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AUTOMOTIVE COMPONENT MANUFACTURERS ASSOCIATION OF INDIA

SUSTAINABLE DEVELOPMENT GOALS

Assessment of the application of Industry 4.0 and digitalization in the context of automotive component manufacturing in India

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FOREWORD
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

The United Nations Industrial Development Organization (UNIDO) found that globally, digitalization, Industry 4.0 and the transition to Advanced Digital Production (ADP) technologies have picked up speed and scale during the COVID19 pandemic and are likely to shape and transform industrial development in the post pandemic years. This presents an opportunity to advance inclusive and sustainable industrial development, in line with Sustainable Development Goal 9, by improving productivity and quality, reducing energy use and environmental impacts, and improving quality of work.

Automotive sector is one of the leading industry sectors in India and through initiatives as the Production Linked Incentive (PLI) scheme, Government of India is actively promoting growth of domestic components manufacturing, which is currently characterized by high participation of micro, small and medium enterprises (MSMEs) lower in the supply chains of original equipment manufacturers (OEMs). The sector experienced a sharp and deep decline early in the pandemic period, followed by steady recovery relatively soon thereafter. MSMEs were disproportionally impacted by the pandemic and experienced diverse difficulties to access credit, labor, skills and markets for their business recovery. UNIDO developed and promoted methods and tools for recovery and rejuvenation of MSME manufacturing units.

The present report provides a snap shot of the digitalization practice of Indian automotive components manufacturing sector undertaken within the framework of the collaborative UDAY PRIDE partnership of UNIDO with the Automotive Component Manufacturers Association of India (ACMA) funded by the Ministry of Heavy Industry (MHI). It is informed by an enterprise survey and a deep dive into select businesses that have adopted select digital technologies. Overall, the analysis shows that digital transformation of Indian automotive components manufacturing is only in its nascent stage. There are good opportunities to catalyze progress, building on expansion and optimization of enterprise resource planning (ERP) systems and strengthening lean manufacturing, along with a focus on digital enhancements of existing machinery and production lines.

It is hoped that the present report will spark interest for Advanced Digital Production technologies and Industry 4.0 in automotive components sector and facilitate coordinated action to facilitate the sector's digital transformation journey.

René Van Berkel
UNIDO Representative and
Head, Regional Office in India

FOREWORD
ACMA

It gives me great pleasure to introduce this publication on UNIDO's extensive experience in supporting its member states to achieve sectoral transformation towards inclusive and sustainable industrial development (ISID).

This report, one of the deliverables of the ACMA-UNIDO-MHI joint project maps and analyses the Industry4.0 landscape in the Indian automotive components manufacturing sector, supported by insightful case studies wherein Industry4.0 has been assessed across the entire value chain, from raw materials to supplier interactions, to production and back-office processes as also to the end consumer. Demonstrated in the UNIDO Medium-Term Programme Framework 2022-2025, the structural transformation as an area of expertise of the Organization, aligns with the application digital transformation and circular economy, relevant to this report.

MSMEs play a vital role in the overall economic growth of India, and with the automotive value chain dominated by MSMEs, the report focuses in-depth on challenges of digitisation in the MSMEs and how learnings from those who have deployed Industry 4.0 successfully can be replicated horizontally. Further, we anticipate that upscaling of innovation ecosystem and digital manufacturing capacities will become more vital for companies to remain competitive in the years to come given the rapid rate of transformation across the automotive industry.

We are appreciative of the cooperation and contribution of all participating companies in the preparation of this publication. We are hopeful that you will find this publication insightful and useful.

Vinnie Mehta
Director General
ACMA

CONTENTS

ABBREVIATIONS

ACMA	Automotive component manufacturers association of India
ADP	Advanced digital production
AI	Artificial intelligence
AMP 2026	Automotive mission plan 2016–2026
CAD	Computer aided design
CNC	Computerized numerical control
DHI	Department of heavy industries
ERP	Enterprise resource planning
GDP	Gross domestic product
GST	Goods and services tax
HR	Human resources
IIoT	Industrial Internet of things
Industry 4.0	Fourth industrial revolution
IoT	Internet of things
IT	Tnformation technology
MHI	Ministry of heavy industries
MSMEs	Micro, small and medium-sized enterprises
OEE	Overall equipment effectiveness
OEMs	Original equipment manufacturers
OSM	Operating system for manufacturing
PLC	Programmable logic controllers
QR code	Quick response code
RFID	Radio frequency identification
RPA	Robotic process automation
SAP-HANA	Systems, applications and products in data processing - High-performance analytic appliance
SMEs	Small and medium-sized enterprises
SPC	Statistical process control
UDAY PRIDE	UNIDO-DHI-ACMA Yojana Professionalism responsibility and innovation in driving excellence
UNIDO	United Nations Industrial Development Organization

I

Introduction

The UDAY-PRIDE (UNIDO-DHI-ACMA Yojana Professionalism responsibility and innovation in driving excellence) partnership programme targets small and medium-sized Indian automotive component manufacturers as its direct beneficiaries, as these have been identified as “the weakest link” in the automotive supply chain in India.

I.A UNIDO PROJECT

Among its many other initiatives, UNIDO in India is running a supplier development programme called UDAY-PRIDE (UNIDO-DHI-ACMA Yojana[1] - Professionalism, Responsibility and Innovation in Driving Excellence). The programme is jointly managed with Automotive Component Manufacturers Association of India (ACMA)[2] and is funded by the Ministry of Heavy Industries, Government of India[3].

This partnership programme targets small and medium-sized Indian automotive component manufacturers as its direct beneficiaries, as these have been identified as “the weakest link” in the automotive supply chain in India.

The objective of the programme is to facilitate the competence building and capabilities of tier 2 and lower tier automotive component manufacturers to enable them to be productive and innovative and hence establish themselves and succeed as preferred suppliers to national and international tier 1 and original equipment manufacturers (OEMs).

Phase II of the UDAY-PRIDE programme, the current phase, started in 2019 and focuses on improving the productivity and capacity for innovation of target beneficiaries. This phase seeks to cover 275 automotive component manufacturing companies through shop-floor interventions and counselling training programmes, along with e-learning and online programmes across various geographical locations in India.

As part of the innovation component of the programme, this report was generated to thoroughly describe the level of digitalization and the implementation status of the fourth industrial revolution (Industry 4.0) in the context of automotive component manufacturing in India. The report forms the basis for the envisioned interventions aimed at disseminating Industry-4.0-related technologies to micro, small and medium-sized enterprises (MSMEs) in India through pilot applications of selected technologies in collaboration with private sector technology and service providers and the promotion of an industry-friendly environment.

I.B AUTOMOTIVE COMPONENT INDUSTRY IN INDIA

1. BACKGROUND

The automotive component industry in India spans different areas of the country, and is composed of a large, integrated and complex network of suppliers from both the formal and the informal sectors. Those in the formal sector (referred to in India as the “organized sector”) are the OEMs; they are engaged in the manufacturing of precision car components and systems. The informal sector (referred to in India as the “unorganized sector”) caters to after-market services or non-automotive industrial sectors. The industry is dominated by MSMEs, and they are the key drivers of India’s economic growth.

Various sub-sectors of the automotive component industry in India include engine parts, drive, transmission and steering parts, body and chassis, suspension and braking parts, electrical parts and others such as fan belts, die-casting and sheet metal parts.

The automotive component industry contributes 2.3 per cent of India’s gross domestic product (GDP), 25 per cent of the national manufacturing GDP and the contribution of automotive components to India’s GDP is expected to account for between 5 and 7 per cent by 2026.

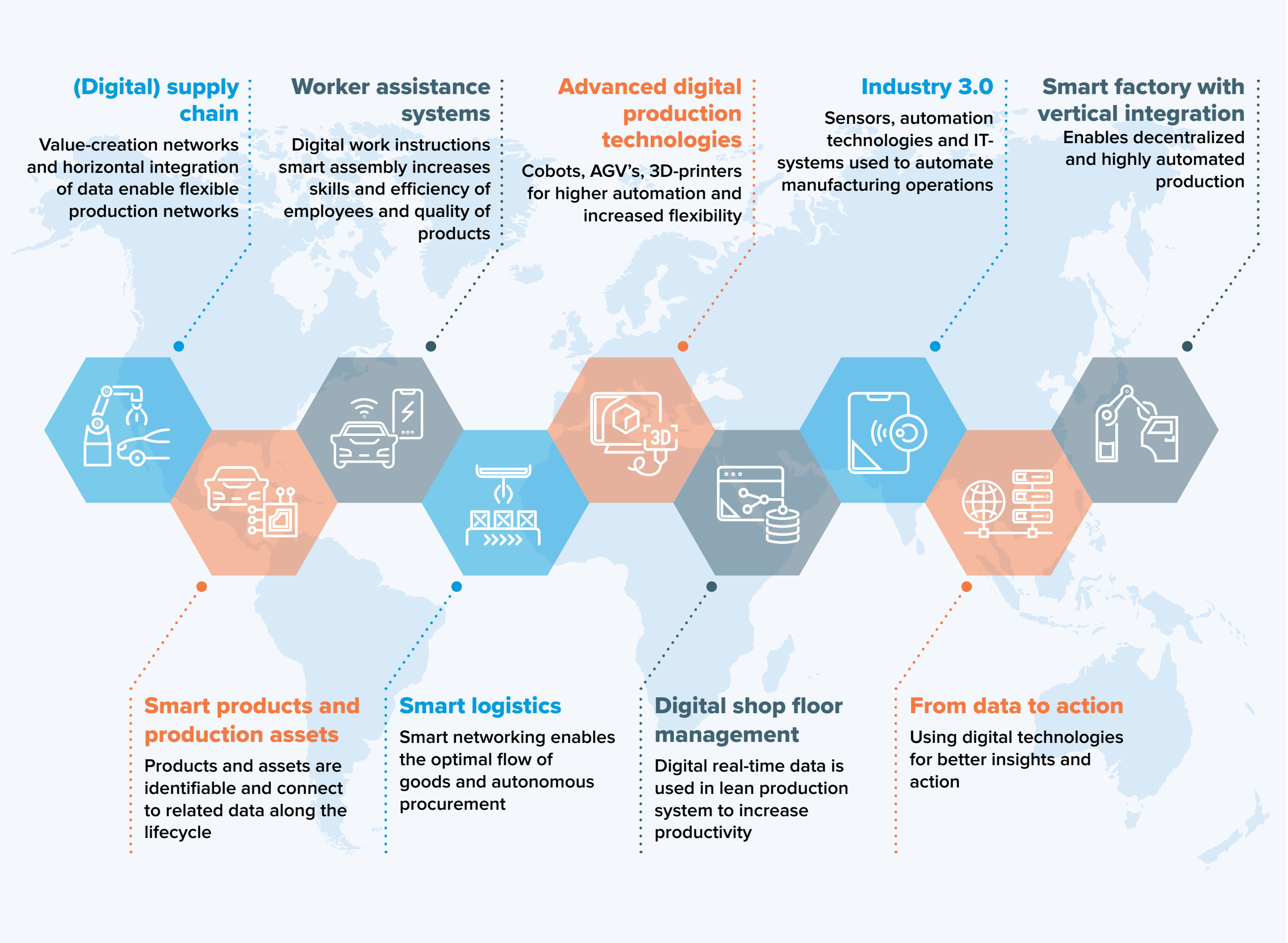
1) “Yojana”: Hindi term meaning strategy.
2) More information on ACMA can be found here: https://www.acma.in/.
3) More information on MHI can be found here: https://heavyindustries.gov.in/.

In the financial year 2019/20, the Indian automotive component industry, against a backdrop of a slowdown in demand and the coronavirus disease pandemic (COVID-19)-related issues, suffered a decline and registered a turnover of $49 billion in 2020, thus contracting by 11.7 per cent compared to $57 billion in the financial year 2018/19.[4] The contribution to the economy of the automotive component industry is expected to grow to $200 billion by 2026. It employs about 1.5 million people directly and 1.5 million people indirectly.

India is emerging as a global hub for sourcing automotive components. In addition to the huge domestic market, the key automotive markets such as the Member States of the Association of Southeast Asian Nations (ASEAN), Japan, the Republic of Korea and Europe are geographically closer to India. India’s growing integration in Global Value Chains provides further boosts to the automotive component industry. “The AMP 2026 is aimed at bringing the Indian Automotive Industry among the top three of the world in engineering, manufacture and exports of vehicles & components; growing in value to over 12% of India GDP and generating an additional 65 million jobs.”[5]

Although the lower-tier automotive component manufacturing segment is still predominately operating with traditional low-technology methods, and highly dependent on manual labour, there is a surge of innovative technologies that are increasingly being adopted and characteristic of the paradigm shift commonly referred to as Industry 4.0.

FIGURE 1: Industry 4.0 technologies – overview of the automotive industry



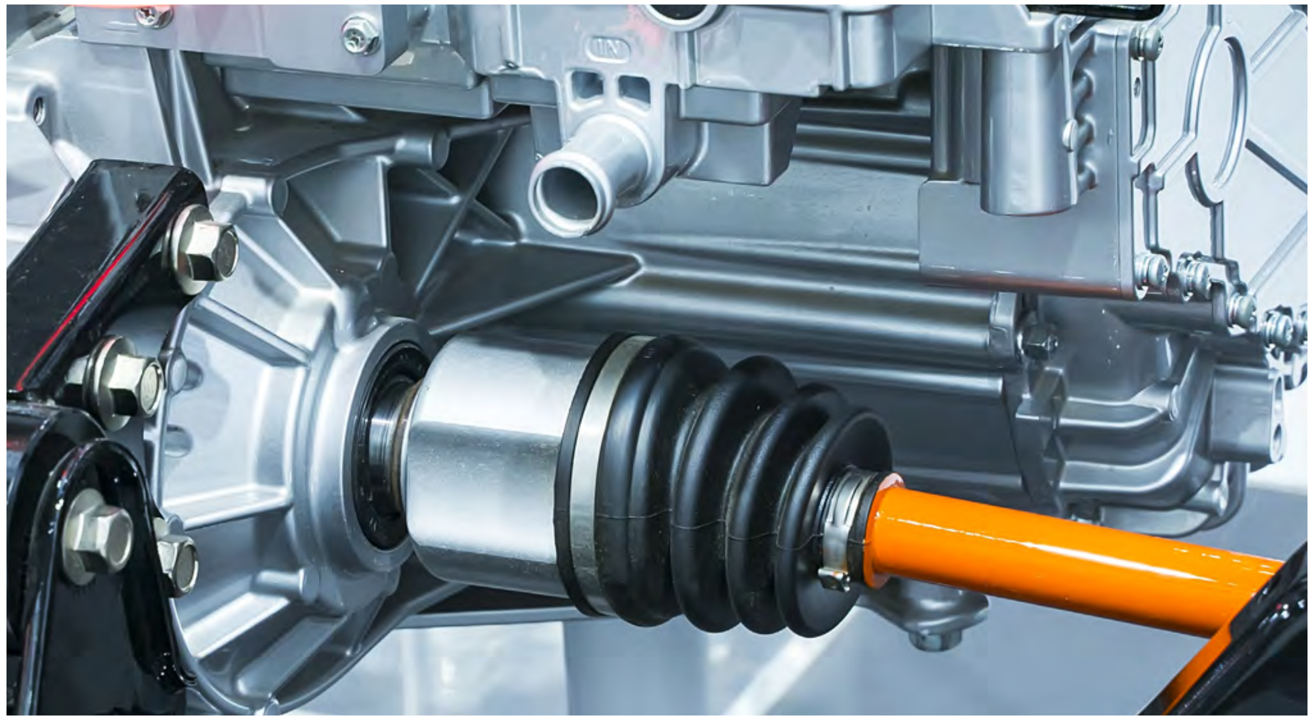
4) https://www.ibef.org/download/Auto-Components-November-2020.pdf
5) https://pib.gov.in/newsite/printrelease.aspx?relid=159612

2. GOVERNMENT INITIATIVES

As the sector shows high potential for future innovative growth, the Government of India has dedicated considerable attention to promoting the development of the Indian automotive component manufacturing sector in terms of utilizing Industry 4.0 technologies.

At the policy level, the Government has taken several initiatives to promote the automotive component industry. For instance, the production-linked incentive (PLI) scheme for the motor vehicle and automotive components industry envisages overcoming the cost disadvantages of the industry for the manufacture of advanced automotive technology products in India. The "Make in India"[6] initiative envisions the creation of a conducive environment for investments, development of a modern and efficient infrastructure, and opening up new sectors for foreign capital, while the "Skill India"[7] initiative focuses on empowering the youth of the country with adequate skills sets for better employment opportunities in relevant sectors and also to improve productivity, another scheme being Aatmanirbhar Bharat Abhiyan, launched by the Indian Prime Minister and emerging from the *Make in India* initiative, and calling for a self-reliant India.

Furthermore, the Ministry of Heavy Industries (MHI) sub-group on the Automotive Mission Plan 2016–2026 (AMP 2026) is the collective vision of the Government of India and the Indian automotive industry on where the vehicle, automotive component, and tractor industries should reach over the next ten years in terms of size, contribution to India's development, global footprint, technological maturity, competitiveness, and institutional structure and capabilities. The AMP 2026 is aimed at bringing the Indian Automotive Industry among the top three of the world in engineering, manufacture and exports of vehicles & components; growing in value to over 12% of India GDP and generating an additional 65 million jobs. [8]



6) https://www.makeinindia.com
7) https://www.skillindia.gov.in
8) https://pib.gov.in/newsite/printrelease.aspx?relid=159612

I.C REASON FOR REPORT

Industry 4.0 will affect all sectors and disciplines, bringing about a structural transformation in the global economy and leading to a new division of labour, which will have a huge impact on developing countries. Current production systems, and global value chains, will become more dynamic, flexible, efficient and sustainable, with great possibilities for customization and personalization. Industry 4.0 has the potential to improve productivity and competitiveness and enable the transition to a circular economy in which end-of-life products are reused, remanufactured and recycled. Taken together, these developments will lead to the emergence of more sustainable production and consumption patterns, and could thus provide opportunities for developed and developing countries to achieve economic growth and sustainable development in line with the 2030 Agenda for Sustainable Development.

In terms of the automotive component manufacturing sector, Industry 4.0 is a paradigm shift from centralized to decentralized smart manufacturing and production. It refers to the digitalization of manufacturing and the creation of a smart factory. Physical objects are seamlessly integrated into the information network. Manufacturing systems are vertically networked with business processes within factories and enterprises, and horizontally connected to spatially dispersed value networks that can be managed in real time – from the moment an order is placed right through to the outbound logistics. [9]

Implementing Industry 4.0 technologies can therefore provide multiple opportunities for automotive component manufacturers relating to enhanced competitiveness, productivity, resilience and participation in global value chains. Nevertheless, MSMEs are facing challenges in the adoption of Industry 4.0 technologies, primarily related to factors such as the costs involved, the lack of skilled labour, failure to provide an implementation plan and security concerns. At the same time, failure to make these necessary investments and changes is likely to cause negative impacts on productivity and competitiveness.[10]

The present report is created in order to gain a comprehensive understanding of the current situation in India in terms of the level of digitalization of and the adoption of Industry 4.0 by automotive component manufacturers so as to:

- Understand the requirements and needs of the automotive component manufacturers
- Identify the challenges and gaps in implementing advanced digital production (ADP) technologies and Industry 4.0 solutions
- Examine existing solutions and best industry practices and the way forward.

9) UNIDO https://www.unido.org/unido-industry-40.
10) https://www.unido.org/news/new-publication-sectoral-transformation-inclusive-and-sustainable-industrial-development.

