

**INDUSTRY 4.0 IN TURKEY AS AN IMPERATIVE
FOR GLOBAL COMPETITIVENESS
AN EMERGING MARKET PERSPECTIVE**



**TUŞİAD
SANAYİ 4.0**

TÜRKİYE'NİN SANAYİ 4.0 DÖNÜŞÜMÜ

INDUSTRY 4.0 IN TURKEY AS AN IMPERATIVE FOR GLOBAL COMPETITIVENESS AN EMERGING MARKET PERSPECTIVE



March 2016
Publication Number: : TÜSİAD-T/2016-03/576

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ISBN: 978-605-165-016-6

Editors: Dr. Nurşen Numanoğlu, Mehmet Evren Eynehan, Gözde Morkoç-Nikelay, Ecem Aksoy

Cover Design: Marjinal Porter Novelli

Typesetting and Page Editing: Kamber Ertem

Grafik Tasarım:

SİS MATBAACILIK PROM. TANITIM HİZ. TİC. LTD. ŞTİ.
Eğitim Mah. Poyraz Sok. No:1/14 Kadıköy - İSTANBUL
Tel: (0216) 450 46 38 Basım CB Basımevi: (0212) 612 65 22

PREFACE

TÜSİAD (Turkish Industry and Business Association), which was founded in 1971, according to the principles laid in the Constitution and in the Associations Act, is a non-governmental organization working for the public interest.

TÜSİAD aims at enhancing the development of a social structure committed to the universal principles of human rights, together with the freedoms of enterprise, belief and opinion, secular state governed by the rule of law, participatory democracy, liberal economy and the rules and institutions of competitive market within a sustainable environment. TÜSİAD, in conformity with Atatürk's principles and objectives, with a view of seizing and outreaching the contemporary civilization level, works for the realization of the above-mentioned objective believing in the pioneer and entrepreneurial nature of business people who consider gender equality in politics, economy and education.

TÜSİAD representing Turkish business working for the public interest, strives for entrepreneurs to operate in conformity with the universal business ethics; supports all the policies aimed at improvement of competitiveness of Turkish economy and social welfare in the globalization process through enhancement of employment, productivity, innovation capacity and the scope and quality of education.

TÜSİAD contributes to the formulation of national economic policies, in an environment with persisting social peace and compromise, for the economic and social development by taking into account the regional and sectoral potentials. TÜSİAD contributes to Turkey's communication taking into account competitiveness at global level, initiates a range of studies to develop political, economic, social and cultural relations as well as communication, representation and cooperation networks at international level to support the accession process of Turkey to the European Union. TÜSİAD conducts researches, generates opinions, develops projects and organizes activities in order to expedite international integration and interaction as well as regional and local development.

TÜSİAD, in the name of Turkish business, forms opinions and proposals, conveys them to the national parliament, the government as well as foreign states, international organizations and public opinion directly or through media and by using other means, aims to create a unity of opinion and action in the direction of the above-mentioned objectives. Following the global financial crises in 2008, industry sector has been positioned at the center of economic growth by most of the countries as a leading sector. In this context, productivity growth and innovative technologies became

determinant factors for added value increase with the knowledge based society transformation. Those factors, which are also crucial for increasing competitive power of Turkish economy, brought the global developments into the country's agenda as vital matters need to be monitored rigorously and simultaneously.

This process points out a transformation spreading the whole value chain. It is believed that Industry 4.0 as a phenomena based on high technology and innovation, is going to be an anchor for the transformation of Turkish industry.

With this understanding, a project had been initiated by the TUSIAD Industrial Transformation Round Table to analyze the opportunities of Industry 4.0, reveal the potential of Turkish industry and define the requirements for realizing its transformation.

This report, which involves The Boston Consulting Group as the content partner, aims to reveal the potential benefits and costs with sectoral and quantitative assessments.

Our report, covers six pilot sectors including automotive, machinery, white appliances, food and beverages, textile and chemicals. We would like to express our sincere thanks to the executives who shared their opinions and helped us to conduct interviews in 25 different companies.

We are also grateful to Mr. Levent Çakıroğlu, CEO in Koç Holding, Mr. Erdal Karamercan, CEO in Ezcacıbaşı Holding and Mr. Agah Uğur, CEO in Borusan Holding; those shared their valuable opinions within the steering committee which was established to ensure a fruitful environment during the preparation of this report.

This report is prepared by Mr. Aykan Gökbulut and Mr. Burak Tansan, Partners and Managing Directors and Mr Tevfik Eren, Senior Consultant and Çağlar Targotay, Project Leader from The Boston Consulting Group (BCG) Istanbul Office, the content partner of this study, under the guidance of Mr. Mehmet Bahadır Balkır and Mr. Mehmet Nurettin Pekarun, co-chairs of the TUSIAD Industrial Transformation Round Table.

