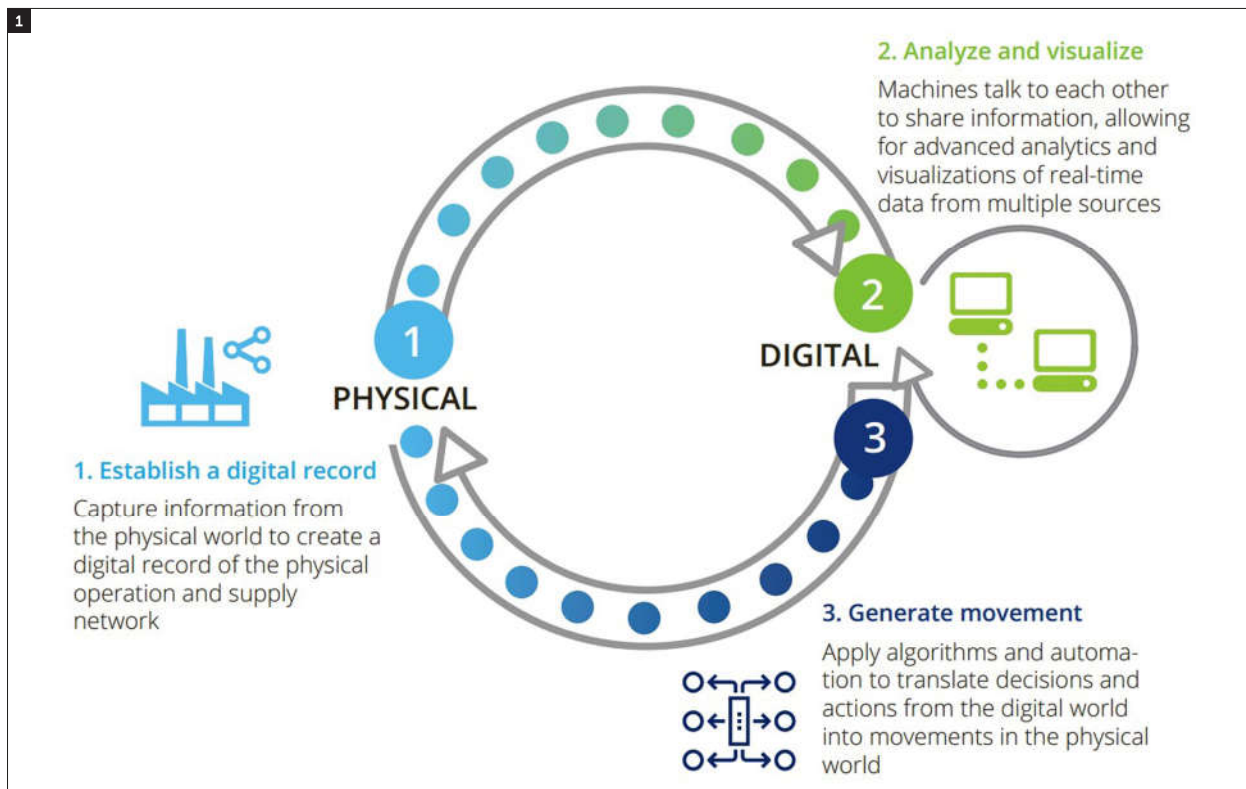


Digitalizing the tire industry

Examining why increased application of digitalization can be implemented for the benefit of tire manufacturing operations

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A growing number of industries are facing up to digital reality. In fact, industry executives know that digital technology can greatly improve the performance of their current business. Therefore an increasing number of companies across all industries are on the verge of embarking on a digital transformation or have already begun the implementation of one. Researchers at MIT have proposed that by 2025 approximately 40% of today's Fortune 500 companies will have disappeared.¹

The marriage of physical assets and advanced digitalization known as Industry 4.0 sees the Internet of Things (IoT), artificial intelligence (AI), robots, drones, autonomous vehicles, 3D printing, cloud computing, nanotechnology –