II

Survey

A survey was disseminated online to a range of automotive component manufacturers from tier 1 to lower tier firms of the automotive industry in India.

II.A SCOPE OF SURVEY

The standardized survey was divided into three distinct parts. The primary part of the survey related to getting basic information about the responding manufacturer. This covered the size and turnover of the company, as well as the variety of products they were manufacturing and their customer profiles. A wide range of companies was included in the survey to get a picture of the whole market.

The second part of the survey dealt with assessing the level of digitalization and usage of Industry 4.0 technologies along all direct and indirect production processes from customer orders, to production planning, machines, maintenance, and IT systems in use. In this way, a complete picture of all the relevant processes was assessed, and insights were gained on a variety of topics.

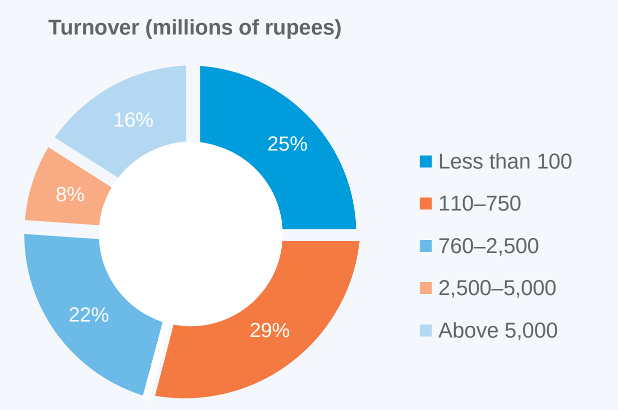
The final part of the survey invited the respondents to categorize challenges that they were facing in all aspects of the companies' processes, from labour workforce to machine breakdowns, high inventory, lack of space, quality, maintenance, and others.

The survey was disseminated online to a range of automotive component manufacturers from tier 1 to lower tier firms, ranging from large entities with more than 1,000 employees and a yearly turnover of over 5,000 million rupees ($67.5 million), to small manufacturers with less than 50 employees and a yearly turnover of less than 100 million rupees ($1.35 million).

In addition, respondents were invited from various cluster regions from the automotive component industry in India to ensure that meaningful deductions on the clusters of topics, common needs and use cases, their frequency and relevance, could be made across the whole manufacturing market in India.

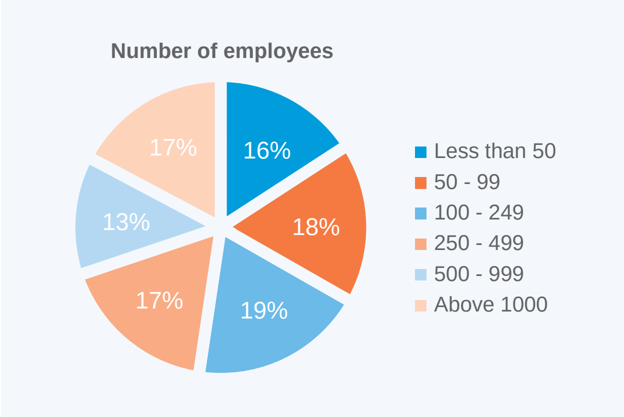
In total, 63 respondents participated in the diagnosis survey with respondents almost equally spread across different backgrounds in terms of turnover and numbers of employees. In terms of yearly turnover, the respondents can be categorized in 4 groups with roughly the same sample size of around 25 per cent; the MSMEs with less than 100 million rupees, small companies with 110–750 million rupees, medium companies with 760 million–2.5 billion rupees, and large companies with a yearly turnover of more than 2.5 billion rupees (1 million rupees = USD 13 140).

FIGURE 2: Respondents' approximate yearly turnover (in millions of rupees)



Similarly, the distribution of respondents in terms of number of employees follows a comparable pattern with the share of employees being nearly equally distributed from less than 50 people to over 1,000 employees.

FIGURE 3: Respondents' number of employees (including temporary workers)



The respondents' profiles have further been categorized into the variety of products manufactured as well as the type of production that is being followed. In terms of the variety of products, most of the firms are engaged in producing a medium to wide variety of products, which is typical for the components manufacturing industry given the diverse customer demand and requirements.

In terms of the type of production, like the variety of products, a wide distribution is observed from individual piece production, to medium series production, to mass production. Again, given the broad range of components that can be manufactured, this trend is expected within the industry; some parts need to be customized as piece production while others are mass produced.

Overall, given the wide range of companies that responded in terms of variety of products and type of production, it can be deduced that the sample responses received allow us to gain insights into the overall automotive component manufacturing market in India.

II.B OVERALL LEVEL OF DIGITALIZATION AND UPTAKE OF INDUSTRY 4.0

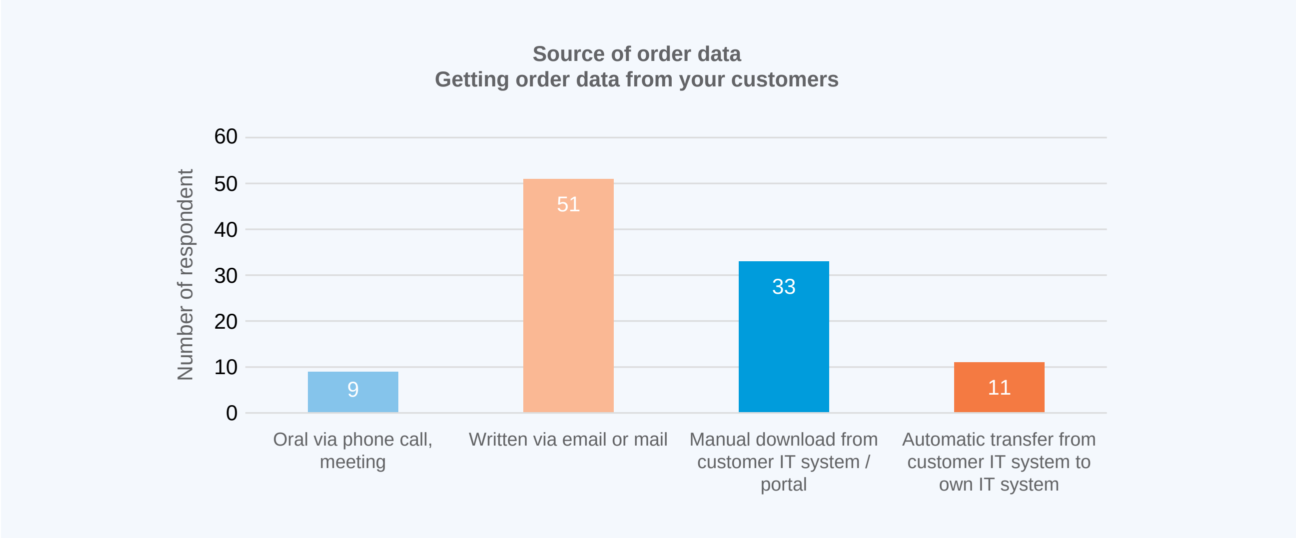
Industry 4.0 spans all parts of the manufacturing process, from supplier coordination to planning, machines, the end customer, and supporting back office IT functions. In order to assist a successful transformation to Industry 4.0, the processes need to become digitalized to facilitate data-based decision-making and process improvement. As such, a critical component will be the data-based transformation of the supply chain to a smart, efficient, and connected system. Traditionally, processes were autonomous and product development, raw materials processing, manufacturing, and end customer delivery to after sales services had little interaction with each other. The usage of product and process data and advanced digital production (ADP) technologies enable these separate siloes to be accessed fully and transparently by companies, allowing them to become more respondent on a real-time basis and increase their productivity and resilience. The advantages of a resilient and responsive supply chain became particularly noticeable during the global COVID-19 crisis.

Within the automotive component manufacturing industry, raw materials are delivered to the manufacturing plants through a standardized process based on anticipated orders and those received from customers. Forecasting is still predominately based on historical data and is often inconsistent or incomplete as the dynamics of the market changes day by day. Procurement from suppliers is, furthermore, traditionally an independent procedure from other parts of the supply chain, thereby posing risks of changes in the order flow occasioned by disruptions further up the supply chain.

1. CUSTOMERS AND SUPPLIERS

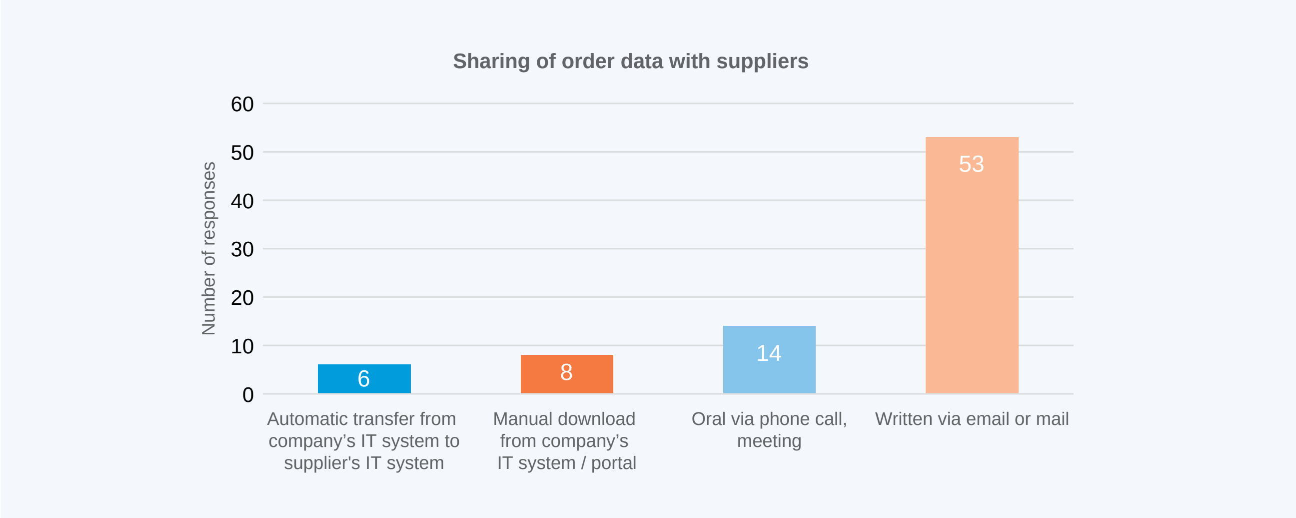
Transparent and real-time data facilitate the manufacturing process and allow for quicker and more efficient communications along the supply chain, modelling "what-if" scenarios and the ability to make immediate adjustments as conditions or parameters change. Delving deeper into the supply chain process requires the exchange of order data. Order data are provided to suppliers to let them know the quantities required based on current customer demand. Traditional methods are based on oral communications through phone calls or meetings, as well as written via email or mail. More advanced systems of sharing order data with

FIGURE 4: Types of ways through which manufacturing firms get order data from customers



suppliers include manual downloads from customer IT systems (such as from business process management software like enterprise resource planning (ERP) systems) and portals, while advanced procedures embed automatic transfers (electronic data interchange (EDI)) from customer IT system to the own IT system. In the Indian context, it can be observed that the majority of data sharing is done in traditional ways through written communication by more than 84 per cent on the supplier side and by 80 per cent on the customer side.

FIGURE 5: Sharing of order data by automotive component manufacturers with suppliers



Original equipment manufacturers (OEMs) for cars, or tier 1, are typically larger companies with a higher level of digitalization and an international footprint, whereas tier 2 or lower, as suppliers of lower-value components, often are MSMEs. The companies participating in the survey report, therefore, asymmetrical data sharing: the data exchange at the customer side is more likely to be supported by IT systems or automated than the communication with the supplier side, which often is done via phone call or email/mail. The method of sharing information on the availability of products and the subsequent delivery status between suppliers and Indian automotive component manufacturers is primarily on a traditional request basis in written format via email or mail for both information on the availability of products and delivery times as well as the status of delivery or shipment of finished goods. At the customer side, the tracking of delivery or shipment is more likely to be supported by IT systems and digital means such as download from online tools (12 companies on the customer side versus 5 on the supplier side), transfer to customer system (8 versus 2), or shipment tracking of logistics service provider (7 versus 3).

FIGURE 6: Obtaining information from suppliers about the availability of products

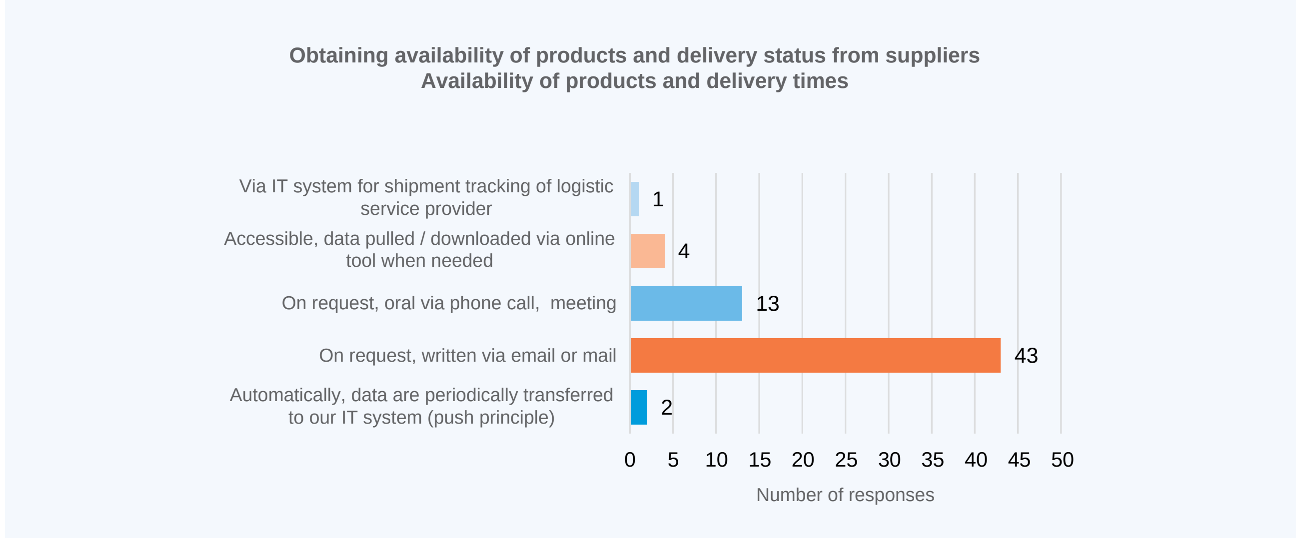
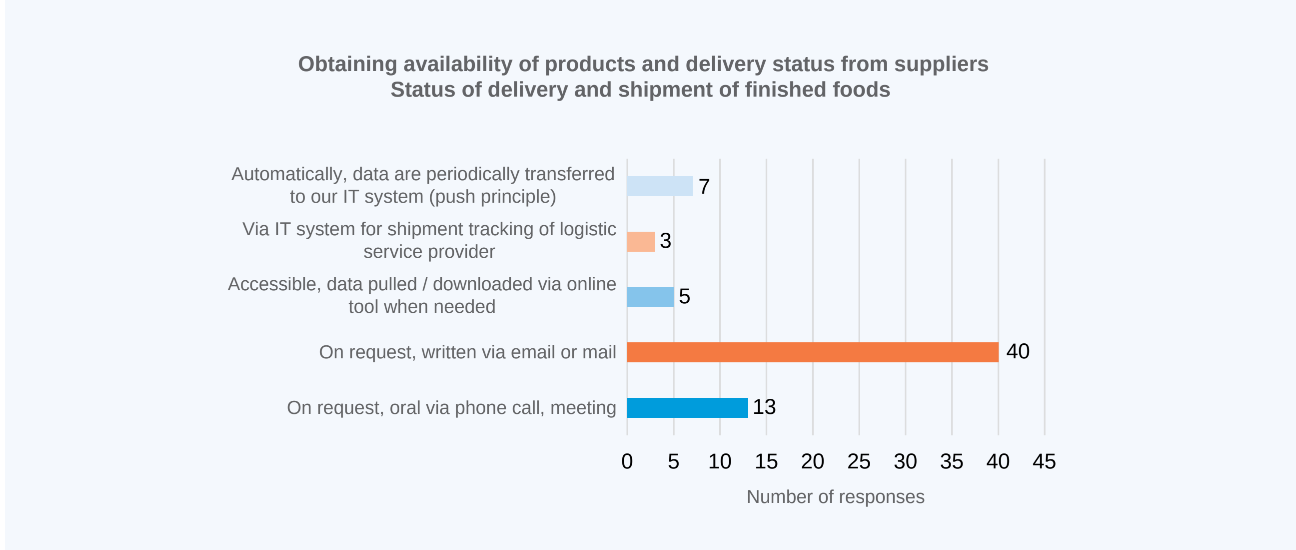


FIGURE 7: Obtaining information from suppliers about the delivery status



Correspondingly, while the channels of communication between manufacturers and their suppliers are largely based on traditional methods, the information management systems used follow a similar trend. In fact, when asked which kind of information management system best described the way that data is handled in relation to **supplier orders and deliveries,** about 50 per cent use a system based on manual data collection of historical data without an underlying IT system, and about 45 per cent of the respondents use an IT system with manual data entry of supplier data or (semi) automated data acquisition. The information management system for **customer related data** shows a higher level of digitalization. About 74 per cent use either an IT system with manual data entry of customer order data or (semi) automated data transfer.