During the preparation of the report, contributions were made by Dr. Nurşen Numanoglu, Deputy Secretary General of TUSIAD, Ms. Gözde Morkoç-Nikelay, Expert of Industrial Transformation and Sectoral Policies Department.

March 2016

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ABBREVIATIONS

AGV: Automated Guided Vehicle

CAGR: Compound Annual Growth Rate

CNC: Computer Numerical Control

CPS: Cyber Physical Systems

CRM: Customer Relationship Management

ERP: Enterprise Resource Planning

FRT: First Run Capability

FTT: First Time True

GITES: Input Supply Strategy

ICT: Information and Communications Technology

IT: Information Technology

LGV: Laser Guided Vehicles

M2H: Machine to Human

M2M: Machine to Machine

MES: Manufacturing Execution System

MOS: Manufacturing Operating System

NGO: Non-Governmental Organization

PLM: Product Lifecycle Management

R&D: Research and Development

REF: TUSIAD-Sabancı University Competitiveness Forum

RFID: Radio-Frequency Identification

SKU: Stock Keeping Unit

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EXECUTIVE SUMMARY

Technology's relentless advance has made it possible to significantly boost industrial productivity, especially since the late 18th century in three main waves. Steam-powered machines, the introduction of electricity in production and increasingly widespread robot automation movement after 1970s triggered these three trail-blazing revolutions.

Today, we are in the midst of a fourth industrial (r)evolution, triggered by digital technologies. Nine technologies—including smart robots, big data, the Internet of Things, 3-D printing, and the cloud—have played a critical role in triggering this revolution.

We define the Industry 4.0 concept that has emerged as a result of this revolution as the integration of the links in the value chain in a way that goes beyond automation. The most important characteristic of this integration is that all of the steps in the value chain are in constant real-time communication. Consequently, a vision of achieving an intelligent, self-adapting industrial process has emerged. This vision describes an industrial journey that is faster, more flexible, more efficient, and produces goods with higher quality.

Industry 4.0 was put forward by Germany and later by other industrialized countries such as the U.S.. Industry 4.0 creates significant opportunities for these countries, which have lost their competitiveness in production over the years, to regain their advantage. For example, according to a detailed study conducted by BCG in 2015, widespread application of Industry 4.0 is expected to have a very significant impact on the German economy in the next ten to 15 years. When we put this impact into numbers, we see that it is possible to achieve a cost-savings effect of up to €90 to 150 billion as a result of increased industrial productivity equivalent to 15 to 25 percent of the conversion costs associated with production. Furthermore, beyond the increased productivity, the Industry 4.0 process is a journey that creates its own higher value-added economy, fundamentally changes the established value chain, and, most importantly, creates an increased demand for skilled labor.

It is critical that Turkey not only stay abreast of these developments but also takes its place among the leading economies implementing Industry 4.0. We must anticipate significant pressure on the factors that constitute the foundation of our competitiveness, such as lower labor costs and logistical advantages, especially at a time when the indicators of competitive strength are so diverse and change so rapidly.

In this respect, the goal must be to ensure and enhance the sustainability of our competitive advantage with Industry 4.0, but, beyond this, to create a Turkish industry with greater added value that receives a larger share of the world's production value chain. We must remember that this will help Turkey achieve its goal of moving from an emerging market to the next level.

This study provides an opportunity to assess the ideas, experience, and knowledge of the executives in many important Turkish industrial companies, with the goal of outlining an economic perspective that goes beyond a conceptual discussion of Industry 4.0 for Turkey. Within this framework, conversion to Industry 4.0 is expected to result in development in four important categories:

Productivity: If Industry 4.0 is successfully implemented in an economy of the present size, manufacturing sectors in Turkey have the potential to achieve benefits of up to TL50 billion. This analysis is based on an estimated increase in productivity of 4 to 7 percent in light of total production costs. When the cost of conversion alone is taken into consideration (production costs other than material costs), the increase in productivity is projected to be 5 to 15 percent.

Growth: The competitive advantage that will be gained through the economy that emerges within the framework of Industry 4.0 and integration with the global value chain is expected to trigger an increase in industrial production that could reach 3 percent a year. This growth means a boost to Turkey's GDP of 1 percent or more and translates into an additional revenue of around TL150 to 200 billion.

Investment: Based on current prices and the size of the economy, it is estimated that approximately TL10 to 15 billion (about 1 to 1.5 percent of manufacturing revenues) must be invested per year to integrate Industry 4.0 technologies into the manufacturing process over the next ten years.