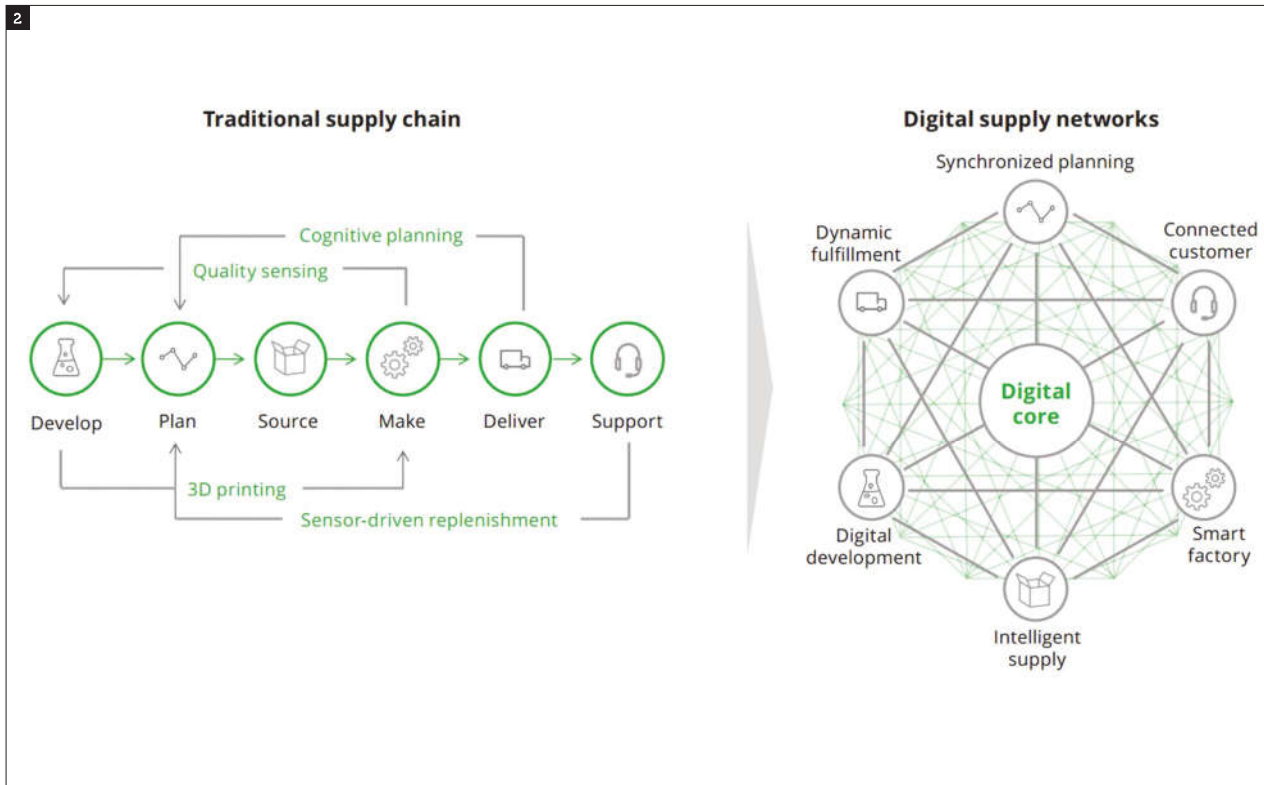
Figure 1: The physical-to-digital-to-physical (PDP) loop and related technologies

and other such devices and technologies – communicate, analyze and act on information, enabling organizations, consumers and society to be more flexible and responsive, and make more intelligent, data-driven decisions.²

Surveys show that the intersection between readiness and responsibility in the Industry 4.0 era shines a light on how traditional business objectives, transformational technologies, evolving skills and growing obligations to the greater good come together and cut across one another. In this rapidly changing world, understanding, developing and executing integrated strategies that leverage Industry 4.0 technologies should be a priority for all organizations. The same technologies that can improve business also can benefit society and should be used for both.