FIGURE 8: The way customer orders and deliveries are handled in the information management system

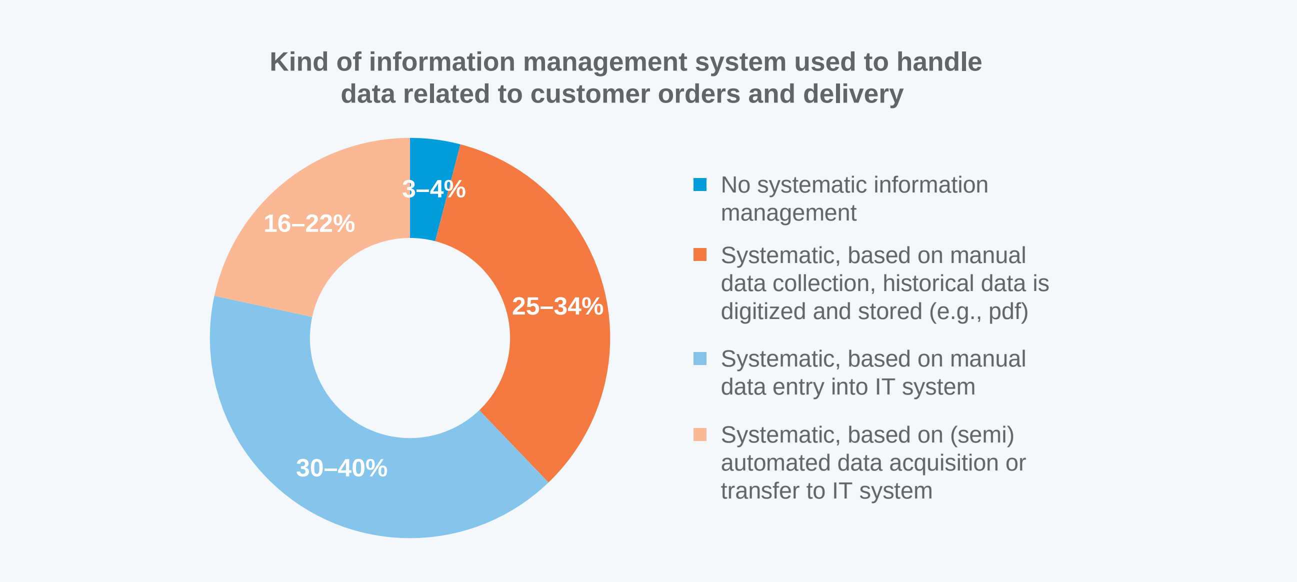
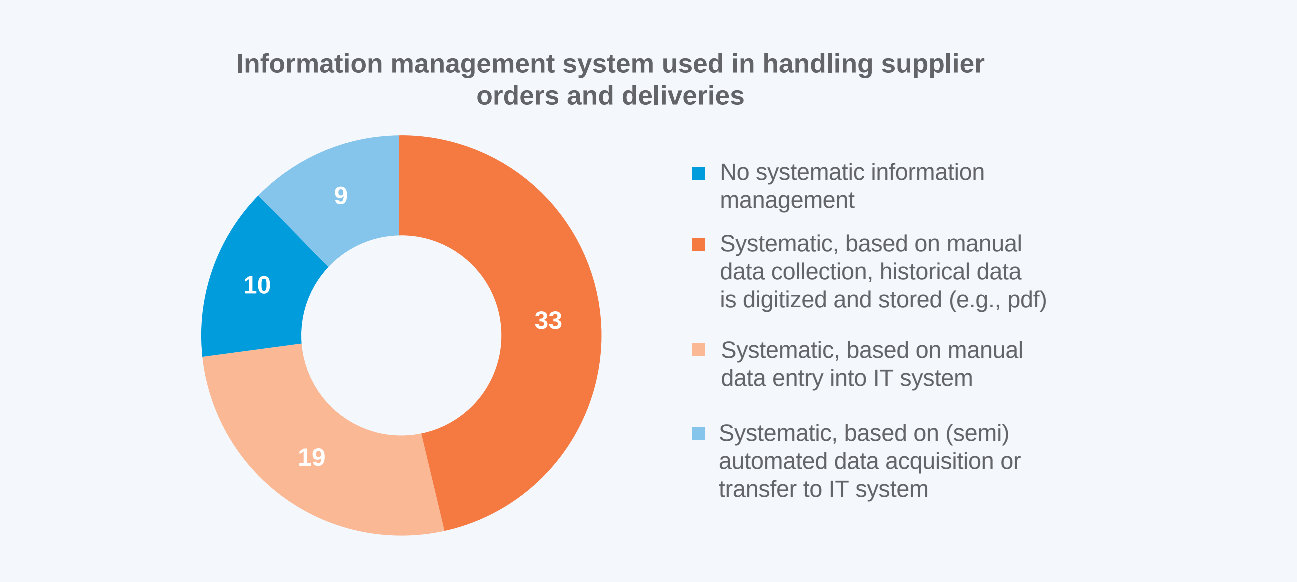


FIGURE 9: Information management system deployed by manufacturers to handle supplier order and delivery information



Data play a key role in the success of Industry 4.0 in terms of the decision-making process. Through timely (real-time) and accurate data, unexpected changes along the supply chain can be communicated faster and the manufacturers can resolve the same and avoid losses and be resilient. In the Indian automotive component landscape, customer or supplier-related data in relation to orders and delivery are not only regularly monitored and controlled, but also embed real-time monitoring (customer side: 34 per cent, supplier side: 30 per cent), with a further 17 per cent (customer side) or 12 per cent (supplier side) of the manufacturers already integrating real-time monitoring combined with automated actions (such as event-triggered tasks).

FIGURE 10: How manufacturing firms use actual data related to customer orders and deliveries

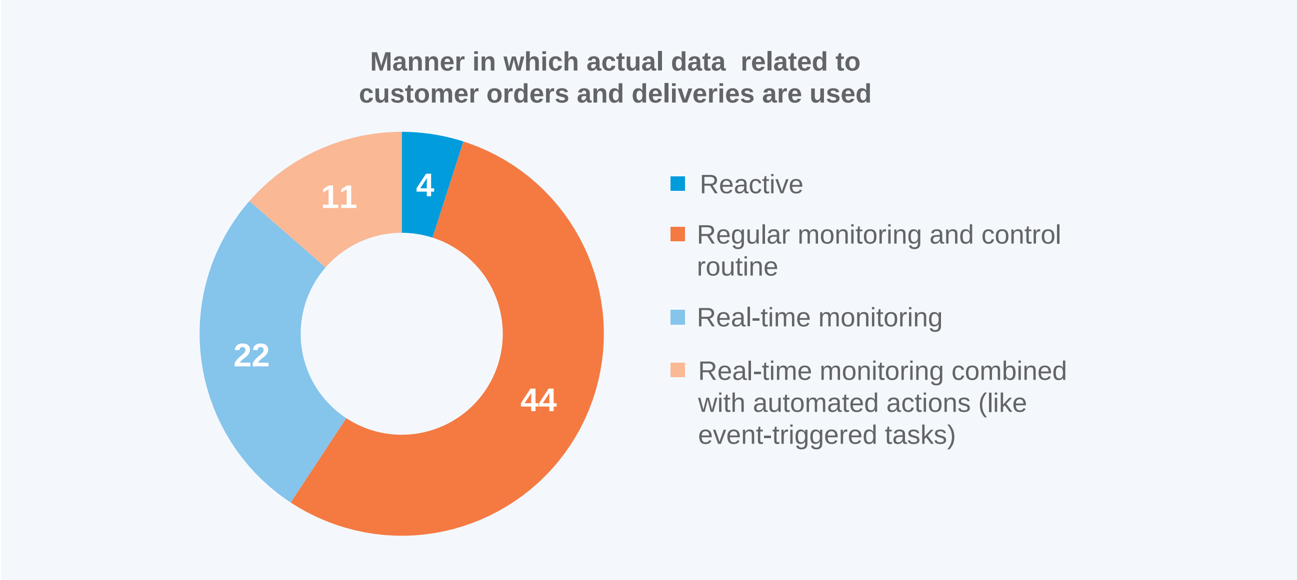


FIGURE 11: Manner in which suppliers use data on supplier orders and deliveries

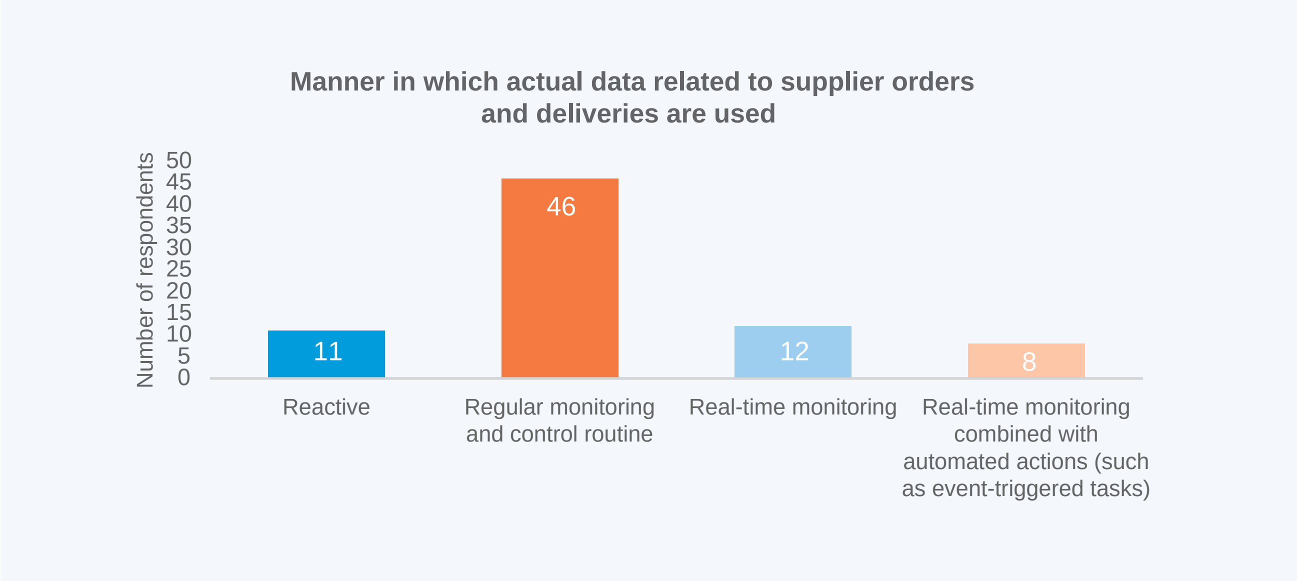


FIGURE 12: Use of historical data related to customer orders and deliveries

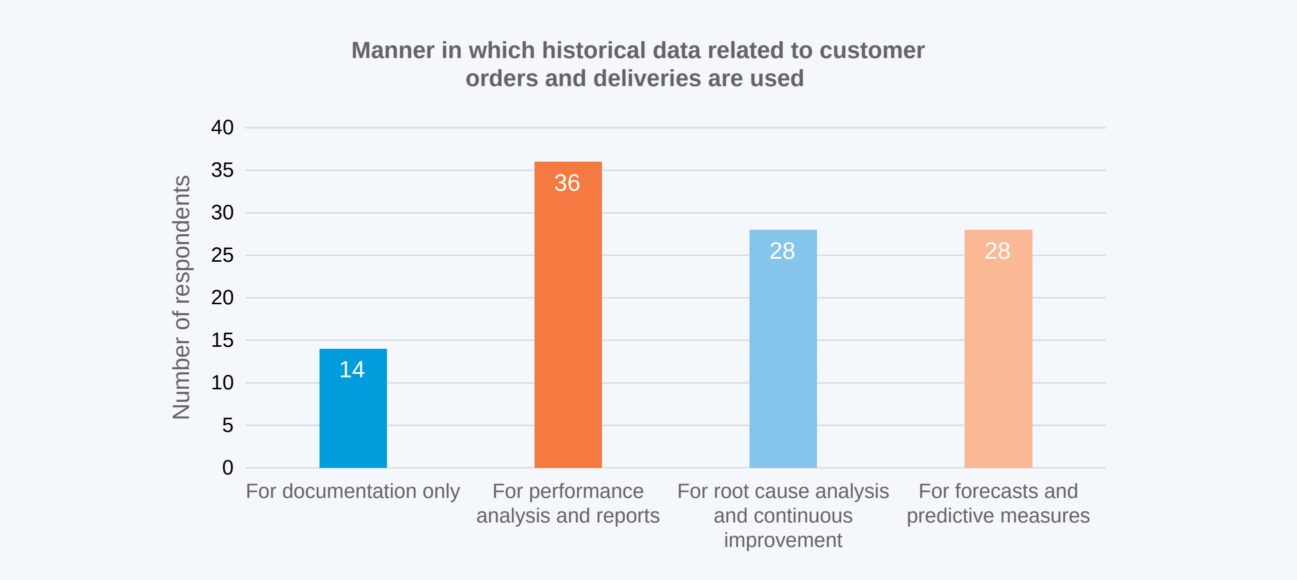
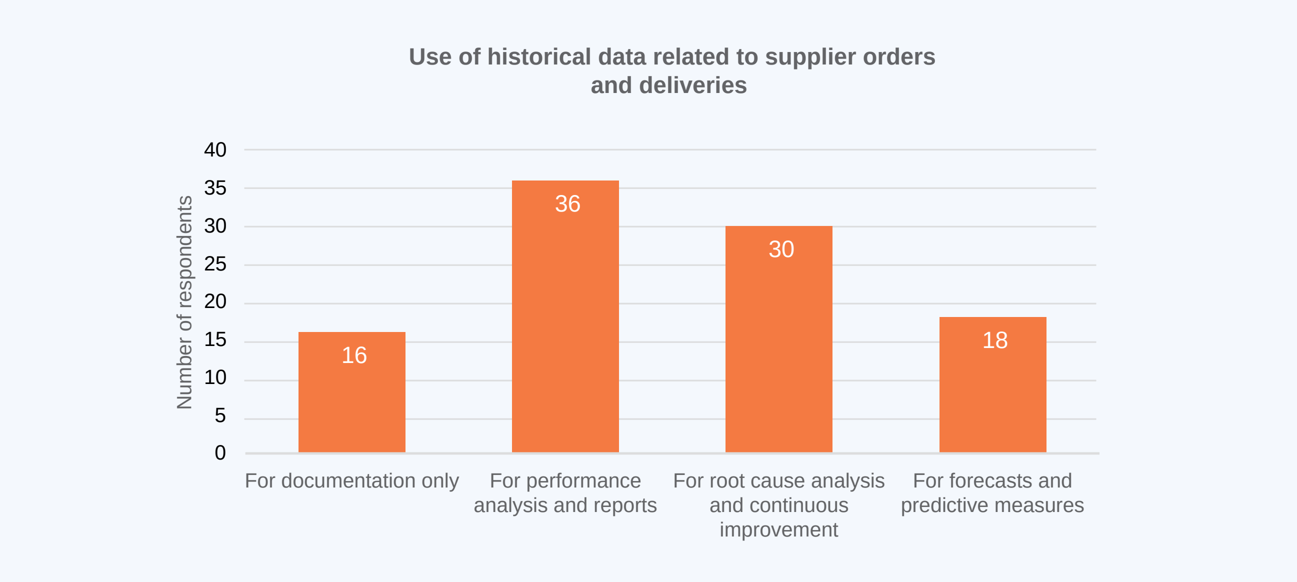


FIGURE 13: Use of historical data related to supplier orders and deliveries



Similarly, historical data received by customers or suppliers related to orders and deliveries are used for root cause analysis and continuous improvement (customer side 45 per cent, supplier side 48 per cent), as well as used for forecasts and predictive measures (customer side 45 per cent, supplier side 30 per cent).

In other words, while the communication channels between the Indian automotive manufacturing supply chain partners are predominantly based on traditional methods, the current and historical data is used in a modern way, indicative of Industry 4.0 approaches. Comparing the customer and the supplier side, the maturity in digitalization of the supply chain is higher downstream at the data exchange between manufacturing companies and their customers. The main reason for the higher maturity on the customer side is that car manufacturers and tier 1 suppliers are typically large and international corporate entities.

2. PRODUCTION PLANNING AND STOCK LEVELS

In terms of production planning and associated stock levels, the use of digitalization and innovative solutions follows a similar pattern to other parts of the production process. In terms of production planning frequency, planning of production orders, machines, and workforce is done daily by the majority of manufactures and materials planning is done on a weekly basis. Nevertheless, although the planning for the different areas of the manufacturing process is done frequently, the methods used to manage resources are predominantly based on spreadsheets, including forecasts covering a number of weeks, or are manual and in an analogous form, and are paper based or use planning boards for machines and workforce.

On the side of planning of production orders and materials, about one fifth of the manufacturers use more advanced digital solutions with real-time information such as ERP, manufacturing execution systems (MES), advanced planning and scheduling , and others. Sensor or tracking technologies that are characteristic of Industry 4.0, that can be used for automatic data acquisition, have only been employed by a small sample of less than 5 per cent over all planning aspects.

FIGURE 14: Production planning frequency

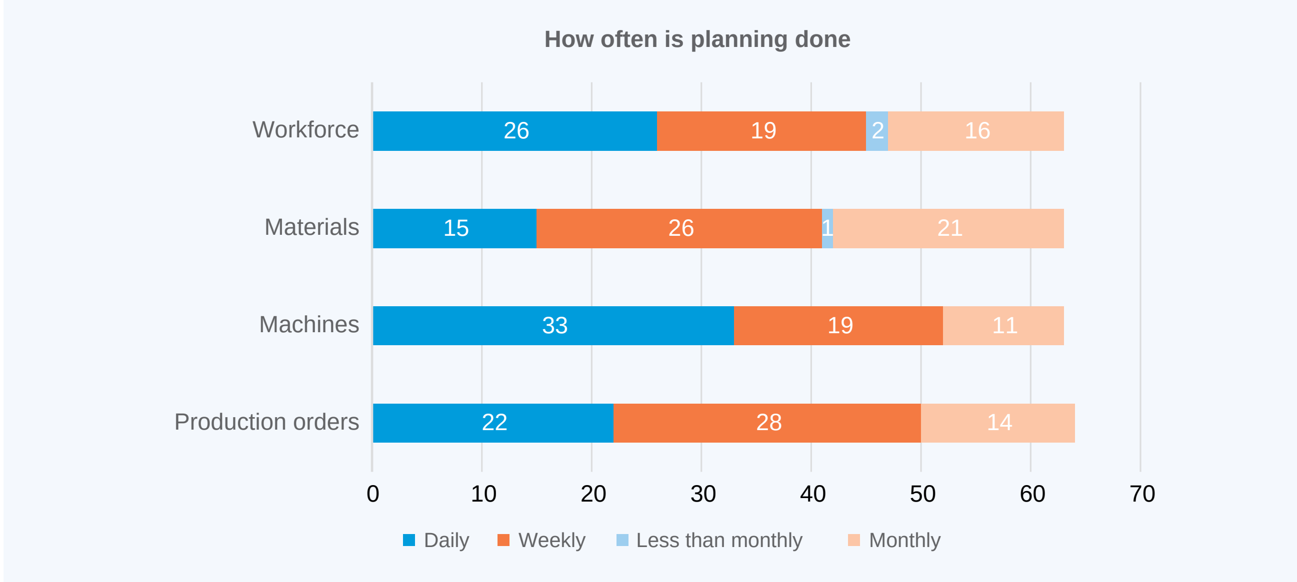
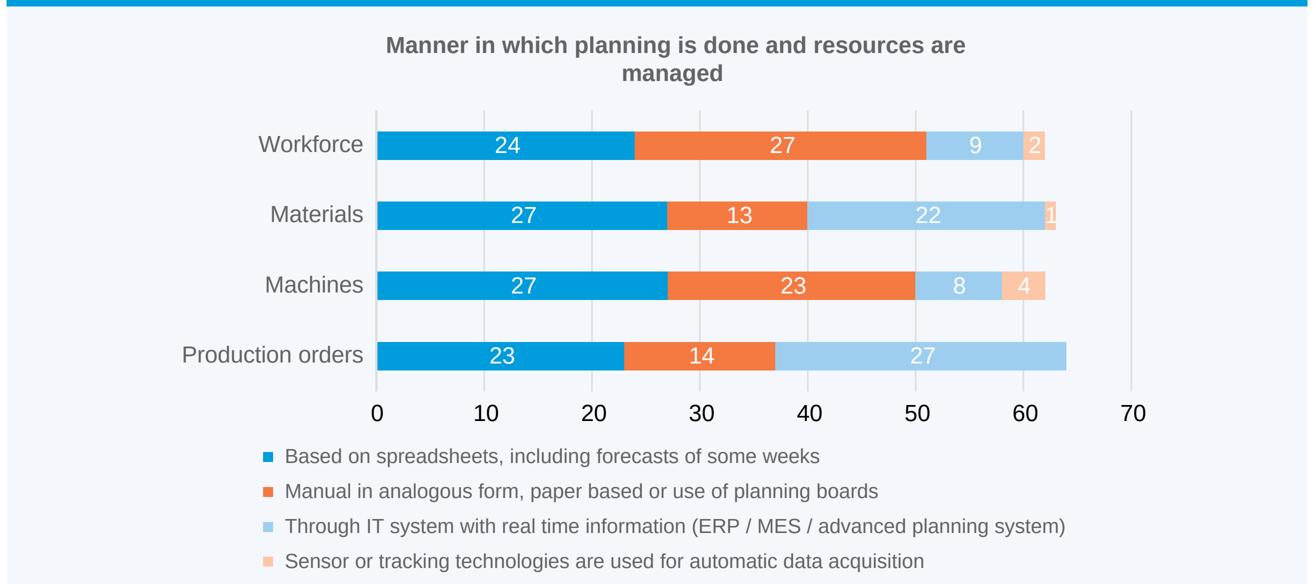


