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Confederation of Indian Industry

Manufacturing Innovation Conclave 2022

Industry 4.0: From vision to action

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Foreword by CII

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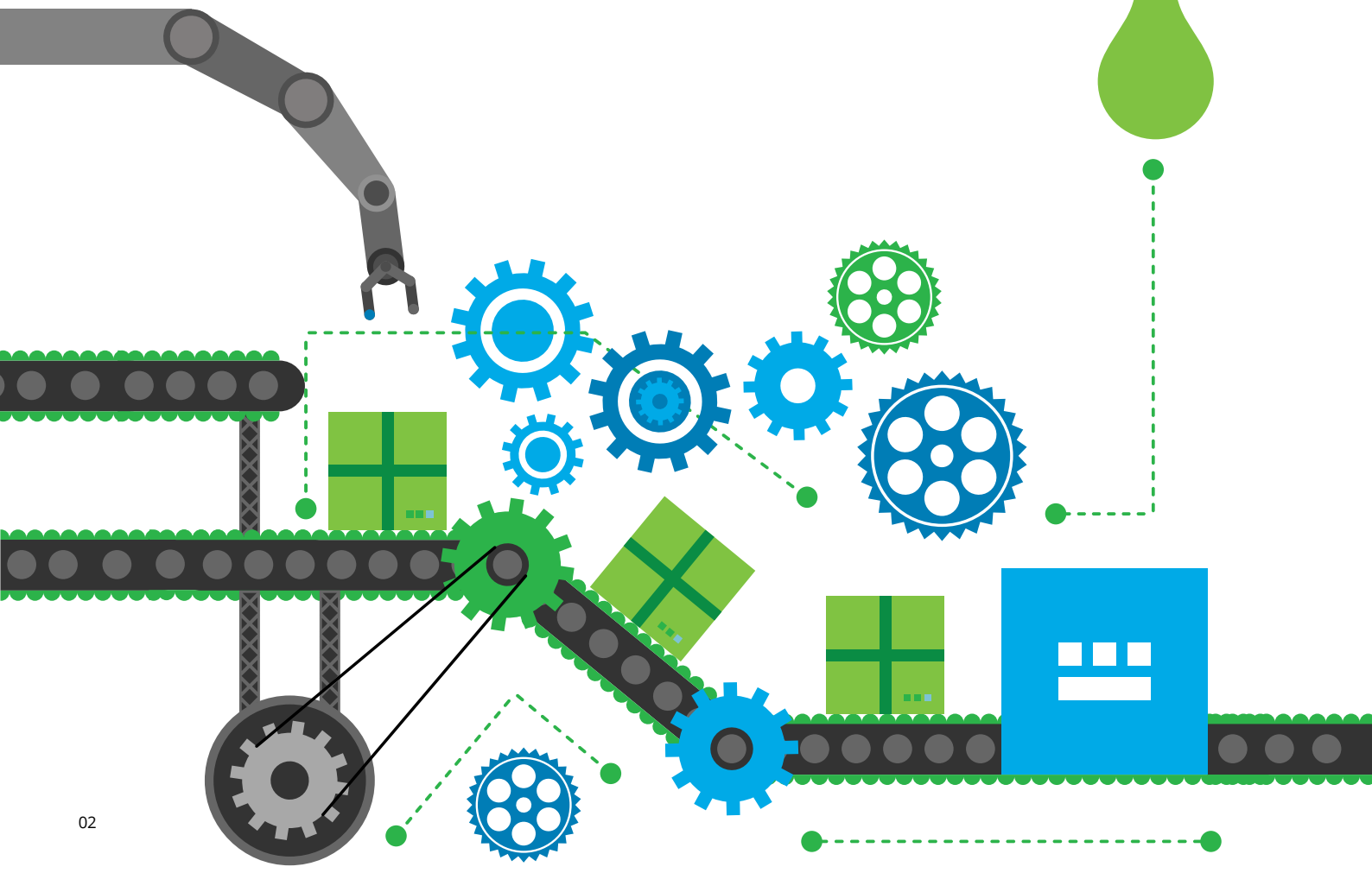
Industry 4.0 is no longer a technology of the future. It is a present and emerging revolution progressing at an exponential pace and disrupting the manufacturing sector. For the manufacturing sector, it has always been important to continuously upgrade with time and fast-evolving challenges. Globally, Industry 4.0 is emerging as a game-changer, characterised by increasing digitisation and interconnection of products, value chains, and business models. There is innovation not only in product development, but also in process development, after-market services, sustainability factors, machineries, etc. In effect, it is changing the working methods across organisations.