For business leaders accustomed to traditional linear data and communications, the shift to real-time access to data and intelligence enabled by Industry 4.0 will likely fundamentally transform the way they conduct business. The integration of digital information from many sources and locations can drive the physical act of doing business, in an ongoing cycle. Throughout this cycle, real-time access to data and intelligence is driven by the continuous and cyclical flow of information and actions between the physical and the digital worlds.

This flow occurs through an iterative series of three steps, collectively known as the physical-to-digital-to-physical (PDP) loop (see Figure 1). To achieve this process, Industry 4.0 combines relevant physical and digital



technologies, including analytics, additive manufacturing, robotics, high-performance computing, natural language processing, artificial intelligence, cognitive technologies, advanced materials, augmented reality and virtual reality.³

The loop involves three steps:

- Physical to digital: Capture information from the physical world and create a digital record from physical data;
- Digital to digital: Share information and uncover meaningful insights using advanced analytics, scenario analysis and artificial intelligence;
- Digital to physical: Apply algorithms to translate digital-world decisions to effective data, to spur action and change in the physical world.

Figure 2: Shift from traditional supply chain to digital supply network

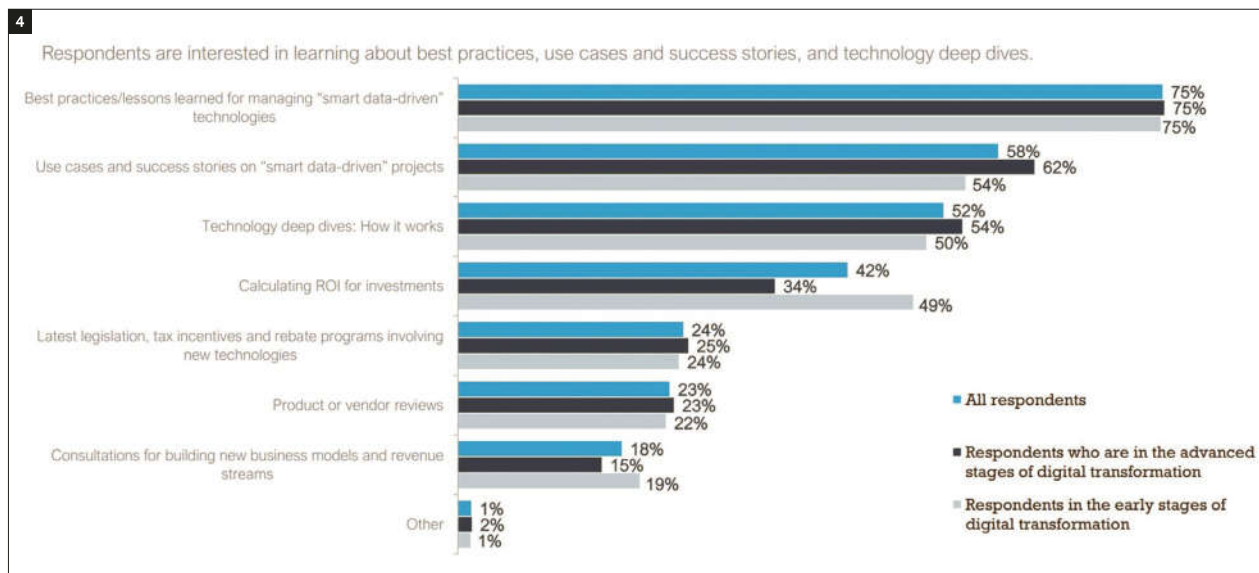
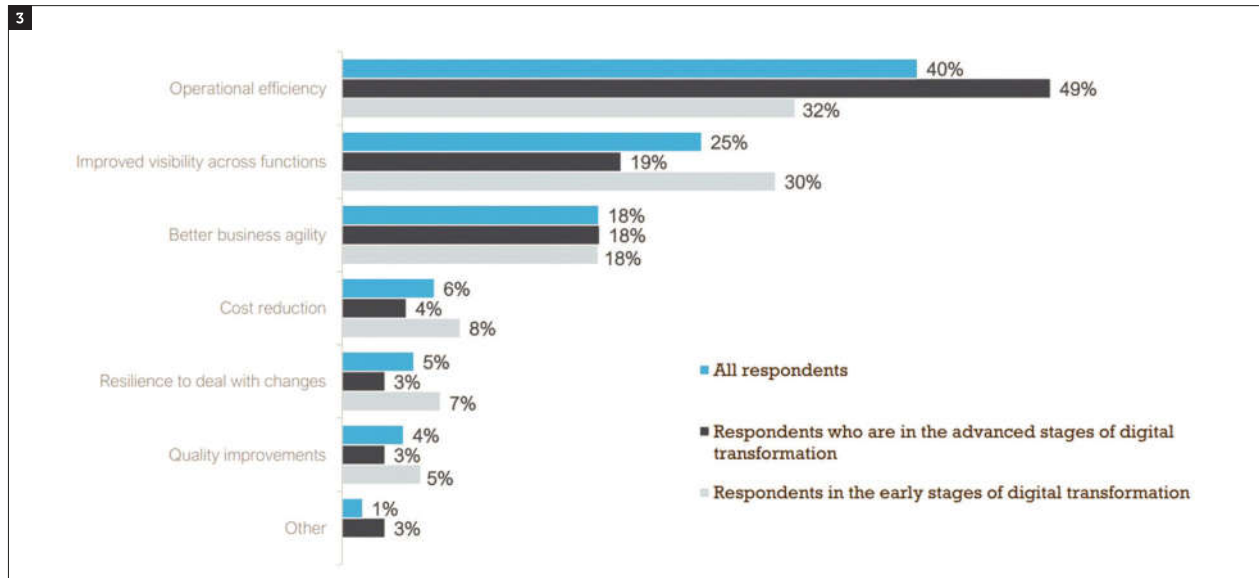
At its broadest level, Industry 4.0 portends a shift not only in how companies will operate and goods will be produced, but how ecosystems – the suppliers, customers, regulatory considerations, investors and other third-party experts and influencers – will function and interact. Industry 4.0 technologies create the potential for interactions between every point of a network. Thus, stakeholders can work together more effectively, using a constant stream of data from connected systems to learn and adapt to new conditions, and even begin to predict rather than react.

