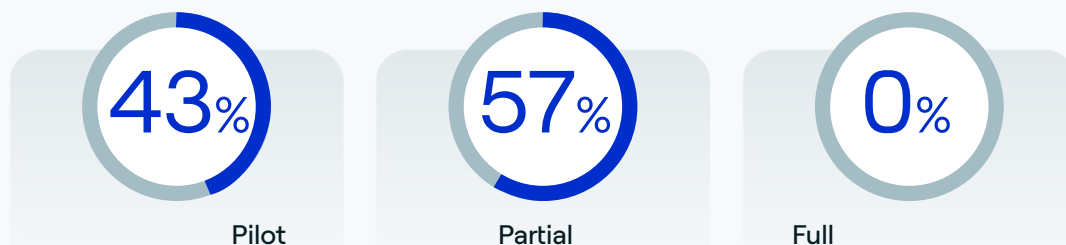
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Interviews highlight rapid IIoT adoption for real-time decisionmaking and efficiency, while AI⁸, though slower to adopt, is transformative, with Generative AI unlocking data-driven strategies and operational optimization¹³.

Which Advanced Manufacturing technologies are currently being incorporated into your operations?



At what stage are these technologies currently implemented?



Digital Competitiveness Across the World

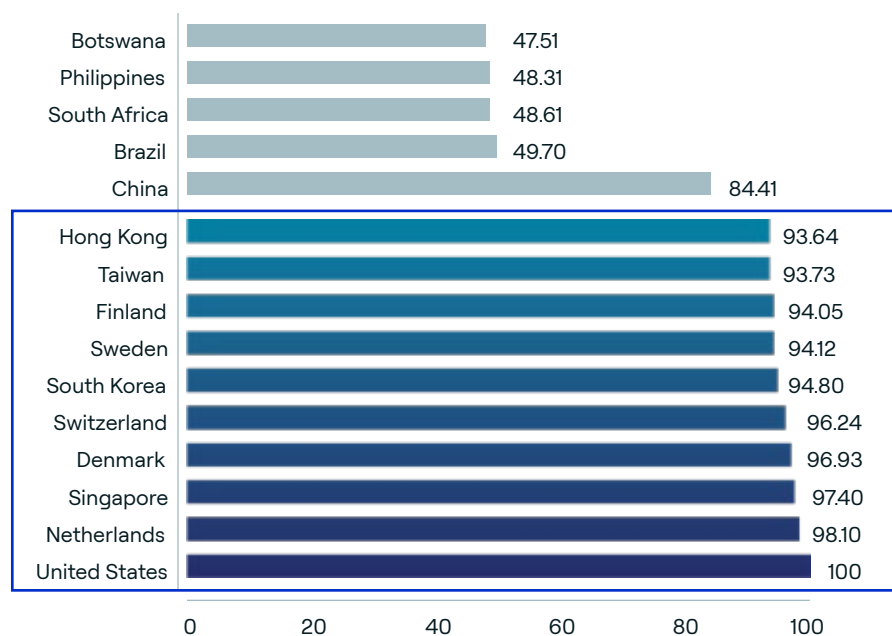
The adoption of advanced technologies and resultant digital competitiveness varies significantly by region.

As previously noted, technology adoption differs widely across the regions analysed, driven by evolving industry demands, financial capacities and limitations, and access to advanced technologies.

The USA, with a digital level of 100¹⁰, prioritises digital transformation to alleviate the effects of labour shortages and to reduce operating costs⁷.

On the other hand, in South Africa, a country with a digital competitiveness rating of 49¹⁰, manufacturers prioritise maintaining competitiveness and meeting customer demands and emphasise less on adopting smart technologies⁷.

Digital Competitiveness Worldwide, 2023¹⁰



“ I think one of the biggest reasons we are adopting these technologies is because of an aging population and a lack of qualified workers in the marketplace.

President, Software Solutions Provider, North America



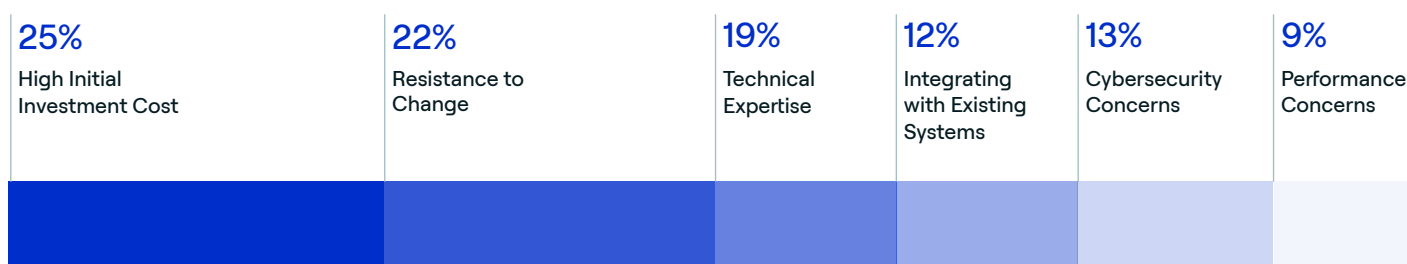
“ We have invested heavily in Automation, but AI, no. We do not know the cost or how anyone else has used it. Of course, we plan on investing in these technologies if they improve operations, but for now, we have only invested in Automation.