I believe Industry 4.0 and its constituent digital technologies will play a critical role as catalysts for the manufacturing sector. It will provide the required intelligence and insights to drive efficiencies in all the stages from product design to production. I invite you all to come together and discuss how we can make the manufacturing sector sustainable and leverage the strengths of emerging technologies to realise the true potential of this sector.



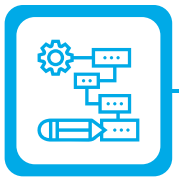
Introduction

The Industry 4.0 market has grown 10 times in the past decade (from US$10.5 billion in 2011 to US$103 billion in 2021). The percentage of IT spend by manufacturing companies on Industry 4.0 has also witnessed a steady growth from 5 percent in 2011 to 20 percent in 2021.

Fuelled by the wide adoption of Industry 4.0, the global Industrial Internet of Things (IIoT) market is projected to reach US$1.1 trillion by 2028, growing at a Compound Annual Growth Rate (CAGR) of 22.7 percent. The key drivers of this growth include benefits such as real-time monitoring, critical insights leading to efficiency improvement, development of new products, and predictive analytics to improve asset reliability.

Industry 4.0 is now moving into a new virtuous cycle enabled by the following:

1. **Big Data Analytics (BDA) and Digital Twins:**
   Organisations can use BDA to uncover business insights, such as hidden patterns, market trends, correlations to predict customer sentiments to make informed business decisions. The use of Digital Twins by organisations can help reduce the time to launch a product and improve product/service performance. Some key application areas include process optimisation, predictive maintenance, quality management, product innovation and safety enhancement.



2. **Connected products and evolving business models:**
   The approach towards customer centricity is continuously evolving, with key emphasis on nurturing customer relationships and maximising value from customers. Technologies, such as cloud computing and Internet of Things (IoT) have enabled the emergence of "as-a-service" offerings (jet engine as-a-service, car tyres-as-a-service, industrial printers as-a-service, etc.) by embedding sensors into products.

3. **Digital ecosystems:**
   Digital ecosystems will play a key role in enhancing transparency and optimising processes across the value chain. Utilising these ecosystems, organisations can generate incremental revenue streams. They can connect with businesses outside of their network and come up with innovative business models.

   Sharing the right data with ecosystem partners is crucial in unlocking new revenue potential, e.g., an automaker can share the data from a vehicle with an auto insurance provider, who can then derive insights on the customer's driving behaviour.

Despite its advantages, implementing Industry 4.0 poses several challenges amidst a highly competitive manufacturing environment. It redraws the lines between industries, forges new ones, and presents seasoned manufacturing firms with unforeseen challenges. Many businesses are yet to make significant investments or form detailed strategies around implementing Industry 4.0 solutions. Further, organisations also need to make large adjustments to their operating and business models to implement Industry 4.0 solutions—a deterrent in the leap to Industry 4.0.

In this paper, we have tried to examine the benefits of utilising BDA, Digital Twins, and connected products, along with their key application areas. Further, we have also highlighted the challenges of implementing Industry 4.0 and delved deeper into how the digital ecosystem can unlock value for its partners as we transcend to the next wave of Industry 4.0.

Advances in Industry 4.0: Big Data Analytics and Digital Twins

BDA and Digital Twins enable manufacturing companies to solve difficult problems by helping organisations model complex processes and fine-tune their operations. Further, organisations can continuously improve their products while significantly reducing the time to launch products.