While the supply chain is not the only application of advanced Industry 4.0 technologies, it seems to provide a useful illustration of how Industry 4.0 can connect an ecosystem, enabling stakeholders to integrate information from many sources and make more holistic

decisions. This shift from linear sequential business operations to an interconnected open system can change industries and lay the foundation for how companies operate, collaborate and compete in the future.³ The shift from a traditional supply chain to a digital supply network is shown in Figure 2.

Digital transformation and disruptive technologies

To capitalize on the shift to Industry 4.0 and effectively create and monetize Industrial IoT (IIoT) solutions, enterprises must embed new digital technologies and capabilities in their legacy assets. In other words, the use of technology to radically improve the performance or reach of enterprises is digital transformation – also known as digital industrial transformation. It should be noted that setting up a



digital industrial operation involves fundamental shifts across all aspects of a business. Specifically, to create value throughout the customer lifecycle, an organization must reorient its business model from linear to always on.

Digital transformation impacts the corporate culture just as much as it does the company's business model. The shift from hierarchical and stable to collaborative and adaptive, the shift from company to customer centricity, the shift from exploitation to exploration, and the implementation of disruptive technologies are important aspects of digital transformation. The digitalization of operations, manufacturing, supply networks and products enables companies to

Figure 3: Benefits of digital transformation

Figure 4: Topics of interest for digital transformation

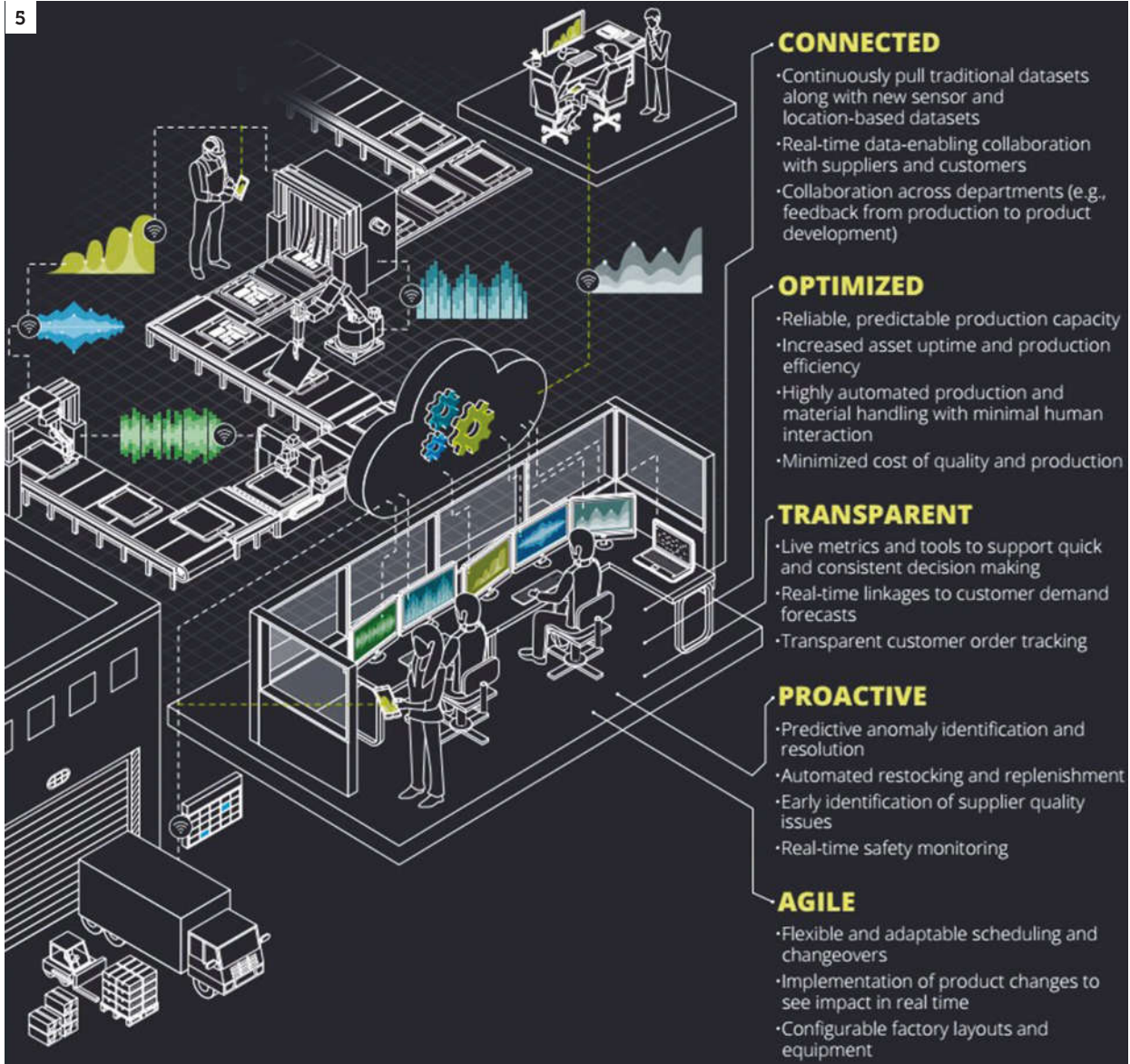
combine learnings from humans, machines, analytics and predictive insights to hopefully make better, more holistic decisions.⁴

Recent studies show that nearly half of respondents in the advanced stages of digital transformation consider operational efficiency to be the biggest benefit.⁵ As seen in Figure 3, respondents in the early stages of digital transformation are just as likely to consider improved visibility across functions the top benefit so far. Also, it is seen that respondents are interested in learning about best practices, use cases and success stories, and technology deep dives. Digital transformation topics of interest are shown in Figure 4.