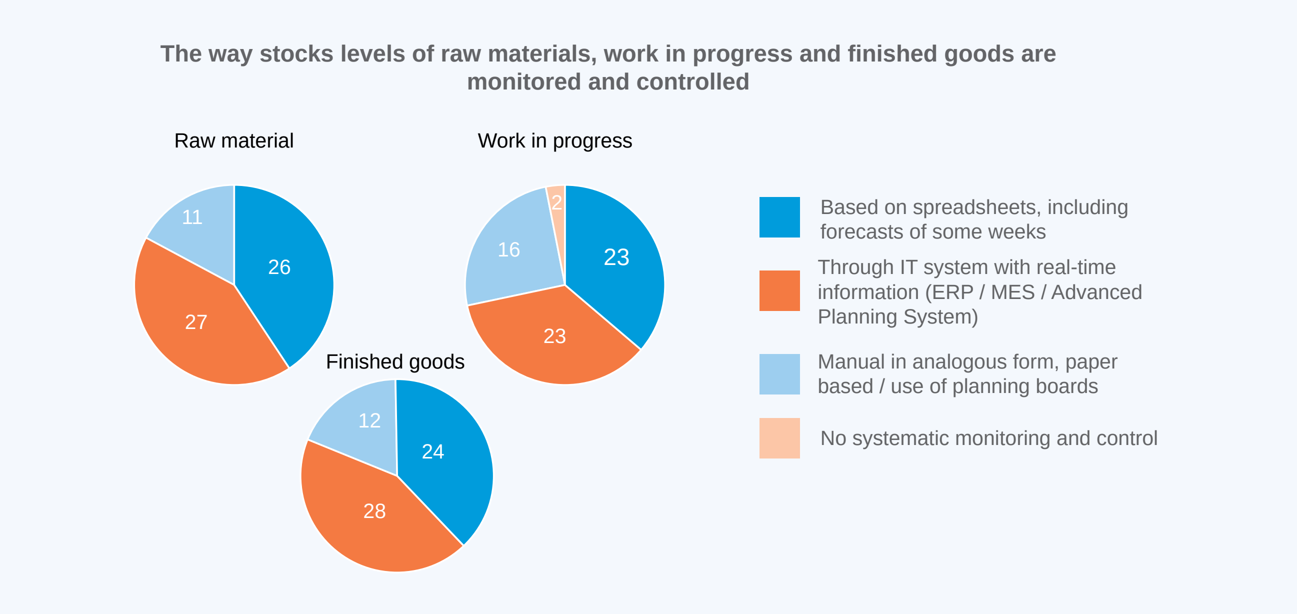
FIGURE 15: Production planning methods and tools



When asked how stock levels of raw materials, work in progress, and finished goods are monitored and controlled, the manufacturing firms use methods similar to those in production planning, albeit slightly more advanced. In fact, the primary way to monitor and control each type of stock is through an IT system with real-time information (such as ERP, MES, advanced planning and scheduling, warehouse management systems) and based on spreadsheets, including forecasts covering a number of weeks, which corresponds to the responses received for materials in production planning. Likewise, only the outliers have implemented sensor or tracking technologies for automatic data acquisition.

In other words, in terms of production planning and monitoring and control of stock levels, production orders, workforce, and machines, some degree of digitalization is in use by the component manufacturers across India, with only a very small sample utilizing highly modern and innovative Industry 4.0 methods.

FIGURE 16: Way in which stock levels are monitored and controlled

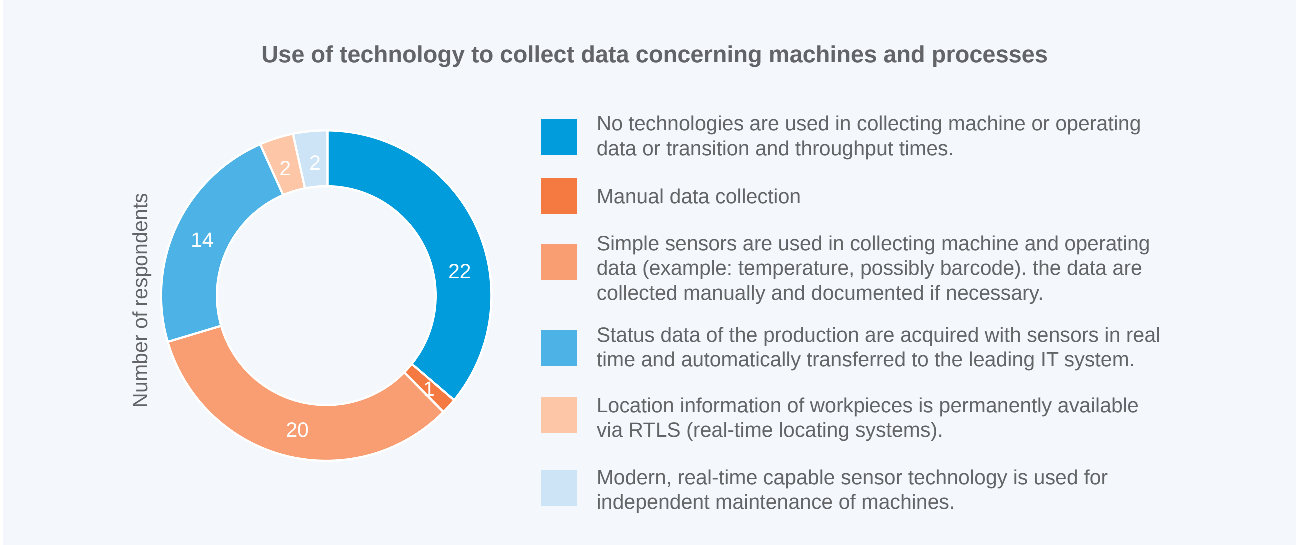


3. MACHINES AND MAINTENANCE

An element essential to successful manufacturing relates to machines and their respective maintenance. Industry 4.0 is grounded in data collection and analysis to be able to get real-time predictions on the status of machines and their productivity and any subsequent downtimes or faults. Two distinct aspects were analysed concerning machines and processes: primarily the use of data and technology to evaluate the performance of machines and processes, in addition to the condition of the machines. Correspondingly, the approach to maintenance was surveyed and classified into reactive approaches, planned approaches, preventive approaches, and innovative predictive measures using sensors and analytics.

In the context of Indian automotive component manufacturing, the use of technology in terms of data collection was generally minimal. In fact, over 36 per cent of manufacturers reported that there are no technologies in use to collect machine or operating data. Similarly, 32 per cent of the respondents confirmed that only simple sensors are used to collect machine and operating data such as temperature and bar codes. Nevertheless, around 23 per cent of Indian automotive component manufacturers have stated that they are using sensors through real time with data being transferred to the leading IT system. Only 2 companies out of 61 , both large manufacturers, have reported the use of modern, real-time capable sensor technology for independent maintenance of machines.

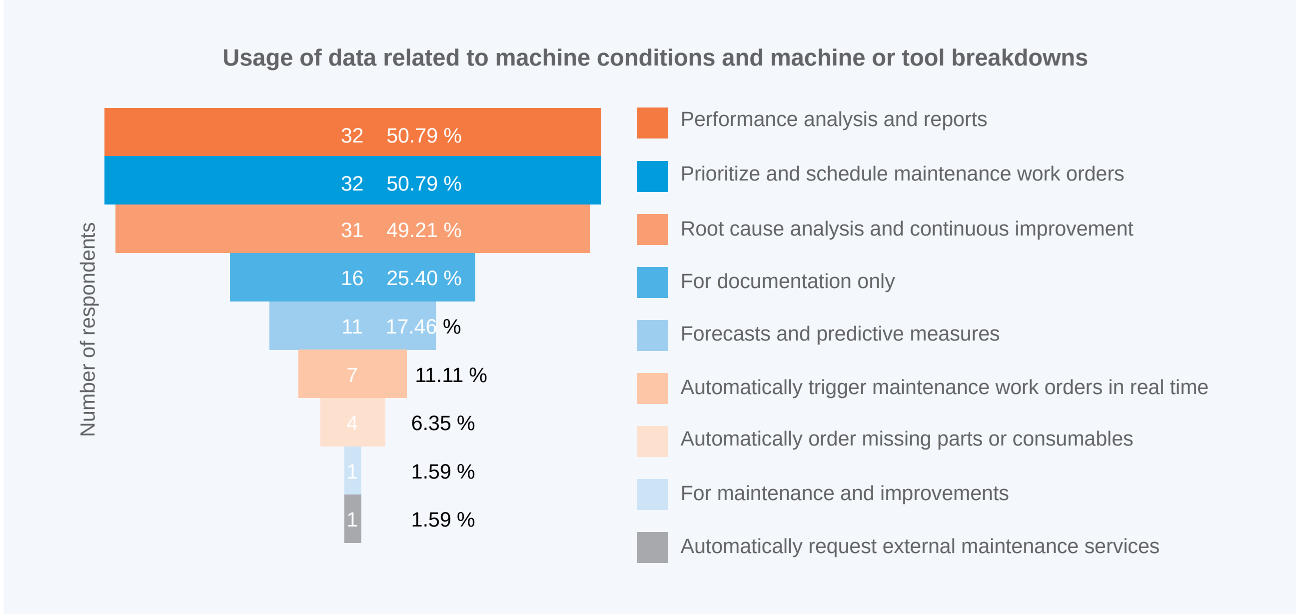
FIGURE 17: Use of technology to collect data concerning machines and processes



Data usage is essential for Industry 4.0 and plays an important part in the decision-making process. Through the implementation of advanced technologies such as smart sensors and cloud computing, data can be extracted and assessed, and trends and other valuable information can be obtained to speed up operations and make manufacturing more efficient. In terms of machinery, data can be important to assess the performance of the machines, identify defects, and understand when maintenance of machines is needed. Through sensors and data analytics, vital elements in smart factories, real-time data can be extracted and analysed through self-service systems.

Data can be used to identify problems and understand the underlying bottlenecks that cause lower productivity. Effective data usage on machines can, therefore, help to reduce costs and eliminate wastage, and become more productive by maintaining the ability to produce goods that are required by customers and avoid any delays. In

FIGURE 18: Using data on machine conditions and machine breakdowns



fact, it is estimated that big data analytics can reduce breakdowns of machines and unscheduled downtime by around 25 per cent[11].

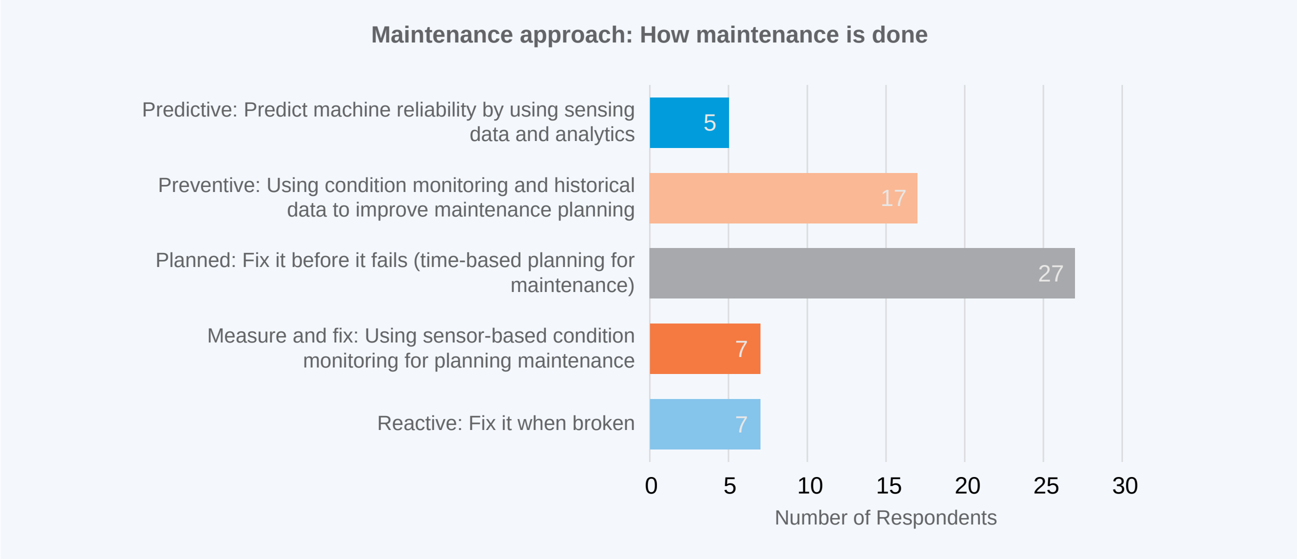
In the Indian context, data are primarily used for performance analysis and reports as well as root cause analysis and continuous improvement. Nevertheless, around 17 per cent of the respondents reported that data are used for forecasts and predictive measures. In terms of automatic actions such as to automatically trigger maintenance work orders in real time, and automatically order missing parts or consumables, only a small sample of companies have implemented these innovative technologies (11 per cent and 6 per cent respectively). There is scope, therefore, to implement advanced digital technologies and improve productivity among firms.

4. MAINTENANCE

Maintenance and repair operations (MROs) are vital for the proper functioning of enterprise assets while being key to the continuity and effectiveness of business operations. Maintenance can be categorized into five different types; reactive, planned, measure and fix, preventive, and predictive, all directly correlating to different degrees of digitalization in the manufacturing process. Traditional methods of maintenance are: reactive, which relates to only fixing machines once they are broken; and planned, in which machines are fixed before they fail based on plans. The measure and fix method has been increasingly used with the introduction of sensor-based condition monitoring and allows for more real-time fixing of machines. More advanced methods relate to preventive maintenance, which relies on condition monitoring as well as historical data to improve maintenance of machines. The most advanced maintenance that is being implemented in many smart factories is classified as predictive maintenance, in which machine reliability is predicted through a mix of sensing data and advanced data analytics.

In the context of the Indian automotive manufacturing industry, merely 7 per cent of the companies deploy predictive maintenance while more than 50 per cent of the manufacturers still use traditional methods such as reactive and planned. The overall trend of a heterogeneous application of digitalization is also observed in this production aspect. A similar pattern is further observed in that on average the larger companies follow more advanced maintenance approaches, while smaller manufacturers use traditional approaches. Maintenance tasks are mainly done using in-house resources (81.5 per cent).

FIGURE 19: Way in which maintenance is done



11) https://www.ien.com/software/article/20998639/how-big-data-drives-production-gains

5. IT SYSTEMS AND ORGANIZATION

Central to the development and continual monitoring of sophisticated digitalization systems and respective Industry 4.0 technologies is a robust IT system.

The most common IT systems in manufacturing companies are enterprise resource planning (ERP) systems which manage the main business processes. These systems track business resources such as the budget, raw materials, capacities and the status of business commitments, and results such as orders and payments. In the Indian automotive industry in general, the medium and large size companies, with annual sales of more than 750 million rupees, have implemented an ERP system. For smaller companies (annual sales of less than 500 million rupees) less than 50 per cent of the companies use ERP systems. Depending on the nature of the manufactured products, computer-aided design (CAD) systems are used. Manufacturing execution systems (MES) are only implemented in a few companies and are not very common even in large companies.

In general, the dissemination of IT systems, ERP, CAD and MES, is higher in the larger companies.

Smaller companies with less than 750 million rupees in annual sales often do not have their own IT employees but work with external IT service providers. Outliers in the SME sector have more IT personnel because their own business contains software and/or hardware services (for example, Gilard Electronics). For companies with annual sales that exceed 75 million rupees , the typical IT arrangement is a central department with between two and five employees. In larger companies the IT teams are bigger, and some of them have a decentralized approach for IT organization.

FIGURE 20: Number of employees engaged in IT department

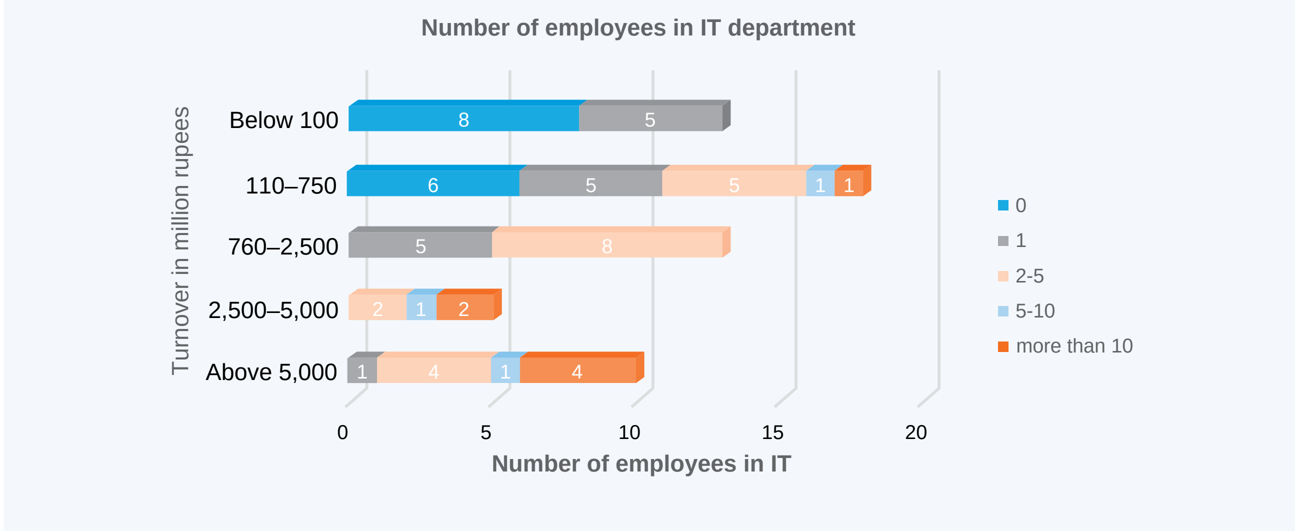
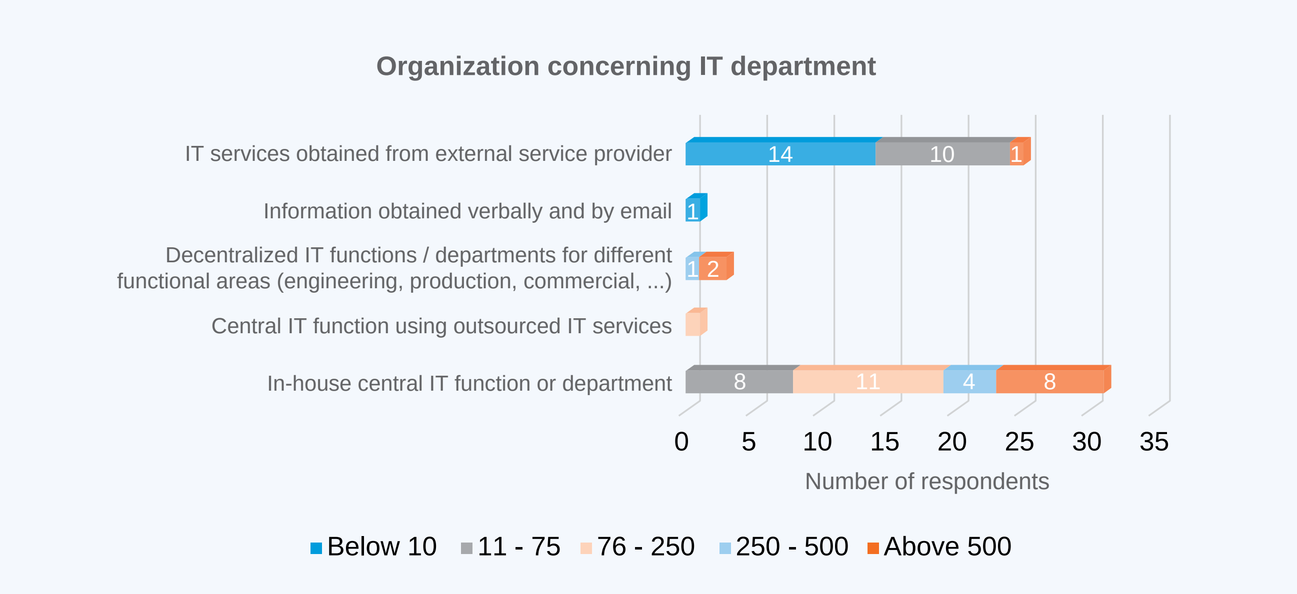


FIGURE 21: Organization of IT facilities



What could also be observed is that the number of employees in the IT department correlated with the level of digitalization applicable in the business and manufacturing processes. The companies that have adopted more Industry 4.0 technologies have larger IT departments.