Benefits

Some key benefits of BDA and Digital Twins in manufacturing include the following:

- **Process optimisation:** BDA and Digital Twins can enable modelling and optimisation of complex process. For example, a leading pharma company deployed BDA and Digital Twins to monitor operations. It helped the operator optimise the yield by choosing the right process parameters. The Digital Twin concept was also deployed to predict the yield quality of the drug for a given set of process parameters and conditions. The batch yield improvements led to the total savings of US$2 million.

- **Predictive maintenance:** A German Automotive OEM deployed a BDA analytics platform to assess data generated from the continuous detection of anomalies by robots in vehicle body construction. This ensured the continuous analysis of streamed data, leading to anomaly detection and determination of a specific health index. As a result, an Integrated Big Data platform was created for the continuous prediction of robot anomalies and failures, leading to reduced downtime in production processes.

- **Quality management:** A large microprocessor manufacturer was required to test each chip produced, amounting to more than 10,000 tests per chip. Using BDA, the manufacturer analysed the manufacturing process data to identify the critical test parameters. This resulted in savings of US$3 million for a single assembly line.

- **Reduction in time to launch a product or service:** During product development, organisations can virtually experiment using Digital Twins, reducing the time taken to complete trials. For example, an Italian luxury vehicle manufacturer used Digital Twins to generate virtual models and carry out simulations. This reduced the number of real-world prototypes, wind tunnel tests, test drives, and the overall development time by 30 percent.

- **Product innovation:** BDA allows organisations to understand their customer base better by gathering and analysing customer feedback, product success, and competitor strategies. As a result, organisations can introduce new products while simultaneously updating existing ones. Some large pharma manufacturers have already started using Digital Twins for pre-clinical testing and modelling of bioreactors, which are likely to reduce their time to market significantly.

- **Safety enhancement:** Using Digital Twins, organisations can conduct product testing under conditions that involve high temperatures or pressures in a virtual environment, thereby avoiding mishaps. Digital Twins can also help workers navigate the worksite better, especially for large work areas, such as mines or power plants. It also enables safety officers to better visualise potential hazards/conflicts and take pre-emptive action.