Industry 4.0 ultimately hinges on the ability to integrate data with

physical processes. Considering all these topics, there are eight key digital transformation trends that business leaders should be aware of:

- The rapid adoption of digital operating models, including integrated cross-functional teams;
- A shakeout as those that have invested in big data governance and analytics leapfrog their competitors;
- Better use of AI and machine learning;
- Continued merger and acquisition activity in the IT outsourcing industry;
- Consultancies forming new digital partnerships;
- Expanding public cloud adoption;



- New digital transformation success metrics;
- More attention to the long-term value of digital initiatives.

One of the most important aspects of digital transformation is the use of disruptive technologies, which are being introduced at an unprecedented rate. Companies that can successfully harness the potential of these technologies can enjoy tremendous growth. Cloud, IoT, AI, VR, AR, mobile technologies and robotic process automation are vital parts of the networked physical-digital universe, helping organizations collect and process vast volumes of data and become smarter digital enterprises.

Manufacturing leaders must understand how both control systems

Figure 5: Five key characteristics of a smart factory

in the factory and manufacturing execution systems – also known as operations technologies (OT) – and general corporate functions and capabilities that synchronize across functional systems – also known as information technologies (IT) – can be enhanced by disruptive technologies. Indeed, manufacturers are already using advanced OT (such as additive manufacturing) and advanced IT (in the form of scanning and embedded sensors) to create new products and improve old ones – delivering new levels of value to customers, along with new data products.

Recent years have witnessed a boom in the democratization of emerging technologies such as AI, IoT, automation, VR and AR,

alongside the scaling of data and analytics capabilities. According to the MIT research, enthusiasm for technologies such as AI is rapidly growing – 62% of organizations in a recent study increased their budgets on AI projects in recent years.⁶ It is to be noted that while automation and controls have existed for decades, the fully smart factory based on disruptive technologies has only recently gained traction as a viable pursuit for manufacturers. Figure 5 depicts the smart factory and some of its major features – connectivity, optimization, transparency, proactivity and agility.

Each of these features can play a role in enabling more informed decisions and can help organizations improve the production process.

Table 1: Key trends across the tire industry value chain

Raw material	Mixing	Stock preparation	Building	Curing	Finishing
<ul style="list-style-type: none"> Nanotechnology for sustainable material development (for example, carbon black) Vertical integration with suppliers Leveraging mobile technology 	<ul style="list-style-type: none"> Advances in compound preparation by modifying material types and chemistry (on materials such as resins, silica and aramid fibers) 	<ul style="list-style-type: none"> Integration of machine control systems with advanced systems such as laser and imaging to optimize processes and maintain efficiency 	<ul style="list-style-type: none"> Modernized assets to increase productivity (increased automation in servicers and building drums) and consistency (image and laser guidance) 	<ul style="list-style-type: none"> Advances in mold technology Retrofitting sensors and modules for condition-based monitoring 	<ul style="list-style-type: none"> Laser carving tools Noise testing equipment
Product advancements					
<ul style="list-style-type: none"> Integrated sensors to measure tread depth and temperature, and provide real-time alerts to drivers 	<ul style="list-style-type: none"> Runflat tires including self-sealing tires and self-inflating tires 	<ul style="list-style-type: none"> Air-free tire technologies 	<ul style="list-style-type: none"> Reduction of noise or noise-damping tire technology (important for quiet electric vehicles) 		

Manufacturers can implement the smart factory in many ways – both inside and outside its walls – and reconfigure it to adjust as existing priorities change or new ones emerge.⁷

It is to be noted that the arrival of digital technologies doesn't necessarily spell the end of human intervention. In other words, digitalization helps to automate processes and enables higher productivity, with fewer manual steps in the production process.