Managing Director, Food and Beverage Manufacturer, Africa

Challenges Hindering Implementation of Technology in Complex Manufacturing

25% of complex manufacturers cite high upfront costs, and 22% point to resistance to change as key barriers to technology adoption.

Top 5 key challenges and limitations hindering the uptake of these technologies?



01



High Initial Investment

25% of companies report that high upfront costs are the **biggest** barriers to adopting cutting-edge technologies⁸. Despite offering long-term benefits, the initial financial burden can be overwhelming, especially for mid-sized or budget-constrained firms⁸.

02



Resistance to Change

The second biggest barrier cited, at 22% of respondents, is resistance to change. Many organizations focus on current and not future operations, which complicates lobbying for and investment in new technologies⁸. Skepticism about these technologies' impact on efficiency and value addition creates further barriers to adoption.

“

The main problem we encountered was that decision-makers did not know how to implement or manage the technology.

CEO, Technological Solutions Provider, Africa

”

Challenges Hindering Implementation of Technology in Complex Manufacturing

As manufacturers integrate more digital solutions, the lack of technical expertise, noted by 19% of complex manufacturers, hinders the implementation process.

03



The Lack of Technical Expertise

19% of respondents indicated that a shortage of skilled professionals to implement and manage new technologies remains a key challenge. Manufacturers also note that their workforce may struggle to use these solutions without proper training⁸.



One of the most significant issues the industry faces is the absence of skilled labour. Companies are recognising this fact and are trying to lessen these knowledge gaps.

President, Software Solutions Provider, North America



04



Integration with Existing Systems

43% of respondents cited that integrating advanced technologies is complex, requiring time for technology alignment, staff training, and resource allocation⁸. While it can initially disrupt operations, the long-term benefits provide substantial value to manufacturers⁸.

What technical difficulties have organizations faced when integrating new technologies with existing systems?

43%

Complexity of Integration

29%

Other

14%

Compatibility Issues

14%

Performance Degradation

Challenges Hindering Implementation of Technology in Complex Manufacturing

As manufacturers are more digitally connected, cyber threats become more prevalent and increasingly expensive, as noted by more than 50% of complex manufacturers.