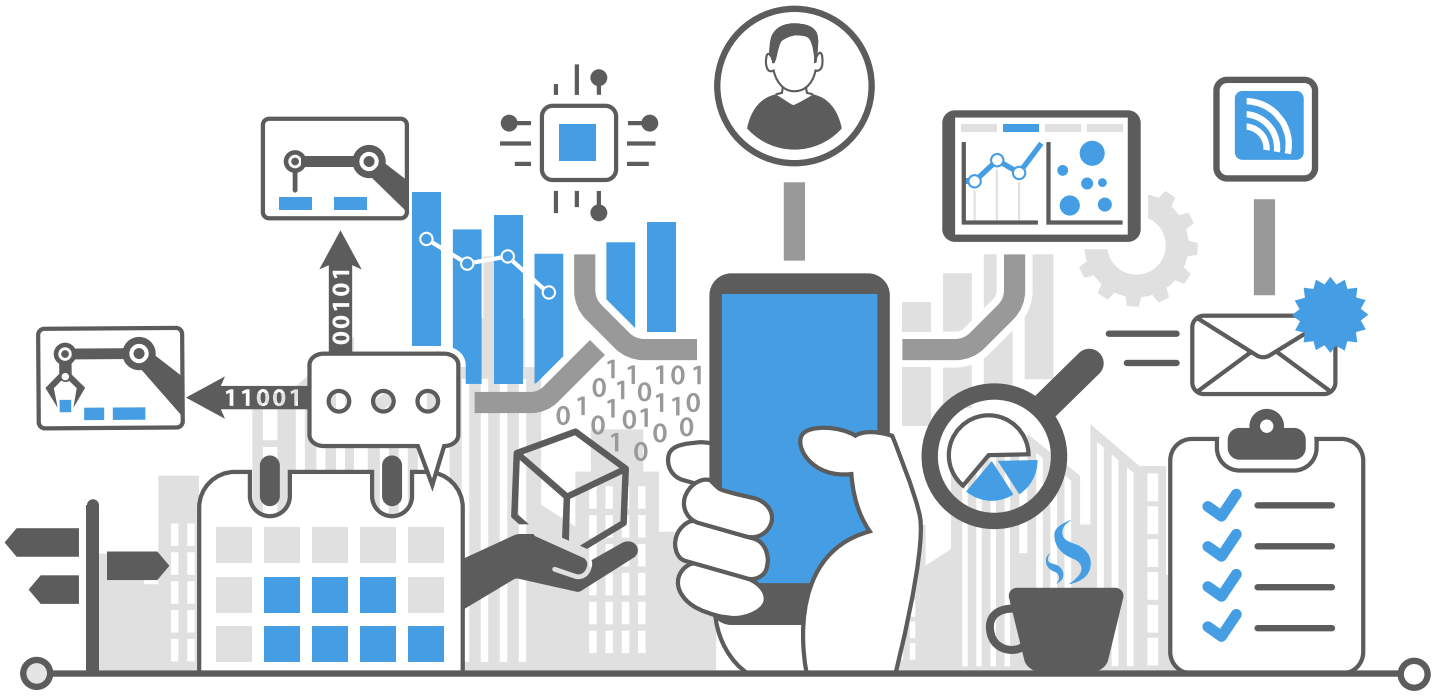
Use case

Digital Twin at a Global Automotive OEM

A leading automotive OEM implemented an IIoT-based factory intelligence platform across their manufacturing plants in the US. The global infrastructure enabled a scalable application platform, enterprise insights, data streaming, and workflow automation.

The company started small by launching pilot projects in three key plants and saved US$4.8 million in one year. Currently, they are extending the pilot projects to other plants and generating more value and are in the scale-up phase.

The BDA and Digital Twin approach can be applied to individual machines, manufacturing processes, or even entire value chains. By integrating digital technologies, BDA, and Digital Twins into the entire organisational processes—starting from research and development to sales—organisations can make better decisions and improve their top-line.



Evolving business models: Connected products and Product-as-a-Service

Industry 4.0 has transformed the way new products are designed and engineered. The use of sensors, wearables, analytics, and Machine Learning (ML), as well as advanced manufacturing, Augmented Reality/Virtual Reality (AR/VR), advanced computer numerical control, and robotics have improved products in multiple ways. Industries have moved from rapid prototyping and testing to adding connectivity features to unconnected products along with innovative features.

Organisations are now moving towards monetising the data that they capture via smart products and bundle services in addition to physical assets. Digital signals from consumer interactions with connected assets on field or from the assets themselves can enable better services and improve warranty claims, visibility into usage patterns, and overall revenue streams.

To utilise these opportunities arising from Industry 4.0, it is necessary to shift from traditional to novel business models.

Benefits

Smart products present a spectrum of new business model innovations to capture value. For example, there has been a recent shift from traditional ownership models (where customer benefits from the product delivered) to a Product-as-a-Service model (PaaS), where the manufacturer retains ownership and takes full responsibility for the costs of product operation, maintenance, and service in return for a fixed fee. This enables customers to pay as they go. Here, the value from the improvement in product performance, reduction in overall cost of production, and higher service efficiency are captured by the manufacturer.

A few examples of applications of such technologies include the following:

01 Producers of lower value consumer goods have realised significant benefits from the adoption of these technologies. For instance, printer manufacturers have introduced smart printers that keep track of the ink limit and order their own ink before it runs out.

02 An FMCG giant introduced a smart toothbrush that can be connected to the consumer's smartphone and helps identify spots they are missing while brushing their teeth. The company ships more than a million such toothbrushes worldwide.

03 A multinational industrial products company can remotely monitor the construction equipment it produces and send servicing notifications to its asset owners.

04 A global wind turbine manufacturer not only manufactures and installs windmills, but also offers active management solutions to its consumers with flexible service contracts tailored to their customer needs.