II.C COMMON CONCERNS AND CHALLENGES

FIGURE 22: Common concerns and challenges

Besides assessing the overall level of digitalization in the Indian automotive component manufacturers, the first survey also seeks to identify common challenges that the manufacturing firms have been facing along the complete manufacturing process.

Respondent remarks:

- *“Skilled labour is often not available”*
- *“Getting workforce and retaining them”*
- *“Lack of training is a major concern”*
- *“Average labour cost”*
- *“Daily absenteeism and poor performance by new operators leading to failures”*
- *“COVID-19 has reduced manpower capacity”*
- *“Absenteeism, owing to remote location and agricultural atmosphere in surrounding area”*

Of a variety of concerns, such as those relating to human capacity, inventory, reliability of suppliers and customers, three key challenges have been identified as having the highest priority. The main concern related to workforce challenges, which is present through all company profiles from large manufacturers to MSMEs. In fact, more than 66 per cent of the respondents have mentioned the concern “Labour capacity, costs, skills, absenteeism” as one of their three top priorities that need to be addressed.

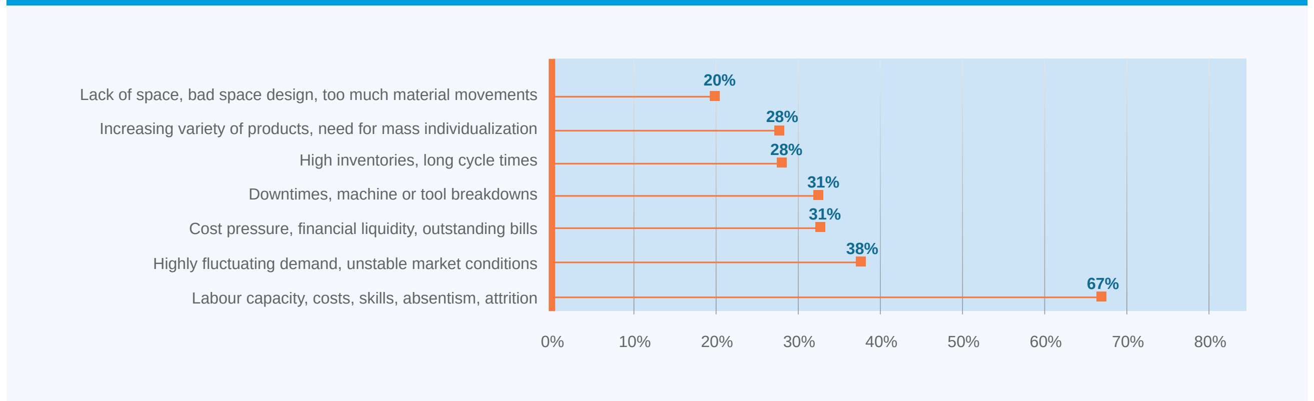
When asked to elaborate on those concerns, respondents described the situation as frequent lack of availability of skilled labour, problems with retaining the workforce, lack of training, high average labour costs, etc.

The second key challenge that has affected more than 37 per cent of all the respondents and is equally distributed among company sizes and turnovers is the unstable market conditions. Highly fluctuating demand, evolving market dynamics, changing policy and regulatory arenas, and more recently, the ongoing COVID-19 crisis, has further exacerbated the instability of the market conditions, making unstable market conditions a second main challenge for the firms.

Respondent remarks:

- *“Investments in current production lines need to be carefully calibrated and sustaining production inventory is hard”*
- *“Highly fluctuating demand and variety, making it difficult to cater to customers’ needs”*
- *“There are price variations in raw materials”*
- *“The fluctuating demand plays havoc with raw material inventories and capacity”*
- *“There are schedule fluctuations from customers, even in the same month”*
- *“Downtime is increased, new capital expenditure is not advisable in today’s unstable economy”*

FIGURE 23: Common challenges faced by Indian automotive component manufacturers



The third major concerns pertain to financial issues, and to equipment breakdowns. These problems are predominant in 30 per cent of the component manufacturers. Financial issues were categorized as cost pressure, financial liquidity, and outstanding bills, while equipment breakdown was summarized into machine and tool breakdowns that have been causing problems in the timely manufacturing and delivery of components.

Cost pressure, financial liquidity, outstanding bills

Respondent remarks:

- *"Customers clear bills irregularly, and there is a lack of financial support from banks"*
- *"Lower inventory management leading to delivery failures"*
- *"Cost pressure to ensure profitability as inventories are high and cash flow gets disturbed"*
- *"Competitive cost of product owing to current market situations"*
- *"Tier customer delays payment more than 60 days, supplier wants payment immediately, goods and services tax (GST) must be paid on time. This creates lots of financial pressure on MSMEs"*
- *"There is a lot of cost reduction pressure from customers"*

Downtimes, machine or tool breakdowns

Respondent remarks:

- *"The cost of repairs is increasing"*
- *"Frequent breakdown in flywheel line"*
- *"Breakdowns, resulting from the old age of model machines that are being used, are observed"*
- *"High tool and machine breakdown, downtimes, machine or tool breakdowns are a big challenge"*
- *"Owing to light fluctuation, electric panels get damaged frequently"*
- *"Machine downtime is increasing owing to lack of preventive machine maintenance"*
- *"Lack of proper planning of maintenance of dies causes continuous issues"*

Implementation of Industry 4.0 technologies in the complete supply chain would mitigate most of the common concerns and challenges that the manufacturers have experienced. This has been further reiterated in the subsequent in-depth analyses of best practice adopted by companies that use sensors and real-time monitoring to cut labour costs, reduce defects and machine breakdowns, and create a better responsiveness and resilience in times of crisis and fluctuating customer demand. The types of technologies and their advantages are discussed in depth in the subsequent sections.

II.D KEY OUTCOMES

The Indian automotive component manufacturers display a very heterogeneous adoption of digitalization and Industry 4.0 approaches. While some manufacturers use modern and innovative solutions that allow for real-time monitoring and data gathering as well as enhancing the responsiveness of these manufacturers to machine breakdowns or changes in customer demands, other manufacturers still operate with traditional methods of manual communications and data gathering, leading to higher risks of inaccuracies and making their operations prone to errors.

In addition, based on the nature of the respondents at large, the size of the company and the number of employees in the IT department correlate with the development stage of digitalization. As such, smaller companies are more likely to use traditional methods, while larger manufacturers are embedding sensors and real-time data analysis and predictive planning into their operations.

Nevertheless, there have been outliers to this overall trend with small and medium lower-tier manufacturers illustrating best practices in their production process. These best practice examples have been further analysed in the next section.

III

Best practices

The overall trend in terms of adoption of Industry 4.0 in the Indian automotive component manufacturing industry depicts a very heterogeneous image, with a strong correlation of larger companies having greater adoption levels.

III.A SHORT INTRODUCTORY REMARKS: REASON FOR SELECTION

Upon analysing the level of digitalization and adoption of Industry 4.0 in the Indian automotive component manufacturing industry, the overall trend depicts a very heterogeneous image, with a strong correlation of larger companies having greater adoption levels. Nevertheless, there were also positive outliers, such as medium sized companies that demonstrate very advanced use of Industry 4.0 technologies and can serve as a basis and role model for other SMEs in the industry to follow.

To gain a better understanding of their digital journey, including which technologies were adopted, as well as the benefits and lessons learned, in-depth interviews were conducted with four such companies. During these interviews, virtual demonstrations of the technologies that have been integrated, as well as advice for other companies on how to embed the Industry 4.0 technologies, have been provided. The companies which participated in the in-depth interviews are listed below:

S. No.	Company name	Location	Main products or components	Category of company size
1	Microsign Products	Bhavnagar, Gujarat	Cable ties with various facilities and cable, wire management products such as saddles, marking sleeves for wire identification	50–99 employees, Less than 100 million rupees turnover
2	Gilard Electronics Pvt. Ltd.	Mohali, Punjab	Switches, receptacles, resistors, relays	250–499 employees, 110 million–75 million rupees turnover
3	Universal Precision Screws	Rohtak, Haryana	Shoulder head bolts, dowel pins, guide rods, lock nuts and similar	500–999 employees, 2.5 billion–5 billion rupees turnover
4	Sanjeev Group	Aurangabad, Maharashtra	Transmission parts	500–999 employees, 2.5 billion–5 billion rupees turnover

III.B SAMPLE CASE STUDY 1: MICROSIGN PRODUCTS

Classic lean production management does not include digital systems or automatic gathering of data but relies on analogous media for process transparency and improvement.

Nevertheless, both worlds (lean and digital) offer opportunities for MSMEs to improve their performance significantly. Offering simple digital solutions to provide instant, real-time performance feedback on digital dashboards, to report incidents such as machine downtime via screens or mobile devices or to automatically trigger predefined actions enables managers and employees to react and improve quickly.

Organizations that on the one hand have incorporated the lean management philosophy of continuous improvement for manufacturing excellence, and on the other hand have the capability to identify if and how digital or data-based solutions could help to improve process transparency and optimization will achieve major improvements in productivity and competitiveness.

In enabling companies to build up their capabilities for lean management as well as digitalization, it is important to start with lean principles to define and stabilize enterprise processes and to understand the importance of using visual management, key performance indicators, and other data to monitor, control and improve these processes. Using digital solutions like the Industrial Internet of Things (IIoT) to capture data and get better and faster insights in manufacturing processes provides a good complement in early stages of lean management introduction. With growing maturity in lean management, further Industry 4.0 or digital solutions might be of benefit depending on the specific situation and challenges of the company.

1. COMPANY INFORMATION AND HISTORY

Microsign Products was founded in 1978 in Gujarat, India, and produces low-cost and low-tech products such as plastic fasteners, clips, clamps, closures and many more products used for the packaging, electronics, automobile, defence, telecommunications and aerospace industries. Microsign Products takes special pride in providing quality products by tapping untapped potential of people living with disabilities. They constitute around 60 per cent of the workforce, but it makes no difference in setting up business performance parameters which are at par with any multinational organization.

The core values of Microsign Products include development of employees. Employees are exposed to new and emerging technologies, industries' best improvement practices and team-building exercises.

2. TECHNOLOGY ADOPTED

The company has gradually moved towards digitalization and started their journey with the digitalization of the main business processes via the introduction of a simple ERP solution. In the earlier set-up, from 2011 to 2014, data generation in the company was limited and offered limited scope for analysis. From 2014 onwards, the company started using software where the company was facing challenges, and also for generating invoices, especially after the introduction of new laws including the goods and services tax (GST) in India.

FIGURE 24: ERP used by Microsign Products

The company moved to a generic ERP system in 2018 in such a way that the system updating was much faster and the invoicing process was not affected. The ERP system is being used to generate various kinds of production reports, including:

- **Idle summary report** which helps the company to identify the reasons behind machine stoppage such as a power cut, problem in the machine and others
- **Machine utilization report** helps the company to find out how much production has been carried out by a particular machine in the previous 24 hours
- **Quality performance report**: various scripts are generated during the injection moulding process. This report helps the company in bifurcating these scripts
- **Machine – mould – operator performance report**: helps in identifying the productivity of the operator.
- **Raw material consumption and finished goods summary report**: gives information on how much raw material is consumed in the production.

The ERP system is also used to generate various customer-specific, customer-required certificates, such as warrant certificate, certificate of conformance and others. Also, invoices, production records, stock reports, daily reports and similar are generated using the ERP system.

The data generated by this software are kept safe and are backed-up on a daily basis. As a result, the company was able to restore the data within 30 minutes after a ransomware attack.

At the shop floor level, the digitalization started when Microsign invested in new machinery and equipment.

The company has moved towards modern injection moulding machines where the controllers of the machines have a number of advanced technologies built in. Previously, the machines used had different controls, for example the hot runner system, the air dryer had separate controls and the operator had to move across different areas to change the parameters. Today, these controls can be managed from a single touch screen of the injection moulding machine. As a result, getting feedback has become faster and also the system makes it easier for the operator to understand the process without moving anywhere.

In addition, Microsign started to invest in advanced technologies for the boiling and drying processes of the plastic material, including digital monitoring and control, and plans to automate packaging of finished goods.

In the manufacture of plastic products, one of the main problems is that the raw materials and the finished products are not easily distinguishable which results in easy mix-up of goods, difficult tracing and a high risk of wrong dispatches. To overcome this challenge and to increase the efficiency and quality of their product, Microsign introduced a bar code and quick response (QR) code as identifier in 2018. To ensure the correct products are dispatched, the company has given definition to individual boxes. Each box is used for a particular kind of product. The QR code is helping the company to identify the right products for the right delivery. As a result, the company is able to ensure that the right products are delivered to the right customer and that the customer also is able to distinguish the different items with the help of the identifier.

FIGURE 25: QR codes used by Microsign Products on packets and boxes to avoid errors in dispatches

3. LESSONS LEARNED AND ADVICE FOR BEGINNERS

During the design of the ERP system, the staff were directly engaged from their respective departments, giving a sense of ownership to the labour force. It makes things simple and accessible for everyone.

The advice of Microsign to other companies on adopting Industry 4.0 solutions is to start now. It may seem like a major capital investment now but in the long run it would help save time, engender peace of mind, and make operations less prone to error with the help of automation.

One of the prominent challenges that companies face when it comes to adopting Industry 4.0 is with respect to workforce. A workforce of people living with disabilities is open to the acceptance of new ideas, and this openness has avoided resistance to change.

III.C SAMPLE CASE STUDY 2: GILARD ELECTRONICS PVT. LTD.

1. COMPANY INFORMATION AND HISTORY

Gilard Electronics Pvt. Ltd. is a medium-sized automotive electronic component manufacturer (switches, connectors and resistors) operating in India, considered to be a front runner in digital transformation.

It belongs to the category of medium-sized companies, 250–499 employees and 110 million–750 million rupees turnover.

Their digital implementation started 34 years ago, and since then they have created solutions to solve limitations and constraints in process controls, sales, business, and other business service functions.

In comparison with other automotive component manufacturers, who traditionally purchase third-party digital solutions, Gilard Electronics, as a manufacturer of electronic devices, has a comprehensive team of software and hardware developers, and designs and implements their own software themselves. In addition, these software solutions are further sold to other SMEs, who are engaged in discrete manufacturing, via Gilard Application Programmers LLP, a subsidiary of Gilard Electronics Pvt. Ltd., that provides Industry 4.0 solutions to the manufacturing sector. The product of the company is a holistic business management software called Operating System for Manufacturing (OSM), spanning ERP and manufacturing operations management functions, which is the software and data backbone for all digital activities at Gilard.

Gilard Electronics began designing and adopting Industry 4.0 technologies five years ago, through sensors on machines to acquire data in real time. Their perspective towards Industry 4.0 in component manufacturing is that it controls two activities, business as well as manufacturing processes. Although smart machines (robotic controls) are an important element in Industry 4.0, data that are submitted to the cloud and are available for decision-making in real time are equally imperative. Through the implementation and continued refinement, monitoring, and evaluation of these innovative solutions, Gilard Electronics was able to serve both global and internal customers and meet their strict demands.

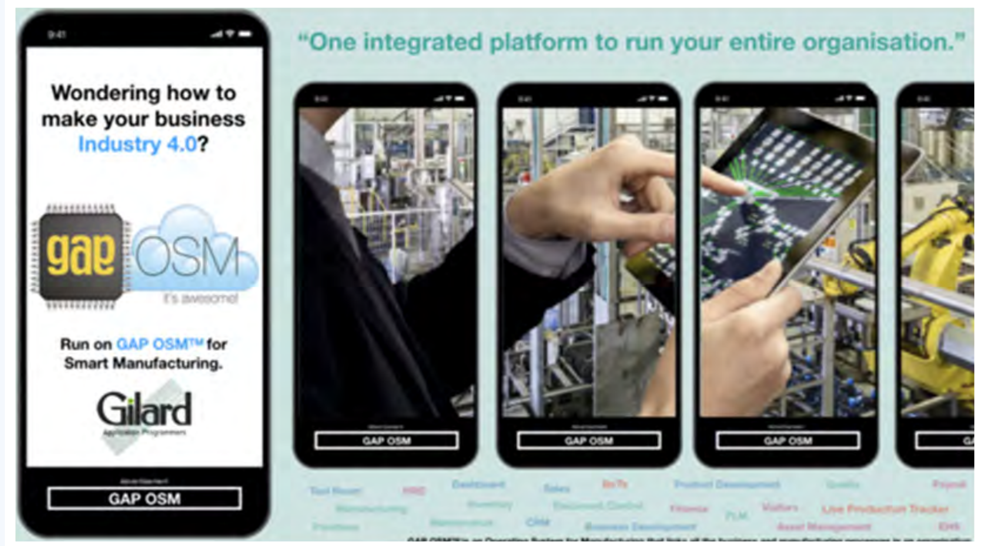
2. TECHNOLOGIES ADOPTED

Gilard Electronics has multiple solutions that have been integrated in their own manufacturing processes as well as being sold to other component manufacturers and are rolled out and relevant in different productive environments. These are outlined below.

Operating System for Manufacturing (OSM)

According to Gilard Electronics, Industry 4.0 is characterized by the convergence of digital and physical realms where new products and services are created. ERP solutions are considered to be the backbone of any manufacturing business, and any company that envisions pursuing this digital transformation should have a robust ERP system in place that can leverage the technologies that could drive Industry 4.0.

FIGURE 26: OSM business management software offered by *Gilard Electronics*



While ERP systems traditionally were set up on the premises of the manufacturing company and were predominantly used to manage structured data (such as financial transactions to buy and sell products, instructions on manufacturing products), modern ERP systems are much more developed. In fact, current ERP systems are designed to operate on the cloud which means that the system can be accessed virtually, off-premises from any location, with the data being held in data-centre operations including security aspects, with the responsibility shifting from the manufacturer towards the vendor. In this case, the manufacturer does not need to spend resources on trying to operate a data centre on the premises, but can concentrate on the production and development of their products. [12]

Furthermore, modern ERP systems are designed in such a way as to allow for external systems to be connected via application programme interfaces (APIs) and for integration of Internet of Things (IoT) solutions based on the data of sensors and smart objects that are attached to manufacturing equipment and machines.

12) https://www.themanufacturer.com/press-releases/erp-solutions-support-industry-4-0/

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The importance of an ERP system has been outlined, particularly in combination with data generated through sensors that can be accessed and further used on a real-time basis. In this regard, Gilard Electronics produced their own system that is copyrighted and rather than having 8 standard modules like comparable ERP systems, has 22 modules ranging from back-office service functions (legal compliance, human resources (HR) recruitment, skills development) to sales functions (new business development, product life management), to manufacturing elements (new product development, machines, IoTs).