Digital transformation in the tire industry

The tire industry's adoption of Industry 4.0 has the potential to deliver accurate, easily repeatable productivity and increased output, as well as cost- and energy-saving efficiencies. Through effective collection, analysis, deployment and leveraging of real-time manufacturing and process data using IIoT and AI, a revolution is already underway. Tire companies

Figure 6: Schematic of data transfer of industrial machines to the server in Barez systems

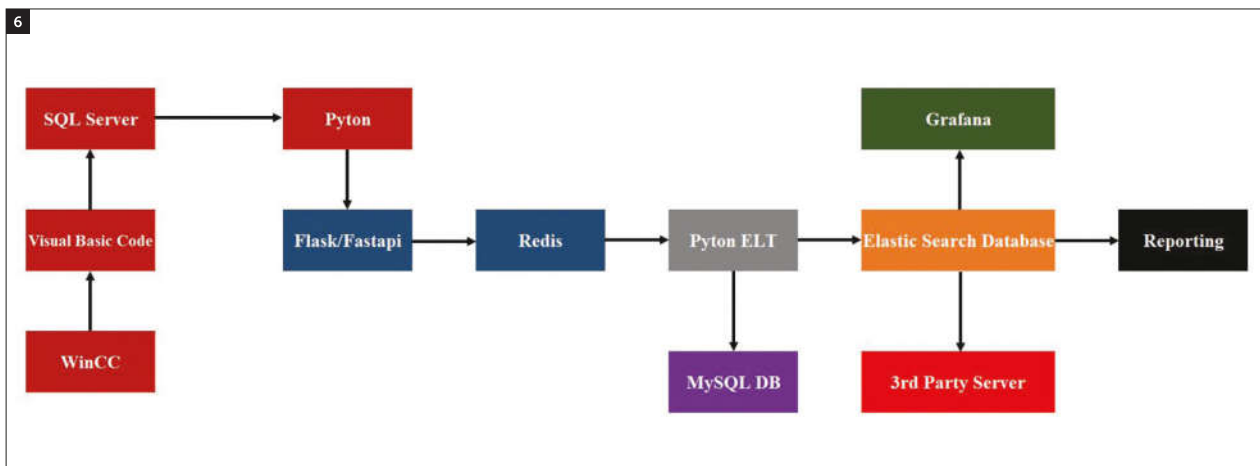
can monitor their collected machine data online, immediately recognize negative trends and react before any major issues occur.

Key lessons from the embracing of Industry 4.0 practices over the past two to five years point to automation playing a wider role in tire manufacturing. However, the implementation of digitalization and automation takes time, with a need to focus on a structured process of change. The smart factory can help tire manufacturers realize excellent management, high product quality and product efficiency, leading to profit maximization.⁷ A survey of tire companies shows that the focus will be on highly automated integrated processes. These companies need a high level of automation with the flexibility to produce a lot of sizes.

Automation is a key success factor in meeting the challenges of the modern tire industry. Upgrading old factories helps manufacturers to better meet new standards,

regulations and requirements, as well as the growing demand for greater quality, performance and sustainability. An increased need for intelligent supply-chain solutions, planning and optimization is the other important aspect of digital transformation. New tire manufacturing plants need automation and highly efficient machines.

To address these issues, many types of analysis are required, and many tools can be used based on Industry 4.0 principles. Maximum quality and uniform production requirements are all pushing tire plant equipment manufacturers to realize that they need increasingly automated and digitally controlled machines for perfect process control. The real value for the tire industry comes with predictive maintenance, where data analysis highlights the breakdown risk and leads to planned corrective actions. When a divergence from the index is



spotted, the system interprets the cause and recommends actions to keep the system running. In addition, on the topics of electric and autonomous mobility, there are lots of open questions in which disruptive technologies like IoT and AI can help.

The need for product innovation enabling the realization of smart tires, yield maximization, flexible production, defect reduction and increased on-time delivery has already set the stage for digital interventions, at scale. These trends have played a crucial role in driving automation and asset modernization, such as modern tire-building machines, and product and process innovations.

As the industry faces stronger challenging headwinds, a combination of upstream innovations focused on materials and composition, along with compound preparation to improve the efficiency of tires, coupled with downstream innovations through automation of assets to enhance tire quality and manufacturing productivity, ensuring industry competitiveness, are foreseen. The key trends gathering traction across the tire industry value chain are shown in Table 1.

Considering the journey toward a comprehensive digital transformation in the tire industry, an extensive suite of digital solutions covering the entire manufacturing value chain of this industry is presented in Table 2. Each solution, and its constituent components, is geared toward addressing specific business levers and offers tangible potential impact across the value chain through the adoption of these solutions.