Some key areas of connected products applications and new business models in manufacturing include:

Car tyres as a service

A leading Indian tyre manufacturer launched a novel model of tyre as a service or "pay per mileage". They have also upgraded their after-sales service function to rent tyres to customers. The "Tyre Cloud" platform collects real-time data on mileage, temperature, pressure, and vibration using an Internet of Things (IoT) terminal. Customers are provided with continuous support and insights, including pre-maintenance services.

Industrial printer as a service

A German industrial printer manufacturer has adopted a pay-per-use model for its industrial printers. With its subscription-based model, the company has achieved a 70 percent revenue increase and expects the pay-per-use business to grow to US$195 million.

Tunnel drilling machinery as a service

A Portuguese construction company collaborated with a Swedish manufacturing company to develop a pay-per-use model for drilling machinery. Using this model, the contractor was able to use the drilling machinery for a fixed rate per cubic meter, ensuring total control over the costs, while the OEM ensured that the equipment was available with minimum downtime.

Growth of connected products

In 2022, the number of connected IoT devices are expected to grow by 18 percent to 14.4 billion. It is expected that by 2025, the number of connected IoT devices will reach 27 billion. This level of growth has been possible due to the advancement of technologies, such as sensor technology, a 100 times increase in computing power over the past 10-15 years, and overall improvement in mobile connectivity with the emergence of 5G.

Growth in India

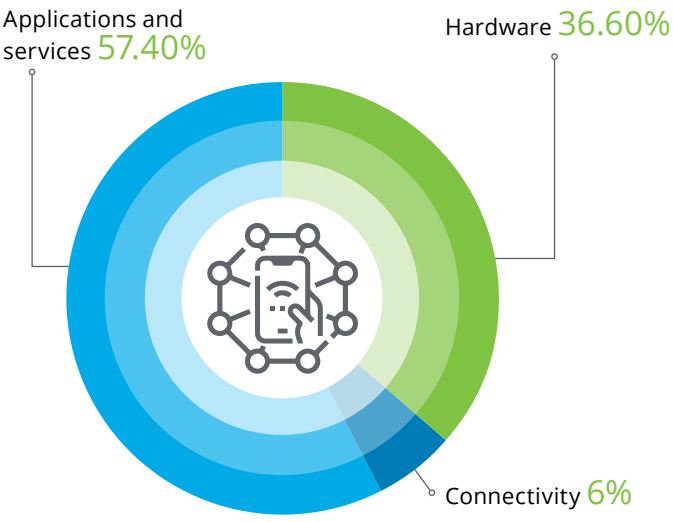
India was not a forerunner in global connected products and had begun its journey much after developed economies. However, the growth of connected units within India is expected to be massive. India has the second-largest base of actively used smartphones in the world coupled with extremely cheap data tariff. The cost of technologies has dropped immensely with the emergence of new start-ups and developments within the PaaS space.

COVID-19 acted as a catalyst for digital transformation with companies across India willing to adopt automation technologies.

In addition, the government's planned investments worth US$100 billion for smart cities is also enabling the adoption of IoT products across industries.

Connected products in the smart-home space in India is also growing exponentially. The market is estimated to reach US$6 billion by FY22, which is an increase of 100 percent from FY20. Categories, such as smart door locks and smart wireless cameras, currently have a market share of ~7.5 percent but are poised to grow at a CAGR of 20-25 percent.

IoT market: Revenue forecast by component in percentage, India 2025



The digital ecosystem

The digital ecosystem comprises organisations, suppliers, customers, and business alliances, who are either providing or receiving product (machine parts/software) and services (cloud computing, AI/ML capabilities). Each ecosystem partner has a distinctive role to play, and when done right, can together unlock more value than any individual stakeholder.

Industry 4.0 moves away from mass production to mass customisation. When applied as point solutions, each ecosystem stakeholder can focus and become efficient in specialised competencies. However, to deliver complex solutions and mass customisation, it is important for ecosystem partners to work together within the same umbrella. The movement towards an Industry 4.0 world is enhanced by a high degree of digital connectivity across the value chain.