Employment: On the assumption that growth targets will also be realized, it is anticipated that the need for labor employed in industry as a whole will increase and, more importantly, that this labor force will be more skilled, be better educated, and earn higher wages. In this context, we can expect that labor employed in low-skilled jobs will decrease, but there will be an absolute overall increase in employment with the rise in industrial production. The income pyramid and Turkey's "know-how" infrastructure will develop with the emergence of a skilled workforce.

The study examined the automotive, white goods, textile, chemical, food and beverage, and machinery sectors as pilot sectors because of the contributions they make to the economy and their ability to serve as potential examples in modeling of many other sectors. When Industry 4.0 applications are evaluated in these sectors, emerging opportunities are the flow of information and materials, integration with suppliers, simulation of the product and production process in the design phase, flexible production, and smart product and production lines that increase predictability. However, there is a significant need for qualified solution partners and human resources. When examined in more depth, the impacts and opportunities summarized here include many variables that depend on the status and needs of the individual sectors. These impacts and opportunities will be different on a company basis when it comes to actual application.

Discussions with industry representatives have shown that awareness of these opportunities is very high and many industrial organizations have already begun to move forward in terms of Industry 4.0 application, even though there are various levels of maturity. Another important and common finding was the belief that this journey could only succeed if all stakeholders contribute and holistic policies are established. It is imperative that a long-term, comprehensive approach be developed to address the numerous structural limitations Turkey faces, such as the workforce, scale, and investment.

All stakeholders have an important role to play in the development of such an approach for a successful Industry 4.0 journey.

- Industrial organizations and suppliers need to stay abreast of the technologies that triggered Industry 4.0 and prepare roadmaps for the opportunities and impact this will have on their own business models. More importantly they need to outline a clear roadmap of their workforce and equipment requirements and act accordingly.
- Important priorities for policy-makers and the public sector, on the other hand, include supporting the development of the nation's technological infrastructure (e.g., in the area of telecommunications, information, communication) with the requirements of Industry 4.0 in mind, preparing the necessary investment and incentive environment, and, most critically, creating long-term education policies to meet the demand for a skilled workforce.

In addition to the aforementioned stakeholders, it is possible to make important comments for the service sector as well. Value chains that develop within the framework of Industry 4.0 will naturally trigger a transformation in the service sectors. Finance, logistics, and software and system integration, which are production solution partners, are also important areas.

Turkey is a young country with an internalized technology and a growing workforce, on the threshold of an opportunity to achieve a huge transformation that will change its role in the global economy. It is urgent and imperative that all stakeholders focus and work within the framework of a joint national plan and objective to join the Industry 4.0 (r)evolution that we believe will be a very fundamental factor in and opportunity to enhancing the development and competitiveness of Turkish industry and allowing the country to take its place among the leading nations. Turkey must identify what is required to make this opportunity a reality and outline a road map to success. Implementation of this roadmap in cooperation with all stakeholders should be one of the most central items on the national agenda for the next ten years.

There is, therefore, a need for a platform where every aspect of the Industry 4.0 approach can be addressed and both the strategic and operational needs and applications can be discussed in depth with the participation of all of the actors responsible for transforming our industrial sectors.

CHAPTER 1

WHAT IS INDUSTRY 4.0?

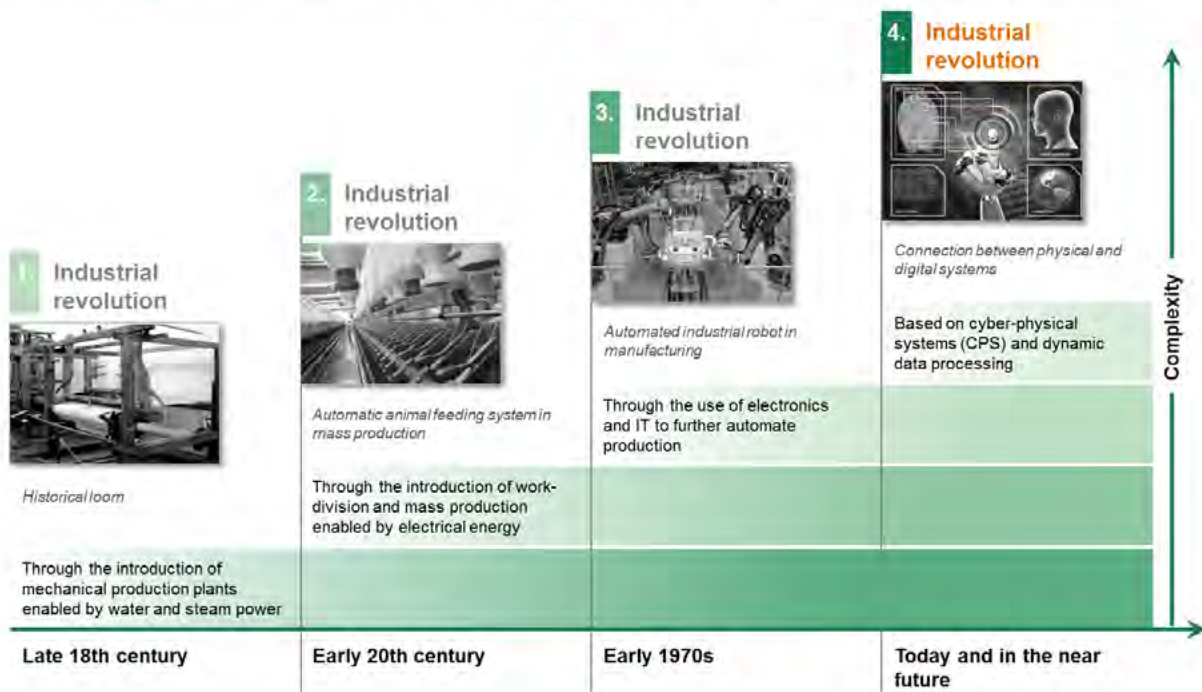
1. WHAT IS INDUSTRY 4.0?