In terms of machines, idle time, pending jobs and other aspects can be observed on the cloud. Similarly, the complete process from raw materials coming in and the data being recorded by workers is directly transferred to the next department (inspection) who view the drawing and the inspection sheet on screen and inspect and approve it online so it gets processed further, to be stored in stores or issued online. It communicates to the accounting department that can process payments to the suppliers. In this way, no time is lost during the complete manufacturing process and all data can be transparently viewed and accessed on any computer at any time.

Process control and monitoring devices (sensors)

Through the integration of hardware process control and monitoring devices (PCMD) as well as accompanying software on machines, the communication channels are enhanced, and up-to-date information concerning customer demand or product alterations are accessible in real time. For example, in case the specification of a specific component changes, all details for the production and distribution process are updated on the IT system including the history of the changes. In case of customer complaints or questions, therefore, all product-related order and production data are available and can be used to interact with the customer in a transparent and reliable way.

FIGURE 27: Process control software offered by *Gilard Electronics*

In addition, each machine in the manufacturing process has sensors and a digital tablet installed that allows for information to be seen on both the machine itself and on any desktop. The sensors are programmed in such a way that machine downtime is precisely traced, and if a machine stops for more than three cycles, a message is sent directly to the supervisor informing them about the downtime. In case no response is received by the direct supervisor, another message is sent to management. In this case, machine downtime can quickly be captured and responded to through the tracking of sensors embedded in the machines. The manager in charge is able to react immediately on upcoming issues.

3. BENEFITS AND OUTCOMES FROM USAGE

Gilard Electronics reported multiple benefits from their digital transformation and the integration of Industry 4.0 technologies along their manufacturing and business support system, relating to cost savings, higher transparency, and productivity.

From the managerial side, the primary benefit relates to the enhanced and easier control of the overall organization. Given that data are available in real time for each process, decisions can be made more quickly, based on transparent information. In addition, rather than having time spent by workers on reporting data to management, systems automatically transfer and communicate these. Consequently, rather than performing day-to-day firefighting tasks on the ground, management can focus on strategy and expansion.

FIGURE 28: Business management solutions offered under OSM software by *Gilard Electronics*

4. LESSONS LEARNED AND ADVICE

The adoption of Industry 4.0 in manufacturing businesses is often correlated with companies who already have advanced practices in place and large revenue streams. This is, however, a big misconception, as companies such as Gilard Electronics are able to implement elements that already provide practical solutions. In fact, even small investments into sensors and software can yield enormous benefits and immediate returns that are applicable to smaller SMEs as well larger entities.

Important advice for digital transformation relates to management conviction. Management needs to be convinced of the benefits of the use in their processes of innovative technologies, and will need to promote a culture of digital change. Mr. Sanjeev Sethi, the owner and Managing Director of Gilard Electronics, has a high level of software and hardware expertise himself and is driving the digital transformation of his business to a data-based company as a digital leader.

Second, a practical approach should be taken that is tailored to the existing digital advancement of the company and is not overly complicated. Through the involvement of software and hardware providers that are operating within the industry and are aware of best practices, manufacturing domain expertise and cyber-physical systems, as well as common loopholes, even companies that do not have a fully-fledged IT services team are able to adopt certain technologies.

In fact, Gilard Electronics further emphasized, while a robust internal IT team can provide many advantages, it is not a prerequisite for successful Industry 4.0 implementation as even low-skilled workers can interact with the system, if the system is designed in an easy and user-friendly way. For this to work at an SME, complicated solutions that are designed for large companies should be avoided, and tailored solutions that are practical for SMEs should be considered.

Other advice provided relates to the aspect of the process that should first be targeted, as implementing everything at once would be difficult and not be effective for SMEs with limited digital knowledge. The foundations of the digital transformation should begin with the business processes (ERP functions), to get all the employees on board.

First, the main processes of the supply chain management should be assessed and digitized to the best extent possible, such as customer-facing functions or purchasing. Only after these business processes have been digitized should the shop floor and machine level be targeted, and machine data should be collected and available in real time to ensure cycle times are met.

Some of the benefits achieved by Industry 4.0 through OSM are as listed below.

Benefits achieved by Industry 4.0 through OSM

Increase in sales

- by achieving 100 per cent on-time delivery
- by reduction in supply time
- by reduction in product costs, making us more competitive
- by reduction in time to market (for new products development)
- by improving the customer satisfaction index and customer confidence

Increase in profits

- by reduction in raw material consumption by reducing waste and rejection at different levels by digitally capturing the data
- by reducing electricity and water consumption by monitoring of individual processes
- by reduction in financial costs by improving inventory control and inventory turnover ratio (ITR)
- by improvement in quality performance, and reduction in rejections and customer returns
- Reduction in expenses and improvement in cash flow

Improved work culture, creating a great place to work

- by improving the implementation of standard operating procedures (SOPs) and converting from a person-based to systems-driven organization
- by fulfilment of legal compliance through digital understanding on responsibility and the work to be done, with data monitoring
- by improving employee accountability, efficiency and satisfaction
- by improving workflow and interaction between individuals and departments
- by improving employee engagement and creating a place of pride for them (through the OSM Employee portal)
- by reducing the attrition rate

Improved supplier performance (quality, delivery and cost)

- by ensuring timely release of payments to suppliers
- by ensuring the correctness of standards and drawing versions issued to suppliers
- by monitoring supplier performance

Improved asset management and plant and machine maintenance

- by implementing Total Productive Maintenance (TPM)
- by reducing the mean time between failures (MTBF) and (Mean T To repair (MTTR) for machines

Increased productivity

- by improving production efficiencies and overall equipment effectiveness (OEE)
- by reducing equipment downtime and idle time
- by improving machine capacity utilization, resulting in enhanced plant capacity without adding more machines

Improved product development capabilities

- by adopting NPD module (which follows APQP/PPAP requirements)
- by controlling the data from design stage to production

Improvement in capabilities of each and every employee

- by digitally monitored skill development
- by on-line training modules

III.D SAMPLE CASE STUDY 3: UNIVERSAL PRECISION SCREWS

1. COMPANY INFORMATION AND HISTORY

Founded in 2006, Universal Precision Screws is a notable Indian manufacturer of high-quality industrial and commercial fasteners and high-precision machining components, supplying customers all around the world including industrial sectors such as automotive, locomotive, oil and gas, windmills, earthmovers, aerospace, defence and die moulding. Their principal business model is very customer centric, providing a wide variety of products, and having established a broad network of regional offices to foster strong customer relationships. This is also further emphasized in their values that highlight a quality, eco-innovative technological customer approach.

Universal Precision Screws is a larger medium-sized enterprise in the category of 500–999 employees and 750 million rupees turnover.

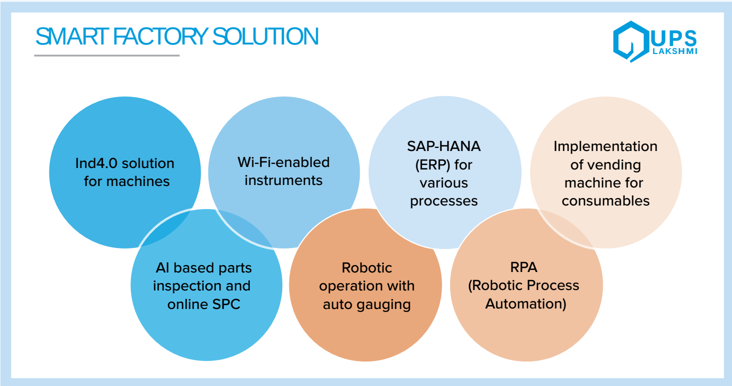
Their customers can be categorized into OEMs, automotive tier 1, and industrial distributors in over 30 countries, which are being supplied with more than 5,000 unique line items.

In 2015, Universal Precision Screws began its digital transformation in the context of smart factory solutions, a central element in Industry 4.0, which in the Indian component manufacturing context was considered an early adopter at that time. Their principle driving force for taking on the digital transformation related to being able to increase productivity and quality, thereby enhancing the service that they provide to their customers.

2. TECHNOLOGIES ADOPTED

Universal Precision Screws has adopted a range of technologies throughout the years. These can be classified into smart factory solutions like artificial-intelligence (AI)-based parts inspection and online statistical process control, Wi-Fi enabled instruments, robotic operation with automatic gauging, an ERP system (SAP high-performance analytic appliance (SAP-HANA)) for various business processes, as well as virtual robot automation.

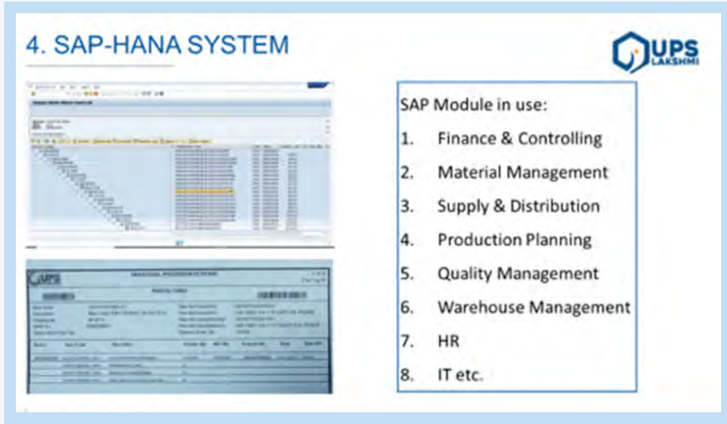
FIGURE 29: Industry 4.0 solutions implemented by Universal Precision Screws



Enterprise resource management (SAP-HANA)

The starting point for digitalization of business processes in manufacturing companies is typically the implementation of an ERP system which manages the main business processes. These systems track business resources such as the budget, raw materials, capacities and the status of business commitments, and results such as orders and payments. Universal Precision Screw uses SAP-HANA, the latest version of the SAP-ERP solutions for all main business processes such as finance and financial control, materials management, supply and distribution, production planning, quality management, HR, and IT.

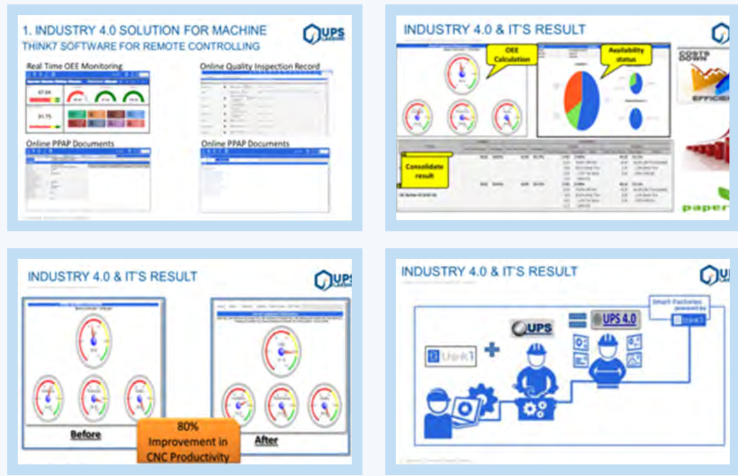
FIGURE 30: SAP-HANA systems used by Universal Precision Screws



Industry 4.0 technologies for machines: smart factory

Programmable logic controllers (PLC) are industrial computers specifically designed to control parts of the manufacturing process such as assembly, machines, or other devices that usually involve a high level of reliability. In the case of Universal Precision Screws, all PLC-related machines have been installed with hardware that provides machine and process data to an IoT software solution, which allows for monitoring the status of machines and manufacturing processes as well as key performance indicators (including OEE and quality metrics) on a real-time basis.

FIGURE 31: Industry 4.0 solutions adopted by Universal Precision Screws



Intelligent production incorporates IT cloud technology and big data, facilitating the recording and retrieval of data and creating an interconnectedness between machines. Smart manufacturing is thereby sought through digitized information that is conveyed on the cloud and accessible to managers in remote locations allowing them to monitor the status on the shop floor and to take immediate action where needed. This system enabled Universal Precision Screws to increase their computerized numerical control (CNC) productivity by 80 per cent because root causes of productivity losses could be identified and fixed easily and quickly.

These technologies allow for monitoring and controlling steps of the manufacturing process that previously were not easily manageable. Online quality inspection would occur at each stage of the production and the next process step would be locked until the quality inspection had been conducted successfully. In case no quality control was recorded after 15 parts, the software would then stop the process and flag this to management. In other words, process adherence is ensured via automatic IT systems so that it is less likely that human failure is causing quality issues. Given the interconnectedness with cloud technology, all relevant documents such as worker instructions or quality checklists are updated in real time which minimizes the risk of workers operating with outdated versions of documents.

Furthermore, a consolidated report is easily generated through automatically provided machine data that reflects management losses that were not captured from previous traditional monitoring methods.

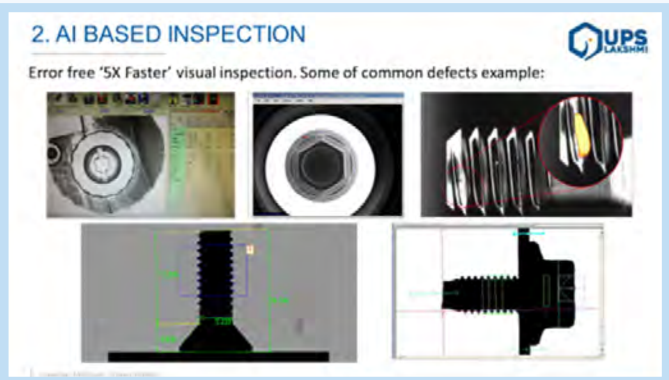
Overall, both process and digital improvements have been observed through the integration of these technologies, with a 30 per cent improvement in the overall equipment effectiveness (OEE) through its implementation and an 80 per cent improvement in CNC productivity.

AI-based inspection

AI-based solutions are increasingly used in the manufacturing process, particularly in terms of enhancing productivity and quality of processes. Through machine vision software, products from the production line are inspected for quality defects. Common defects in these automotive components relate to visual defects such as scratches, plating that would not be deemed acceptable to the end customer. These defects are sometimes very minimal and difficult for the human eye to detect.

While traditional methods of manual inspection by the workforce would require the continued presence of multiple workers who would inspect the products and judge whether they pass certain quality standards based on what they see, AI-based inspection replaces this process.

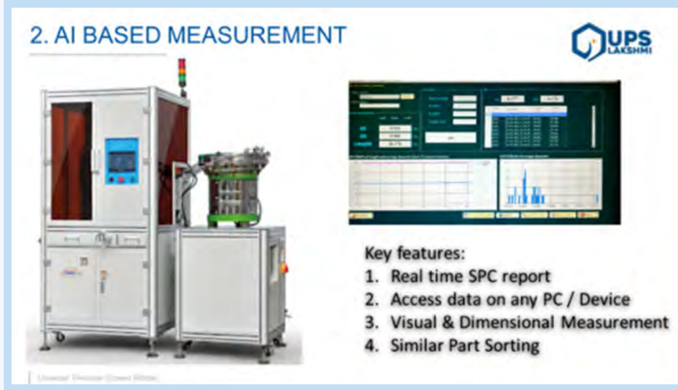
FIGURE 32: AI-based inspection at Universal Precision Screws



This AI-based inspection is at least 5 times faster than traditional manual inspection, with around 20 per cent higher accuracy. In fact, at Universal Precision Screws , inspection now takes an average time of 1 second, in comparison to 20 seconds for manual inspection by the labour force.

This results in lower lead times and fewer customer complaints with regard to the cost and time of inspection that in the past slowed down the production process. Fifty per cent of the workforce that used to be used for inspection was shifted to other, more important, tasks in the process, with the machine-based solution conducting the inspection for Universal Precision Screws.

FIGURE 33: Measurement using AI at Universal Precision Screws



On the documentation side, the AI-based inspection is interconnected with the cloud (IoT-based) and therefore produces an online report with the data available in real-time and accessible on any device.

Wi-Fi-enabled instruments

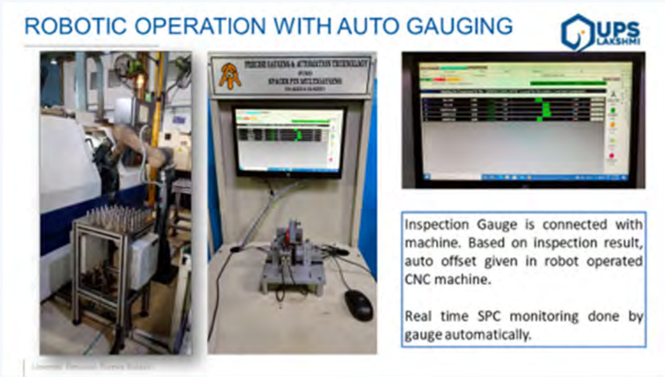
To supplement the implemented technologies, Wi-Fi-enabled instruments are used and integrated into digital support processes to simplify the documentation of the calibration and testing processes which ensures the accuracy of the manufacturing equipment. While traditional methods rely on humans entering data for recording processes with paperwork and manual entry, the adoption of these instruments allows for an interconnectedness with ERP systems, eliminating all the paperwork and manual entry.

FIGURE 34: Wi-Fi-enabled instruments used by Universal Precision Screws

Robotic operation

Robots have been installed in certain manufacturing processes, such as in the loading and unloading of parts. Instead of the human workforce conducting these tasks, robots are now doing the loading while at the same time the automatic gauging machine is employed to check the product characteristics against a set of parameters. If the part is considered acceptable by the automatic gauging machine, it is placed in the acceptable bin; if it is considered faulty, the robot will place it in the faulty bin.

FIGURE 35: Robotic operations with automatic gauging in Universal Precision Screws



Robotic process automation for administrative tasks

While in manufacturing processes robots are used to automated mechanical tasks, the technology robotic process automation (RPA) is used for repeatable business processes. This software technology allows the automation of routine tasks by analysing entry parameters and reacting with predefined actions.

At Universal Precision Screws, RPA technology is currently being installed in the back-office functions that relate to data entry, where all data will be connected with the system, thus reducing errors of manual data entry by the workforce. For example, there is a large customer base, with over 100 invoices created daily and sent to the customers once the products have been delivered. This task can easily be automated via RPA. The expected results of robotic automation include working without any delay, workforce savings and reduced supervision, as well as error-free work.

3. BENEFITS AND OUTCOMES FROM USAGE

Universal Precision Screws reported numerous benefits related to productivity, quality and brand image, through the implementation of Industry 4.0 technologies throughout the manufacturing process.

Productivity was improved by 60 per cent overall on implementing systems, as well as specifically 80 per cent improvement in CNC productivity from adopting digital and process improvements.

Quality had seen a large improvement as processes that were previously not monitored were controlled on a real-time basis through monitoring machine data or Wi-Fi-enabled instruments. As such, the first approval became more accurate with robust quality gates in place. Furthermore, the usage of AI-based inspection resulted in higher and more efficient detection of faults in components in comparison to human error and oversight issues.

Traceability was increased as a result of digitally supported processes that the labour force had to follow for the machines to continue operating as well as the process documentation sheets and instructions being reflected at current status, avoiding the use of older versions of the documents. Through the ERP system, the data are stored and available at real time and facilitate management oversight and tracking of materials and products and commercial data more efficiently.

Cost savings were also reported as a main benefit from these solutions. In fact, the workforce was reduced as automation was implemented, reducing costly human error, and internal planned preventive maintenance (PPM) was reduced by 20 per cent.

Brand image was reported to also have benefited from the introduction of new technologies. Supplying to more than 400 customers, the enhanced data sharing and systems in place have improved the confidence that customers have in the quality, safety and credibility of the purchased products and services.