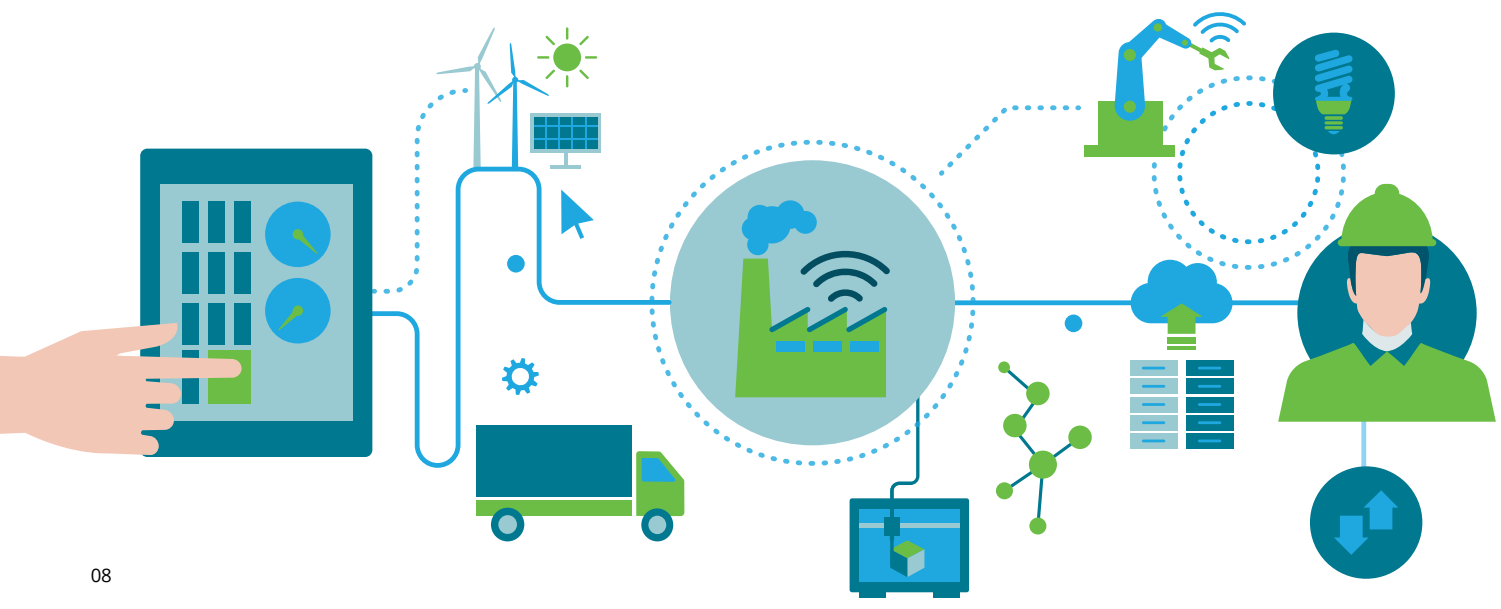
Nurturing such ecosystems and alliances necessitates support from key stakeholders and a robust management system. Developing ecosystems with a strong governance system that is both agile and has strong decision making, is critical. It is also essential to define Key Performance Indicators (KPIs)/Service Level Agreements (SLAs) and set realistic goals and review them.

To ensure scalability of the ecosystem partnership, it is essential to gauge the maturity of the processes and offerings (both internal and external), and wait until they are at their minimum maturity. It is also crucial to bridge the cultural differences between the ecosystem partners to ensure smooth collaboration.

For a connected operation to have the desired agility, each part of the value chain (from planning to manufacturing to customer service) should be connected to the digital ecosystem. This helps build synergies amongst business functions, leading to faster implementation of actions.

For instance, imagine a manufacturing unit with IoT-equipped welding robots. With the help of Industry 4.0 technologies, process data points are analysed, and the maintenance cycle is predicted. Now, the maintenance requirement is communicated to the Original Equipment Manufacturer (OEM). But if the OEM is part of the digital ecosystem, the maintenance can be scheduled automatically. Also, OEM can use its expertise to postpone or reschedule the maintenance per the process data points. This is how ecosystems can be utilised to extract the most value.