Barez Industrial Group's program to automate the production line and analyze its data is realized via the design and implementation of a method for online collecting and reporting of process data of extruders and cure presses in the company's Kerman factory. The basic concept of this development is to automate the collecting process of these machines' data. Therefore fast, simultaneous and integrated information on all machines in the factory can be provided on an SQL server.

The schematic model of the data transfer of industrial machines to the server in the Barez factory is shown in Figure 6.

The general process involves various steps in which data is collected from different parts of the production line in different areas using different protocols such as OPC, RS485 and ADC. The

greatest advantage of this project is that the machine data can not only be gathered but can also be analyzed via artificial intelligence to implement predictive maintenance. Also, this technology is used to improve automation and optimize product processes.

It is clear that datalogging capabilities and on-site assessment

Table 2: Digital solutions covering the entire manufacturing value chain of the tire industry

Solution	Value chain applicability	Key components	Potential impact
Digital production	Across the value chain	<ul style="list-style-type: none"> • Integrated system to capture machine parameters • Digital logbooks to capture manual inputs • IoT and analytics platform for comprehensive insights and management reporting • Barcode-enabled scanning of input and output material • The system checks to ensure a streamlined process without errors • Bladder and mold management • 4M traceability 	<ul style="list-style-type: none"> • OEE (10-25%) • Consumable cost (5-15%)
Digital quality	<ul style="list-style-type: none"> • Mixer • Calendering units • Extruders 	<ul style="list-style-type: none"> • Advanced process controller detecting process anomalies • Ideal operating envelope for controllable parameters to achieve high throughput and quality • Real-time recommendations to avoid probable quality rejections 	First pass ratio (5-10%)
Digital maintenance	<ul style="list-style-type: none"> • Mixer • Extruders • Cutters • Tire building machines • Curing presses 	Integrated reliability-centered maintenance solution comprising: <ul style="list-style-type: none"> • Digital FMEA • Digital fault tree • Asset remaining useful life and failure prediction of critical assets • Spares management 	<ul style="list-style-type: none"> • Availability (5-10%) • Maintenance and spares cost (5-15%)
Digital supply chain	<ul style="list-style-type: none"> • Raw material procurement • Production • Dispatch 	<ul style="list-style-type: none"> • Digital SI&OP brings together forecasting, capacity planning, material resource planning • Inputs for actual production capacity and constraints are leveraged from the connected factory solution 	<ul style="list-style-type: none"> • Plan adherence (10-20%) • Inventory reduction (10-15%) • OTIF (5-10%)
Digital production	Across the value chain	Digital cost-based value stream map with inputs from connected factory	<ul style="list-style-type: none"> • SKU-wise cost and margin • Visibility • Profitability analysis (2-5% uplift)
Digital health and safety	Across the value chain	<ul style="list-style-type: none"> • Digital datalogging and reporting for all HSE-related KPIs • Video analytics-based worker and site safety (for example, PPE violation detection, perimeter protection, intrusion detection, and so on) • ID-based access control for critical areas to ensure access to relevant stakeholders 	LTI/FR reductions



Figure 7: Dashboard of tire curing press pressure developed for the Barez Industrial Group

of the tire manufacturing process lead to situation-specific recommendations and can yield efficiency improvements. During the collection process, a large amount of data is gathered. By evaluating this data using big-data analysis and pattern recognition, the quality of the product can be enhanced. This means a huge reduction in product defects.

To get the results of the integrated data collection, a web application has been implemented on the server. In this panel, through the respective dashboards, the graph of any production line variable changes, including temperature, pressure, weight and production count in any period, is available using Grafana.

The dashboard related to the pressure of tire curing presses can be seen in Figure 7. In this figure, the first graph on the upper left shows the data reception rate. The second and third graphs show, respectively, the internal pressure on the left and right sides of curing press 46-1. The next graph shows the tonnage pressure of curing press 46-3, and the last one shows the tonnage pressure of curing press 45-1. **tire**

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