4. LESSONS LEARNED AND ADVICE

Before starting with Industry 4.0 technologies on the shop floor, Universal Precision Screws digitized the main business processes via an ERP system.

Although the initial price was seen as a major obstacle to the implementation of Industry 4.0 technologies, a three-month return on investment (ROI) was reported by Universal Precision Screws. To overcome the initial implementation costs in an early phase, Universal Precision Screws collaborated with start-up vendors who created a customized IoT platform for them. Start-ups often are also able to provide suitable solutions at a lower cost.

In terms of the road map for technologies, at the shop floor level it was advised to start with real-time monitoring of equipment (IIoT solutions) that can be acquired for varying processes and complexity. As a second important step, developing competent staff is essential as they will need to know how to operate the technologies. For this, training on Industry 4.0 and how to operate the new technology is advised, with the use of knowledge management systems software for identifying, gathering, storing, evaluating and organizing valuable information in day-to-day operations.

In terms of risks, cyber security is considered the biggest threat when implementing IoTs. To ensure that the data acquired by IoT solutions is kept safe and the business can continue to operate, Universal Precision Screws chose a vendor that could provide them with a robust firewall which was suitable to protect their processes.

III.E SAMPLE CASE STUDY 4: SANJEEV GROUP

1. COMPANY INFORMATION AND HISTORY

Sanjeev Group started their journey in 1988 by venturing into engineering and manufacturing various types of parts and tier 1 automotive components. They later expanded into other sectors, including agricultural, power and construction machinery.

Sanjeev Group is a larger medium-sized enterprise in the category of 500–999 employees and 750 million rupees turnover. They are mainly engaged in the production of gear assemblies, gears, shafts, shifter forks, machined forgings and machined castings, and supply both local and international markets. Some of their major clients are considered the largest automotive brands in India, such as Bajaj Auto, Mahindra Group, CG Power and Industrial Solutions Limited and Kirloskar, as well as global brands including General Motors, Eaton Corporation, John Deere, ZF Friedrichshafen and Transaxle and Manufacturing of America.

FIGURE 36: Sanjeev Group vision for Industry 4.0

Having a customer base with a vast geographical presence, management of the supply chain and meeting the high expectations and quality requirements of OEMs is challenging, especially with the different customer products, the variety of products, quality standards and volume variation across customers. The adoption of new technologies is helping the Sanjeev Group to overcome these challenges.

Industry 4.0 brings many changes to manufacturing practices. Therefore, it was important for the Sanjeev Group to simplify what the company would like to achieve with these changes. They defined the vision in the year 2016 in three parts:

- **Real Time:** Adding speed to the operations by making whatever is happening at the operations available to all levels in real time.
- **Transparent:** Bringing transparency in the supply chain through connected data structures.
- **Agility:** Through real-time and transparency, automating some decision points and also making quick decisions possible through access to real-time data.

2. TECHNOLOGIES ADOPTED

From vendor to customer there are multiple data points which are generated. The data generated through these points are connected to the cloud. Through business intelligence and analytics, the relevant data are available to various departments such as finance, purchasing, and others, and are available on a real-time basis.

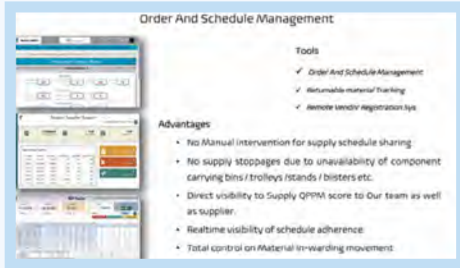
With the adoption of digital technologies, Sanjeev Group avoided the manual process of repeatedly entering the same data along the manufacturing process. Sanjeev Group has a dedicated independent company that has assisted them in implementing Industry 4.0 solutions. The specific technologies and their usage are further described below.

Supply chain management, order and scheduling management

One of the challenges that the company faced while adopting digital technologies across their supply chain is that different customers have different interfaces thereby making it more difficult to harmonize the systems. As customers of Sanjeev Group typically are large corporates, Sanjeev has to be able to connect to these different interfaces which calls for adaptations of the ERP system.

On the other hand, most of the vendors to the Sanjeev Group are SMEs which are not so mature when it comes to digitalization of supply chain management. The Sanjeev Group therefore established a communication portal with their vendors in 2016 which supports order and scheduling management. This portal is automatically connected to the Sanjeev ERP. Any change done in one place in the portal is reflected everywhere, providing all users with access to the same information. The system provides space for the vendors to make changes in their own areas.

FIGURE 37: Advanced solutions implemented by Sanjeev Group for order and scheduling management

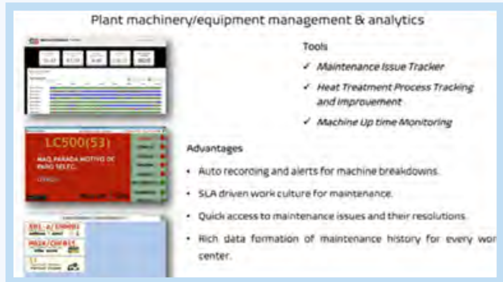


This has helped to reduce the chances of conflict and the need for conflict resolution has gone down. Other benefits of the portal include no manual intervention for supply scheduling sharing, no supply stoppages owing to unavailability of component carrying bins, trolleys, stands. Real-time insights are available on the supply of materials in digital format using advanced radio frequency identification (RFID) technology.

Plant machinery, and equipment management and analytics

Sanjeev Group deals with products whose processing ranges from forging, to gear cutting, to heat treatment. While most of the process is automated, machine maintenance used to be a challenge, especially in those machines which are old and where automation is not possible. To overcome this challenge the company uses a vibration analysis mechanism to minimize the downtime and to ensure better predictive maintenance.

FIGURE 38: Plant machinery, and equipment management and analytics used by Sanjeev Group



Similarly, the company has been striving to achieve a smart factory and has connected their machines, assisting in monitoring uptime, and creating logs which help in predictive maintenance. This has brought a cultural shift among the maintenance team. In the earlier setting, the maintenance team would only become aware of machines being down if a worker informed them, leading to production inefficiencies, energy wastage and higher costs. In the present setting, the maintenance team has access to what is happening in the machines, and relevant information such as possible errors in the machines. This has led to faster reaction and optimal utilization of time and energy, and has created a rich database.

Plant and warehouse goods movement

The plant and warehouse are connected to the vendor using a similar method to that implemented in the order and schedule management. The tools used are digitalized inspection stations, automated guided vehicle stock movement, dynamic storage system and a materials dispatch planning application.

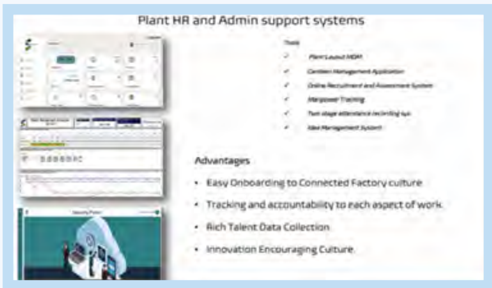
FIGURE 39: Advanced tools used for managing plant and warehouse goods movement by Sanjeev Group

The plant and warehouse movement helps in tracking which material is in transit, the quantity, as well as the expected time of arrival. This data helps in better planning of machines, better set-ups and helps in ensuring that the material arrives in good time. The deployment of these tools resulted in first in, first out (FIFO) movement of inventory, which is difficult to achieve if the inventory is not organized in the right place, and better inventory control. As a result, the requirement of the number of people for warehouse and store management has decreased. The adoption of Industry 4.0 technologies has evolved over time and the Sanjeev Group has taken a step-by-step approach. The first step towards digitalization was automated scheduling to the vendor, the second step was the goods receipt (GR) integration with the vendor portal, the third step was vehicle tracking and materials tracking. In parallel, the company also deployed location mapping within the warehouse.

Plant HR and administration support systems

The company also digitalized HR and support systems by using plant layout master data management, a canteen management application, workforce tracking, two stage attendance recording, and others. With these technologies on board, the company was able to track the 3Ms (Man, Machine and Materials) together.

FIGURE 40: Advanced tools used for managing plant HR and administration support systems by Sanjeev Group



As a result, the company was able to collect important information, such as the starting time of machines and starting level of production, etc. Also, with the help of online recruitment and assessment systems, competency matchmaking was undertaken even before face-to-face interviews were conducted. This resulted in rich data collection of potential talent among the people who were approached and also the talent of the people who were being on-boarded. This also helped the company to pursue job rotation by knowing each person's strengths.

3. BENEFITS AND OUTCOMES FROM USAGE

The digital journey has brought the Sanjeev Group multiple benefits. Previously, paperwork was used to create various measurable targets, the achievement of which was then monitored by support systems. Middle management used to spend a great deal of time gathering data from different places and different people. This made the data prone to inaccuracies and outdated.

Available data concerning the performance of employees helps them to perform better. Visualizing key performance indicators, that help every employee to compare their performance against the goals and benchmarks, is driving performance improvements and personal accountability.

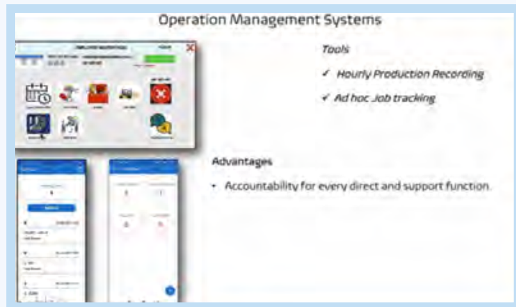
4. LESSONS LEARNED AND ADVICE

One of the main lessons is for management to recognize the importance of what these changes brought by Industry 4.0 mean for the company, as well as to learn to use data analysis systems. Rather than spending time on generating the data, the management should focus more time on processing and analysing the data.

The next lesson relates to the steps needed to implement Industry 4.0 technology. The first step should be to digitize and enhance the quality of data that is generated in the manufacturing process. Once that has been achieved, more advanced technologies can be implemented. In fact, Industry 4.0 technologies such as machine learning are highly dependent on structured and reliable historical data of high quality being available. It is important, therefore, to have the right quantity and quality of data.

Further advice that the Sanjeev Group would offer to beginners is to integrate simplified technology: for instance, the use of local language on kiosks or screens in every plant helps the workers to pick up complicated technologies more easily.

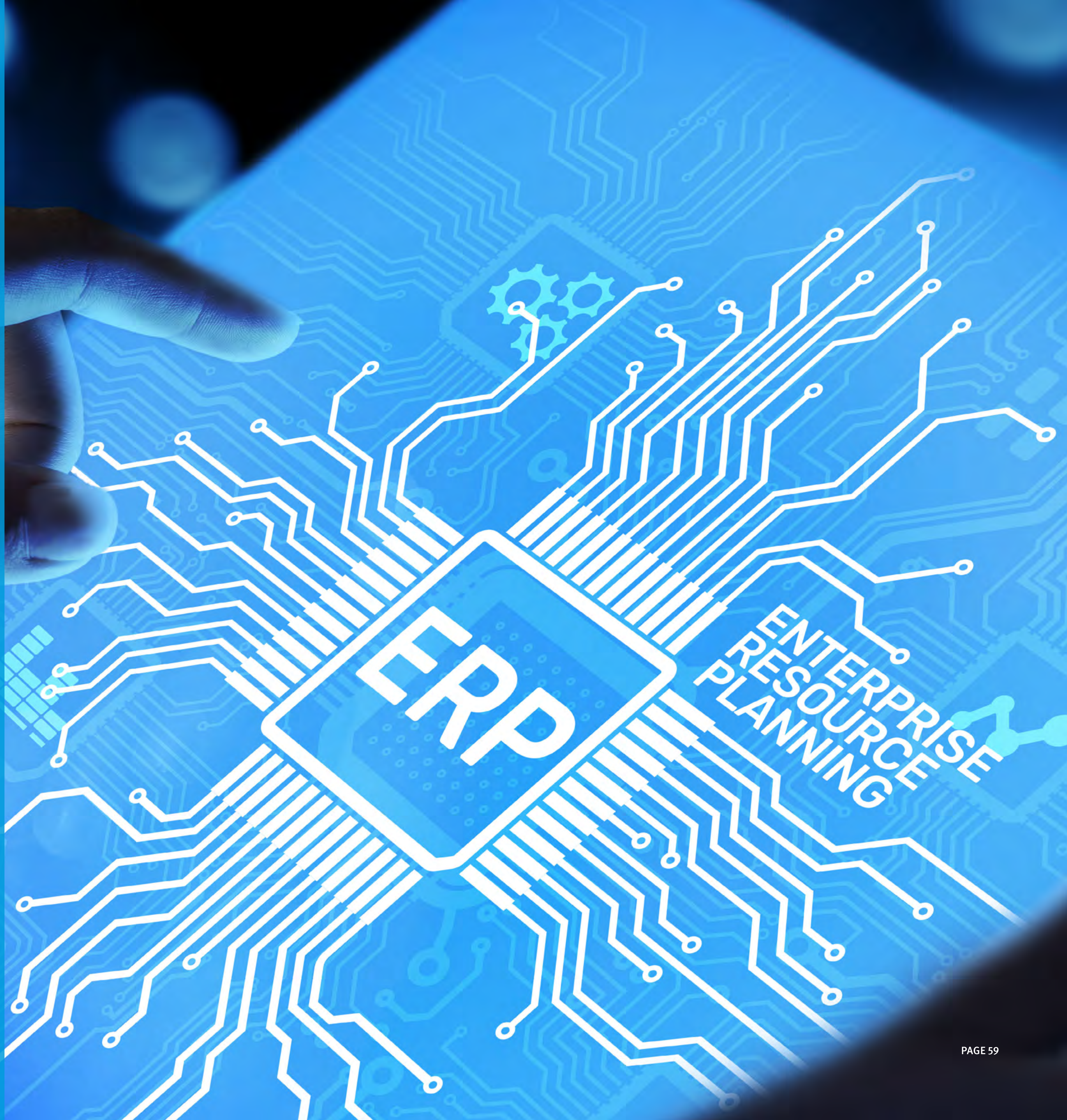
FIGURE 41: Tools used for operations management systems by Sanjeev Group



IV

Summary and conclusions drawn from the survey and in-depth analyses

The introduction of an ERP system enables a company to automate communication processes with customers and suppliers.



IV.A ERP AS A STARTING POINT AND DATA BACKBONE FOR MSMEs

As observed in the survey and the in-depth interviews, the implementation of an appropriate ERP system is the typical first step towards the digitalization of manufacturing companies. In the sample of our survey more than 50 per cent of the companies below 750 million rupees turnover per year do not have an ERP system.

ERP systems support and digitize business processes such as purchasing and procurement, supply chain management, finance and accounting, human resource management, customer relationship management, materials and inventory management, master data and product master data management and order management, and production planning and control. ERP systems are engaged in optimizing production but operate at medium (days) or longer (month) term and provide a low level of detail. They do not provide appropriate data or processing mechanisms to operate production in real time.

ERP systems have been part of automation (= Industry 3.0) and are a mature and proven software offering. There is no need to conduct pilot studies to prove the feasibility or the benefits of ERP systems. But many MSMEs in India probably start at an "Industry 2.0" level without having any IT systems or digital solutions implemented. The decision makers in these MSMEs might not be sufficiently informed about the features and benefits of an ERP system.

The introduction of an ERP system enables a company to automate communication processes with customers and suppliers because ERP systems contain the relevant data concerning products, orders, stock levels and more which could be exchanged via electronic data interchange (EDI) with customers or suppliers.

As such, the introduction of an ERP system is highly recommended for companies facing one of the following challenges:

Challenge 1
Missing transparency about customer or supplier orders.

Challenge 2
Challenges in demand and capacity management due to unstable market conditions.

Challenge 3
Problems with materials and inventory management or with high product variety.

Challenge 4
Inefficiencies in handling of orders, finance and accounting and logistics processes.

IV.B LEAN MANUFACTURING AND DIGITALIZATION

Classic lean production management does not include digital systems or automatic gathering of data but relies on analogous media for process transparency and improvement.

Nevertheless, both worlds (lean and digital) offer opportunities for MSMEs to improve their performance significantly. Offering simple digital solutions to provide instant, real-time performance feedback on digital dashboards, to report incidents such as machine downtime via screens or mobile devices or to automatically trigger predefined actions enables managers and employees to react and improve quickly.

Organizations that on the one hand have incorporated the lean management philosophy of manufacturing excellence and on the other hand have the capability to identify if and how digital or data-based solutions could help to improve process transparency and optimization will achieve major improvements in productivity and competitiveness.

In enabling companies to build up their capabilities for lean management as well as digitalization, it is important to start with lean principles to define and stabilize enterprise processes and to understand the importance of using visual management, key performance indicators, and other data to monitor, control and improve these processes. Using digital solutions like the Industrial Internet of Things (IIoT) to capture data and get better and faster insights in manufacturing processes provides a good complement in early stages of lean management introduction. With growing maturity in lean management, further Industry 4.0 or digital solutions might be of benefit depending on the specific situation and challenges of the company.

IV.C LABOUR-RELATED CHALLENGES IN INDIA

As seen in the survey results concerning the major challenges and concerns, Indian automotive companies are facing very specific problems regarding finding and retaining the workforce, upskilling and efficiency of unskilled workers and capacity management. Sixty per cent of the companies, in all categories of company sizes, reported these challenges as a topic of priority.

In Indian MSMEs, a high percentage of manual work is done by people with little education, speaking different languages. High attrition rates and absenteeism, especially in rural areas during applicable agricultural seasons, often cause workforce shortages and variations and limit the performance, quality and delivery capacity of the companies.

The interviewed partners in the best practice interviews emphasized that easy, understandable digital solutions support the management and upskilling of a diverse workforce and facilitate fast performance improvements.

Industry 4.0 solutions from international solution providers which have been developed for the European or North American market do not address the specific needs and situation of Indian MSMEs. This topic is an India-specific search field for innovation, identification and dissemination of suitable solutions. As a follow-up task, we will explore the specific needs and existing solutions and approaches for workforce-related issues in Indian MSMEs.

V

UNIDO approach and way forward

Overall, UNIDO aims to ensure that its Member States take full advantage of the breakthrough of Industry 4.0 digital technologies and the subsequent digital transformation.

Based on the findings of this report, it becomes apparent that the Indian automotive component manufacturers display a very heterogenous adoption of digitalization and Industry 4.0 approaches, and that MSMEs can reap benefits from adopting these technologies.

V.A UNIDO APPROACH

The UNIDO approach to the fourth industrial revolution – Industry 4.0 – is a multilevel and multi-stakeholder approach and foresees engagement in knowledge-sharing and capacity-building; technical cooperation, policy advice and normative activities; and the formulation of strategic partnerships with key stakeholders, including the private sector and academia. As such, in the context of Industry 4.0, the approach of UNIDO relates to driving sectoral expertise and digital transformation at all levels: macro, meso and micro.