A factory equipped with digital ecosystems can perform data analysis for optimal decision making. The data gathered by sensors and interconnected machinery can generate a sizeable amount of Big Data, which can be used to investigate historical trends, spot patterns, and improve decisions. To gain deeper insights, digital ecosystems also integrate data from other areas of the organisation as well as the wider ecosystem of suppliers and distributors. Manufacturers can base production choices on sales margins and staff by examining data from human resources, sales, or warehousing.

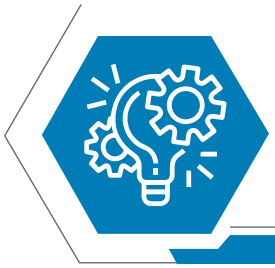


Benefits

Some benefits of digital ecosystems include the following:

Lower operational costs:
Establishing business processes with customers and an external partner can reduce the operational cost by streamlining the work and information flow. It ultimately improves operational efficiency.

A leading German automobile manufacturer has worked to combine data from all its machines, plants, and systems across 120+ facilities of its group. The platform uses Machine Learning, IoT, and data analytics tools to optimise processes in real time. Approximately 1,500 suppliers and partners are globally connected through this ecosystem, the adoption of which, has helped the group reduce operational costs and increase transparency.



Rapid technology adoption:
Within the digital ecosystem, each ecosystem partner draws value from one another in terms of technology. The technology advancement made by one ecosystem partner must be replicated by the connected partner as well. This facilitates the rapid adoption of technologies.

To accelerate innovation around Industry 4.0, an industrial technology conglomerate launched a specific programme using “AI and data analytics”, collaborating with a leading US university to strengthen futuristic skills within the company’s talent based on the organisation’s requirements. The organisation works to address business challenges by reaching out to a broader ecosystem of start-ups and research labs.

New revenue sources:
A digital ecosystem enables all ecosystem partners to access a wide range of data, which is agreed to be shared. In addition, huge amounts of data flows between ecosystem partners, while business processes are running. This data can be used to create value-added products and services, which can then act as a new revenue source.

Key risks in successful Industry 4.0 implementation

When working with the technologies of Industry 4.0, the journey must be structured and well conceptualised from the beginning.

Some risks and challenges associated with Industry 4.0 implementation are as follows:

- **Perceived high cost and expensive maintenance:** Few organisations may be uninterested in digitising existing assets due to high maintenance costs and investments.

  Mitigation: Businesses can bring down these challenges by simply avoiding the use of outdated technologies, non-optimal infrastructure, and overengineered systems. Further, infrastructure development can be modularised to optimise costs.

- **Security and privacy of data** Along with the opportunities and benefits for the businesses, Industry 4.0 also brings about potential risks around privacy and security of data. There is a high exposure risk from data leaks as these data sets are accumulated from different sources and vary in type and size.

  Mitigation: The integration of BDA, connected products, and ecosystems makes it essential for businesses to establish proper practices for data encryption, data back-up, password protection, identity and access management, and intrusion detection and prevention software. Moreover, all organisations must adhere to the three core principles of data: **Confidentiality, integrity, and availability.**

- **Integration with existing assets:** It is a complex exercise to integrate technologies such as Digital Twins with existing assets, especially when there is little scope to add sensors to existing machines. Smart products also need to run through a single, established technology standard. This is crucial for products to understand each other and work in unison.

  Mitigation: At present, there is a lack of a universally accepted standard of communication to programme smart products. Organisations need to spend time and incur additional costs on universal software in the markets that connect and help IoT-based products interact.

- **Hardware and software capabilities:** There is a lack of technical expertise and skills in general in implementing and maintaining IoT-based systems. Moreover, Digital Twins require certain hardware and software capabilities that some organisations may not have.

  Mitigation: Such organisations would need to invest in technical capabilities and ensure employees have the required skillsets to make the best use of Digital Twins. They could also adopt an ecosystem-based approach and acquire such skills from the ecosystem.