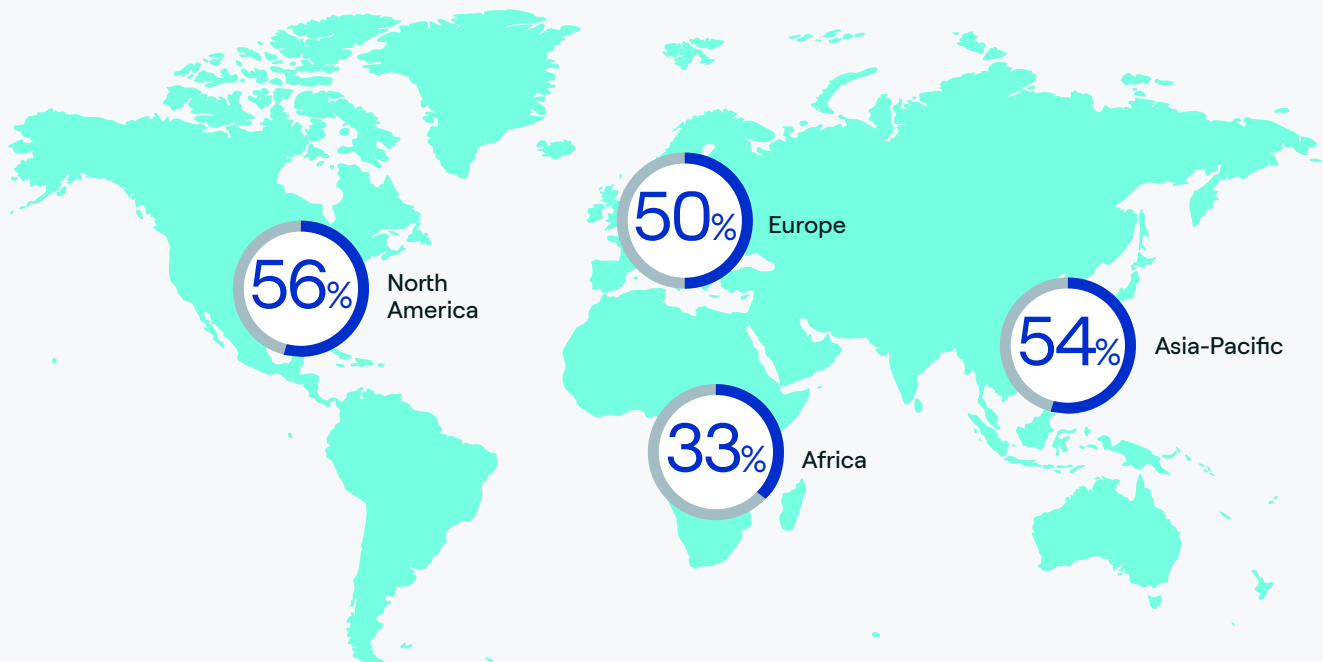
05



Cybersecurity Concerns

The Complex Manufacturing industry faces growing cybersecurity challenges due to increased connectivity and reliance on digital technologies. Many organizations surveyed acknowledged previously under-prioritizing cybersecurity, which created vulnerabilities that risked disruptions and financial losses⁸. Over 50% of industry experts in North America and Asia-Pacific view cybersecurity as a critical concern⁸. As manufacturers further innovate and integrate new technologies, prioritizing cybersecurity will be essential to protecting operations and maintaining competitiveness.

Is cybersecurity a concern for your company or the industry?
Respondent agreement, by region



“

Despite greater cybersecurity awareness, companies must implement stronger safeguards to effectively protect themselves against cyberattacks.

CEO, Software Service Provider, North America

”

Mitigating the Challenges of Implementing Technologies

Securing executive buy-in, developing an implementation plan, and investing in a strong support team are key strategies to overcome challenges during technology implementation.

Pre-Inception Planning and Explaining^{8,14}

Pre-planning eases concerns about adopting advanced technologies and prepares for future challenges¹⁴. A detailed report highlights the urgency of adopting these technologies to remain competitive, urges immediate investments, and suggests phased financial strategies to spread costs¹⁴.

The survey revealed that manufacturers often underestimate timelines⁸. Setting realistic timeframes ensures effective resource allocation, smooth integration with existing systems, and better expectation management.



Management Support and an Interfunctional Project Team¹⁴

C-suite Executives (CXOs) who lead or support the project are key for building momentum, securing buy-in and addressing resistance. Their leadership fosters ownership, easing fears and skepticism about the benefits of implementing technologies.

A skilled, cross-departmental team fosters buy-in by showing the relevance of advanced technologies for simplifying tasks.



Prioritising Hiring and Investing in Development¹⁴

Effective hiring and training are essential for reducing risks in technology adoption. Recruiting skilled workers ensures the expertise needed for successful implementation, while tailored training equips existing employees to adapt.

This strategy improves workforce competency, fosters continuous learning, reduces resistance, and builds confidence in new technologies, all of which lead to smoother integration and better performance.



“

Our company realised that departing employees held unique expertise in using our advanced technologies. To preserve these competencies, we now train many employees during and before new implementation phases.

President, Software Solutions Provider, North America

”

Insights and Conclusions: A Summary of the Key Findings

Successful adoption of technology in Complex Manufacturing hinges on strategic planning, investment in talent, and robust cybersecurity measures.



The adoption of advanced technologies remains a critical priority for complex manufacturers seeking to optimize operations and maintain competitiveness. Smart technologies, such as automation, robotics, AI, and IIoT, are increasingly shaping the industry by streamlining processes and enhancing efficiency.



Automation and robotics stand out as the most widely adopted technologies, with 37% of respondents identifying them as integral to their operations. These technologies offer immediate benefits, including precision in assembly lines, stringent quality control and wastage reduction, while their seamless integration with existing systems accelerates adoption.



Other smart technologies are gaining traction at varying paces. AI, adopted by 19% of respondents, holds significant future potential despite its slower implementation rate. Its ability to improve data analytics, optimize maintenance, and minimize downtime positions it as a disruptive force in the industry. IIoT, adopted by 18%, is seeing a slightly faster uptake, valued for enabling real-time, data-driven decision-making and enhancing operational efficiency.



Regional adoption trends highlight diverse priorities. In Africa, manufacturers focus on automation and robotics to maintain competitiveness and meet customer demands, while in North America and Europe, digital transformation addresses labor shortages and reduces operating costs. Sustainability is a shared priority, with 50% of manufacturers investing in eco-friendly technologies to reduce their environmental impact and meet ESG goals. Europe and North America, in particular, are leveraging AI, IIoT, and additive manufacturing to advance sustainable production practices.



Legislative initiatives, such as EU directives, are accelerating technology adoption in Europe, while North America addresses workforce challenges through innovation. In Africa, the focus is on building robust processes to support the integration of new technologies, underscoring the varied approaches to navigating the industry's smart technology landscape.



List of Abbreviations

Abbreviation	Definition
4IR	4th Industrial Revolution
AI	Artificial Intelligence
AR	Augmented Reality
B2B	Business-to-business
B2C	Business-to-consumer
CXO	C-suite Executives
ERP	Enterprise Resource Planning
ESG	Environmental, Social, Governance
EU	European Union
IIoT	Industrial Internet of Things
IT	Information Technology
USA	United States of America
VR	Virtual Reality

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