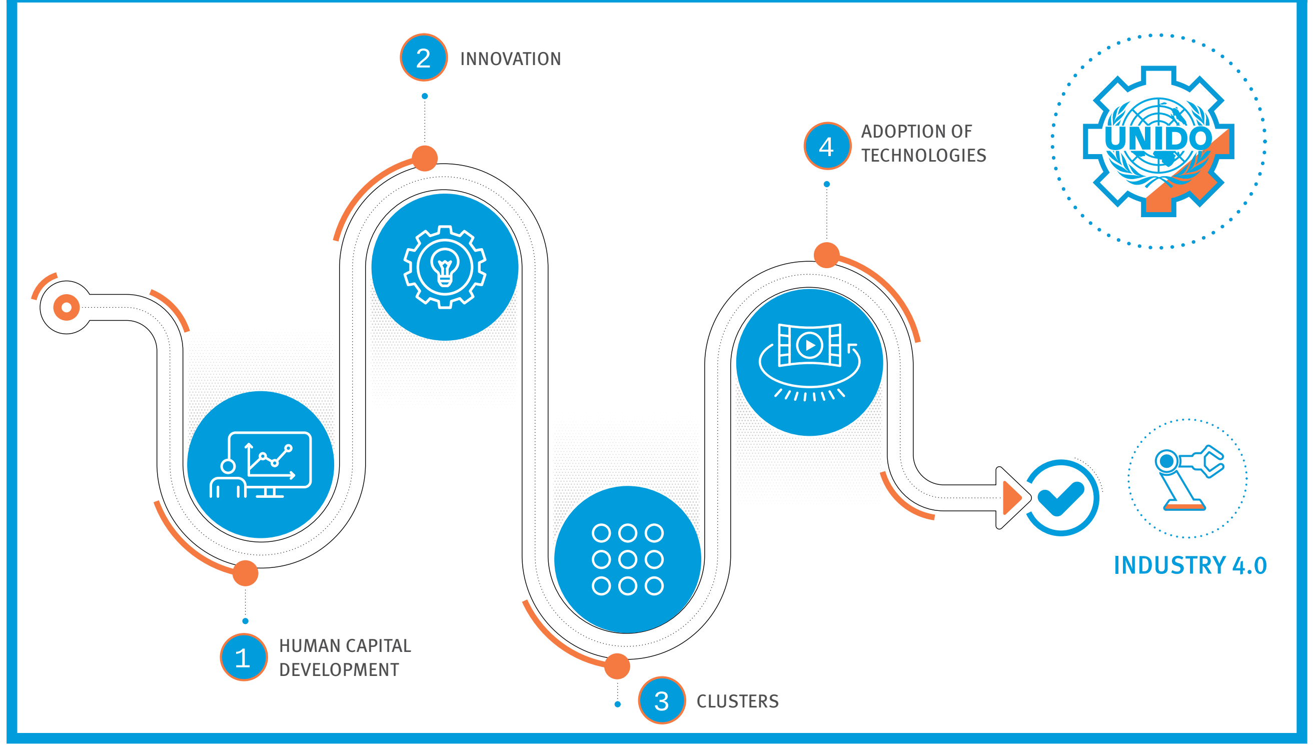
The digital transformation journey comprises four distinct pillars: human capital development (including skills in data analytics, information processing and cybersecurity); innovation (specific tools that enable companies to design new products, processes and business models); clusters (synergies between coordinated actions), and adoption of technologies (more productive and competitive processes in medium and small companies). UNIDO is assisting Governments and the private sector with the development of advanced technology foresight analysis, by using benchmarking to carry out policy reforms, and devising far-reaching industrial development strategies, road maps and innovation-friendly policies. [13]

The approach followed by UNIDO is holistic, ranging from awareness-building to helping to initiate, develop and strengthen SMEs. This approach emphasizes the need for strong collaboration with all stakeholders to meet the shared objectives by performing agreed activities that lead to concrete actions.

Given the importance of digitalization at firm level, UNIDO provides support for its Member States to keep abreast with innovations and technologies and the rapid transformation processes of Industry 4.0 at that level. Enterprises are given support through the transfer of technologies and expertise and the introduction of innovative processes, including digitalization and automation of production processes, e-commerce and enterprise management tools and practices, thereby ensuring a smooth transformation to Industry 4.0. This process also includes skills development and training of SMEs with a view to enhancing their capacity to prepare for the adoption of industry 4.0 technologies. In the light of this aspect, UNIDO in India will take the outcomes of this report as a starting point to further support the adoption of Industry 4.0 within the Indian automotive component manufacturing space through suitable technologies that can be replicated across the industry and provide sustainable benefits to the companies relating to higher productivity, better reputation, and lower costs.

Overall, UNIDO aims to ensure that its Member States take full advantage of the breakthrough of Industry 4.0 digital technologies and the subsequent digital transformation, thereby ensuring the promotion of inclusive and sustainable industrial development (ISID) and advancing the sustainable development agenda. The vision of UNIDO is to become the leader in addressing the opportunities and challenges stemming from Industry 4.0 and their impact on inclusive and sustainable industrial development and economic development. To achieve this vision and mission, UNIDO plans to take further action to help developing countries adapt to digital transformation, to overcome the constraints they are facing and help them open up to the new opportunities offered by Industry 4.0 to drive positive and sustainable change.

FIGURE 42: Main pillars of the digital transformation journey



13) https://www.unido.org/news/new-publication-sectoral-transformation-inclusive-and-sustainable-industrial-development.

V.B WAY FORWARD

Based on the findings of this report, it becomes apparent that the Indian automotive component manufacturers display a very heterogenous adoption of digitalization and Industry 4.0 approaches. While some manufacturers are utilizing modern and innovative solutions that allow for real-time monitoring and data gathering as well as enhancing the responsiveness of these manufacturers to machine breakdowns or changes in customer demands, other manufacturers are still operating with traditional methods of analogous communications and manual data gathering, leading to higher risks of inaccuracy and leaving them prone to errors.

On average, larger companies having an international footprint, such as OEMs and tier 1 suppliers, demonstrated a higher level of digitalization whereas lower tier suppliers of automotive components often are MSMEs with lower rates of adoption. In addition, when comparing the customer and the supplier side, the maturity in digitalization of the supply chain is higher downstream at the data exchange between manufacturing companies and their customers.

In terms of the main problems that automotive component manufacturers face, including labour skills and cost, unstable market conditions and equipment breakdowns, these could be mitigated by Industry 4.0 solutions. Furthermore, based on the in-depth analyses, it becomes apparent that MSMEs can also reap benefits from adopting these technologies, including increases in productivity, higher quality maintenance, brand image improvement, as well as cost savings. In addition, based on transparent and real-time information, leaders get more insights in critical processes and incidents and are able to decide and act faster. In companies practicing lean manufacturing, digital systems deliver more real-time information about process and people performance and maintain a database which enables real-time visual management, data-based problem solving and process improvements, as well as best practice sharing and predictive measures.

In other words, a practical approach should be taken that is tailored to the current digital advancement and the specific business situation of the MSMEs in order to assist with the adoption and implementation of Industry 4.0 solutions. In line with the UNIDO vision on Industry 4.0 and addressing the challenges that have been illustrated in this report, different measures depending on the maturity of the solutions in the Indian market will be implemented.

1 Create awareness and motivation

- Training and awareness activities
- Communication material, presentations
- Events, conferences, technical fairs
- Sharing of best practices and case studies
- Guided tours of model plants
- Demonstrations and laboratories
- Communicate information on existing government support

2 Gather practical experience and deeper insights

- Identify pioneers, for example OEM and tier 1, for experience exchange and guided tours
- For topics to be explored, conduct pilot projects with MSMEs
- Involve Industry 4.0 providers and innovative machinery builder in innovation activities (for example, by innovation competitions, collaborative computer programming events)
- Build up laboratories and demonstrators, provide practical demonstration of use cases, technologies and benefits (on site and with virtual conferences / guided tours)
- Evaluate and iterate frameworks, such as in pilot programmes
- Gather baseline and post-implementation results to evaluate benefits and costs

3 Create foundation and prerequisites

- Integrate Industry 4.0 in proven frameworks (lean management, for example), develop a complementary framework on the introduction of Industry 4.0 and IIoT technologies for process improvements on the shop floor level
- Collect information on requirements, gaps and status quo
- Build knowledge base on technologies and provider, local and international
- Build up expert and support network, such as partnerships with local experts (for example, research and education) providing combined expertise on shop floor IT and lean management
- Develop a qualification programme on digital transformation and Industry 4.0 topics for lean production experts
- Enhance the lean management qualification programme for MSMEs with basic knowledge concerning digital tools and solutions
- Work on Industry 4.0 and digital policies (such as IT security, funding)

4 Choose and implement standard offerings and support

- Offer vendor-neutral support and advice for MSMEs in choosing appropriate solutions and providers
- Gather and publish information about Indian and regional solutions and solution providers
- Support MSMEs with loans or funding programmes to reduce entry barriers and financial risks

ANNEX

1	Email address	
Company Information		
2	Name of organization	
3	Name of person completing the form	
4	Role of person completing the form	
5	Main Location(s)	
6	Number of manufacturing sites	
7	Turnover (millions of rupees) (approximately)	☐ Below 100 ☐ 110–750 ☐ 760–2 500 ☐ 2 500–5 000 ☐ Above 5 000
Workforce details		
8	Number of employees (including temporary workers)	☐ Below 49 ☐ 50–99 ☐ 100–249 ☐ 250–499 ☐ 500–999 ☐ Above 1 000
9	Percentage of temporary and contract workers	
10	Number of shifts per day	☐ 1 ☐ 2 ☐ 3
11	Hours per shift	☐ 8-hour shift ☐ 12-hour shift ☐ Other ______
12	Worker assistance technologies in use, e.g. digital checklists, picking assistance, work instructions on mobile devices, scanning tools, robots, augmented reality applications, etc.	
Products and production processes		
13	List and describe the 3-5 products, components or product families with the highest relevance to your business	
14	Variety of products (if variety is different for different products: mark all that apply)	☐ Low ☐ Medium ☐ High ☐ Other_____
15	Type of production (mark all that apply)	☐ Piece production ☐ Small series production (10–100) ☐ Medium series production (100–1 000) ☐ Large series production (1 000–100 000) ☐ Mass production (›100 000)
16	Which kind of production materials are processed?	☐ Metals ☐ Plastics ☐ Rubbers ☐ Electricals ☐ Assemblies ☐ Others______

17	Nature of production processes	☐ Machining / CNC machining / castings / fabrication / stamping … ☐ Injection moulding ☐ Rubber extrusion ☐ Other…
Customer order and delivery process		
18	Our customers are … (mark all which applies)	☐ Automotive OEM ☐ Tier 1 (who directly supply to OEM) ☐ Tier 2 or higher ☐ Non–automotive
19	Names of customers	
20	How do you get order data from your customers? If answer is different for different customers, mark all that apply (more than 1 selection possible)	☐ Oral via phone call, meeting ☐ Written via email or mail ☐ Manual download from customer IT system / portal ☐ Automatic transfer from customer IT system to own IT system
21	How do your customers get information about availability and delivery status of your products? If answer is different for different customers, mark all that apply (more than 1 selection possible) [availability of your products and/or delivery times]	

	On request, oral via phone call, meeting	On request, written via email or mail	Accessible, customers download data via online tool when needed	Automatic, data are periodically transferred to customer IT system (push principle)	Via IT system for shipment tracking of logistic service provider	None of these / no answer
Availability of your products and/or delivery times						
Status of delivery and/or shipment of finished goods						

22	Which kind of information management system best describes the way you handle data related to customer orders and delivery?	☐ No systematic information management ☐ Systematic, based on manual data collection, historical data are digitized and stored (e.g., pdf) ☐ Systematic, based on manual data entry into IT system ☐ Systematic, based on (semi) automated data acquisition or transfer to IT system
23	Which option best describes the way you use actual data related to customer orders and deliveries? (mark all which apply)	☐ Reactive ☐ Regular monitoring and control routine ☐ Real-time monitoring ☐ Real-time monitoring combined with automated actions (such as event-triggered tasks)
24	How do you use historical data related to customer orders and deliveries?	☐ Used for documentation only ☐ Used for performance analysis and reports ☐ Used for root cause analysis and continuous improvement ☐ Used for forecasts and predictive measures
25	Do you use digital platforms or marketplaces to distribute your products or to connect to your customers? (Concerning customer order and delivery process)	☐ No ☐ Only email ☐ Yes, other than email (specify in next question)
26	If yes, please specify which digital platform or marketplace you use:	
Suppliers and supplier data		
27	Who are your main suppliers and which kinds of products or services do you get from them?	
28	How do you share order data with your suppliers? Mark all columns that apply.	☐ Oral via phone call, meeting ☐ Written via email or mail ☐ Manual download from customer IT system / portal ☐ Automatic Transfer to supplier's IT system from own IT system

29 How do you get information about availability of products and delivery status from your suppliers? Mark all that apply (more than 1 selection possible) [Availability of products and/or delivery times]

	On request, oral via phone call, meeting	On request, written via email or mail	Accessible, we download data via online tool when needed	Automatically, data are periodically transferred to our IT system (push principle)	Via IT system for shipment tracking of logistic service provider	None of these / no answer
Availability of products and/or delivery times						
Status of delivery and/or shipment of finished goods						

30 Which kind of information management system describes best the way you handle data related to supplier orders and deliveries?

- ☐ No systematic information management
- ☐ Systematic, based on manual data collection, historical data are digitized and stored (e.g., pdf)
- ☐ Systematic, based on manual data entry into IT system
- ☐ Systematic, based on (semi) automated data acquisition or transfer to IT system

31 Which option describes best the way you use actual data related to supplier orders and deliveries? (Mark all which apply)

- ☐ Reactive
- ☐ Regular monitoring and control routine
- ☐ Real-time monitoring
- ☐ Real-time monitoring combined with automated actions (such as event-triggered tasks)

32 How do you use historical data related to supplier orders and deliveries? (Mark all which apply)

- ☐ Used for documentation only
- ☐ Used for performance analysis and reports
- ☐ Used for root cause analysis and continuous improvement
- ☐ Used for forecasts and predictive measures

33 Do you use digital platforms or marketplace for purchasing incoming goods or to connect to your suppliers? (Concerning suppliers and suppliers' data)

- ☐ No
- ☐ Only email
- ☐ Yes, other than email (specify in next question)

34 If yes, please specify which digital platform or marketplace you use:

Production planning

35 How is planning done?

	Daily	Weekly	Monthly	Less than Monthly
Production order				
Machines				
Materials				
Workforce				

36 How is planning done? How are resources managed?

	Manual in analogous form, paper-based, use of planning boards	Based on spreadsheets, including. forecasts of some weeks	Through IT- system with real-time information (ERP/ MES/Advanced Planning System)	Sensor or tracking technologies are used for automatic data acquisition
Production order				
Machines				
Materials				
Workforce				

37 How are stock levels of raw materials, work in progress and finished goods monitored and controlled?

	No systematic monitoring or control	Manual in analogous form, paper- based / use of planning boards	Based on spreadsheets, including forecasts of some weeks	Through IT system with real-time information (ERP / MES / advanced planning system)	Sensor or tracking technologies are used for automatic data acquisition
Raw materials					
Work in progress					
Finished goods					

Production, shop floor, and machines

38 Flow of workpiece

- ☐ The workpiece is moved manually and on the basis of known processes from one production station to the next. Relevant data are recorded manually and stored in paper form.
- ☐ The workpiece is transferred manually from one production station to another on the basis of known processes. The path through production is automatically recorded at crucial points.
- ☐ The workpiece is transported from one production station to the next, such as using a conveyor belt system. The path through production is automatically recorded in real time at many points, using RFID, for example, and simultaneously mapped in the leading IT system.
- ☐ The workpiece is transported partially or fully automatically from manufacturing station to manufacturing station. The route through production is automatically recorded in real time at many points, for example using RFID, and simultaneously mapped in the leading IT system on the software side. The paths of different workpieces are compared and checked for interactions or correlations. This knowledge is used to optimize the sequence planning.
- ☐ The work piece steers itself through the production process fully automatically and autonomously, bringing along processing information, for example via RFID. Timely planned orders are compared with the outstanding processing steps of current workpieces in order to optimize production.

39 Which technologies are used in your production? (Mark all that are used)

- ☐ PLC (programmable logic controller)
- ☐ SCADA (Supervisory control and data acquisition)
- ☐ Mobile devices
- ☐ RFID tags and gateways
- ☐ QR / bar codes
- ☐ Real-time location systems
- ☐ Edge cloud devices / gateway M2M (machine-to-machine) communication
- ☐ IoT (Internet of Things) applications
- ☐ Cloud solutions for storing and evaluating real-time data
- ☐ Machine learning / artificial intelligence applications
- ☐ 3-D printer, additive manufacturing technologies
- ☐ Forklifts, tugger trains
- ☐ Automated guided vehicles
- ☐ Kanban system / electronic Kanban system
- ☐ Pick by light / vision / ... systems
- ☐ Others ______

40	Use of technology to collect data concerning machines and processes	☐ There are no technologies in use to collect machine or operating data, transition and throughput times. ☐ Simple sensors are used to collect machine and operating data (for example: temperature, possibly barcode). The data are collected manually and documented if necessary. ☐ Status data of the production are acquired with sensors in real time and automatically transferred to the leading IT system. ☐ Location information of workpieces is permanently available via RTLS (real-time locating systems). ☐ Modern, real-time capable sensor technology is used for independent maintenance of machines.
41	How do you use data related to machine conditions and machine or tool breakdowns? (Mark all which apply)	☐ Used for documentation only ☐ Used for performance analysis and reports ☐ Used to prioritize and schedule maintenance work orders ☐ Used for root cause analysis and continuous improvement ☐ Used to automatically trigger maintenance work orders in real-time ☐ Used to automatically order missing parts or consumables ☐ Used for forecasts and predictive measures ☐ Used to automatically request external maintenance services ☐ Others ________
42	Is breakdown maintenance of machines managed in-house or outsourced?	☐ In-house resources ☐ Outsourced, external service providers
43	Which maintenance approach best describes the way maintenance is done currently?	☐ Reactive: Fix it when broken ☐ Planned: Fix it before it fails (time-based planning for maintenance) ☐ Measure and fix: Using sensor-based condition monitoring for planning maintenance ☐ Preventive: Using condition monitoring and historical data to improve maintenance planning ☐ Predictive: Predict machine reliability by using sensing data and analytics
Information technology		
44	Organization concerning IT (select all which apply)	☐ No IT function or department, done by external IT service provider ☐ Central IT function or department ☐ Decentralized IT functions and departments for different functional areas (engineering, production, commercial, ...) ☐ Other ________
45	How many employees work in IT (full-time equivalent)?	☐ None ☐ 1 ☐ 2–5 ☐ 5–10 ☐ More than 10 ☐ Other _______
46	Which IT systems are in place? (like ERP (enterprise resource planning), manufacturing execution systems, computer aided design, ...)	☐ Office tools and email ☐ ERP system (enterprise resources planning) ☐ MES system (manufacturing execution systems) ☐ CAD system (computer aided design) ☐ Other _______

Areas with major concerns and challenges

47 Areas with major concerns or challenges: Mark the 3 topics with the highest priority (Only 3 selections possible – one item per column; if your area of concern is not part of this list, name and describe it in the subsequent question)

	1. Priority	2. Priority	3. Priority
Labour capacity, costs, skills, absenteeism			
Lack of space, bad space design, too much material movement			
High Inventories, long cycle times			
Lack of flexibility or missing capabilities to fulfil customer needs			
Increasing variety of products, need for mass individualization			
Highly fluctuating demand, unstable market conditions			
Lack of transparency on performance, order status			
Reliability or quality of supplier deliveries			
Reliability or quality of own deliveries			
Cost pressure, financial liquidity, outstanding bills			
Too much firefighting required			
Downtimes, machine or tool breakdowns			

48 If not part of the list above, please describe area(s) of concern

49 For 1. Priority area of concern as selected above: Describe situation and causes for topic of concern

50 For 2. Priority area of concern as selected above: Describe situation and causes for topic of concern

51 For 3. Priority area of concern as selected above: Describe situation and causes for topic of concern

LIST OF FIGURES

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