The next wave

Organisations, until now, have been implementing Industry 4.0 projects with a focus on solving recurring internal challenges or specific issues for the organisation (for e.g., better availability, fewer quality defects, visibility of distribution, right pricing). These solutions have helped them bring in more transparency in their internal systems and savings in their operational costs. However, the next wave of evolution for Industry 4.0 will be to develop solutions that push the boundaries further and help organisations achieve overall optima for their entire value chain.

Some areas where Industry 4.0 can add significant value in the years to come include:

01 Optimise the overall cost of operations/ cost to serve.

02 Create new products that will be customised to the customers' needs.

03 Bring together several ecosystem players to create new products for OEMs.

04 Establish new business models, developed by both, the manufacturer, and ecosystem partners.

Driving this new wave of improvements will require a great deal of collaboration between multiple ecosystem partners to come together and develop new integrated solutions. For example, as companies are thinking of reducing the time to market, technologies such BDA would allow integration of disparate algorithms, enabling optimisation across the entire value chain, backed by data. The integrated data would help simulate the impact on key parameters using Digital Twins, empowering organisations to take well-informed decisions at the organisation level.

Organisations will have to look beyond the existing internal alliances for Industry 4.0 needs, which includes collaborating with external partners. The outward look would give rise to newer business models with Industry 4.0 at its centre. For this to happen, there is a need for a stronger digital ecosystem with partnerships at business levels. For example, partnerships between BDA service providers, Digital Twin solution providers, and connected solutions. Building one architecture to accommodate these aspects would lead to newer business models, and further, manufacturers enriching the data from their own domains. This will enable the ecosystem to develop services that are of value to customers and can therefore be monetised and the integration of partners in a digital ecosystem at the system architecture level.

It is time for the Industry 4.0 ecosystem to collaborate at the business level and meet the growing needs of manufacturers. For this to happen, organisations need to fund newer business models that enable the digital ecosystem. New-age start-ups that aid OEMs in building a digital ecosystem will need to collaborate and come up with a new wave of solutions to solve industry challenges. Incubator programmes for ecosystem partners would help bring more synergy between them and lead to a new wave of solutions and business models.

Conclusive remarks

Digital technology, the data generated through IIoT, and the analysis of the data holds enormous value for manufacturing companies. These technologies supplement each other in driving business outcomes.

To unlock the true potential of Industry 4.0, organisations will have to create connected products, take them to the customer with innovative business models. Subsequently, harness a thriving digital ecosystem with business partners that support the digital transformation journey across the value chain will be pivotal to their success.

01 Industry 4.0 is entering a new cycle of evolution, based on the advances in Industry 4.0 technologies, such as BDA and Digital Twins. These are enabling newer business models that can drive growth and profitability for organisations.

02 Manufacturers need to shed their siloed approach and integrate systems across the value chain to realise the full potential for the organisation.

03 An ecosystem approach will lead to the coming together of various stakeholders in solving complex business problems and offering new and innovative products and services. Newer business models that evolve from an ecosystem would benefit the manufacturers as well as the ecosystem partners.

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CII is a non-government, not-for-profit, industry-led and industry-managed organization, with around 9000 members from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 300,000 enterprises from 286 national and regional sectoral industry bodies.

For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

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As India completes 75 years of Independence in 2022, it must position itself for global leadership with a long-term vision for India@100 in 2047. The role played by Indian industry will be central to the country's progress and success as a nation. CII, with the Theme for 2022-23 as Beyond India@75: Competitiveness, Growth, Sustainability, Internationalisation has prioritized 7 action points under these 4 sub-themes that will catalyze the journey of the country towards the vision of India@100.

With 62 offices, including 10 Centres of Excellence, in India, and 8 overseas offices in Australia, Egypt, Germany, Indonesia, Singapore, UAE, UK, and USA, as well as institutional partnerships with 350 counterpart organizations in 133 countries, CII serves as a reference point for Indian industry and the international business community.

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