Fourth wave of technological advancement in industry

Since the dawn of the Industrial Revolution, technological advances have driven three stages of industrial revolution, characterized by dramatic increases in industrial productivity. In the late eighteenth century, steam-engine-powered factories became the norm. The discovery and usage of electricity led to mass production in the early part of the twentieth century, and industry became “automated” in the 1970s. We are now living through the fourth stage of industrial revolution, in which value chains are becoming integrated end-to-end through cyber-physical systems and dynamic data processing (see Figure 1).

Figure 1: Stages of the Industrial (R)evolution

Industry 4.0 is the fourth stage of the industrial (r)evolution



Numerous trends, grouped into four main categories, are profoundly changing business paradigms and reinforce the idea that competitiveness of companies and regions are at the verge of a thorough transformation, giving way to this new era of industrial revolution (see Figure 2). These trends can be summarized as follows:

Terra trends – Increased mobility and trade flows across regions

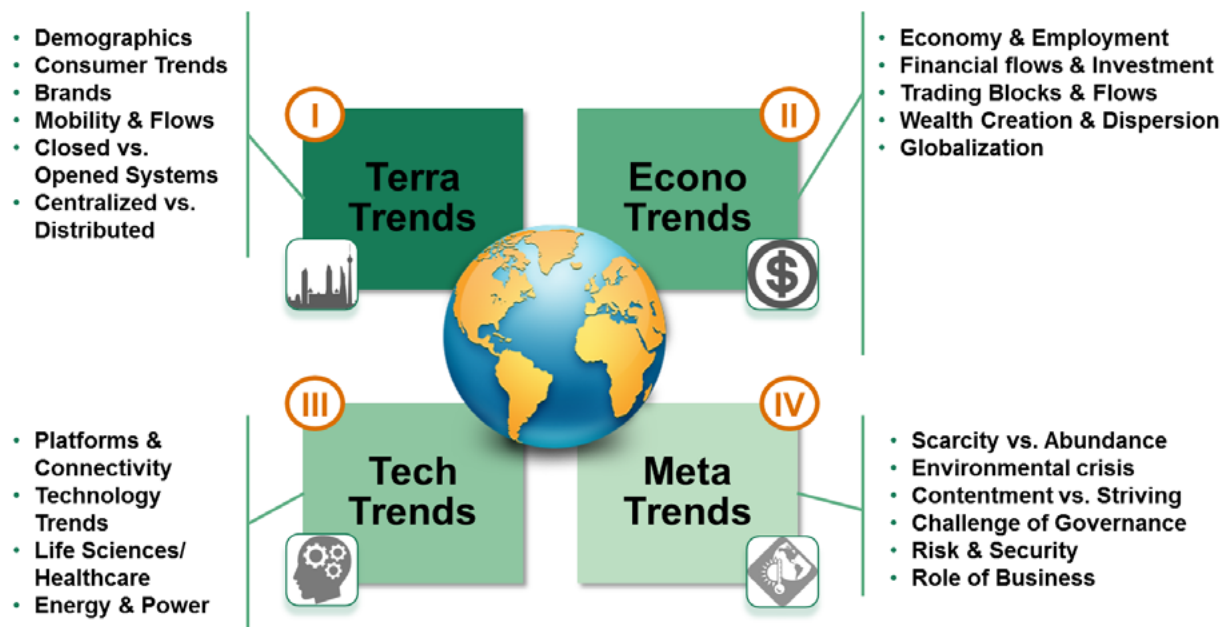
Economic trends – Increased globalization with new rising global economies and financial flows

Technology trends – Increased connectivity and platform technologies

Meta trends – Increasingly scarce resources, environmental and security concerns

Figure 2: Trends Shaping the Future of the World

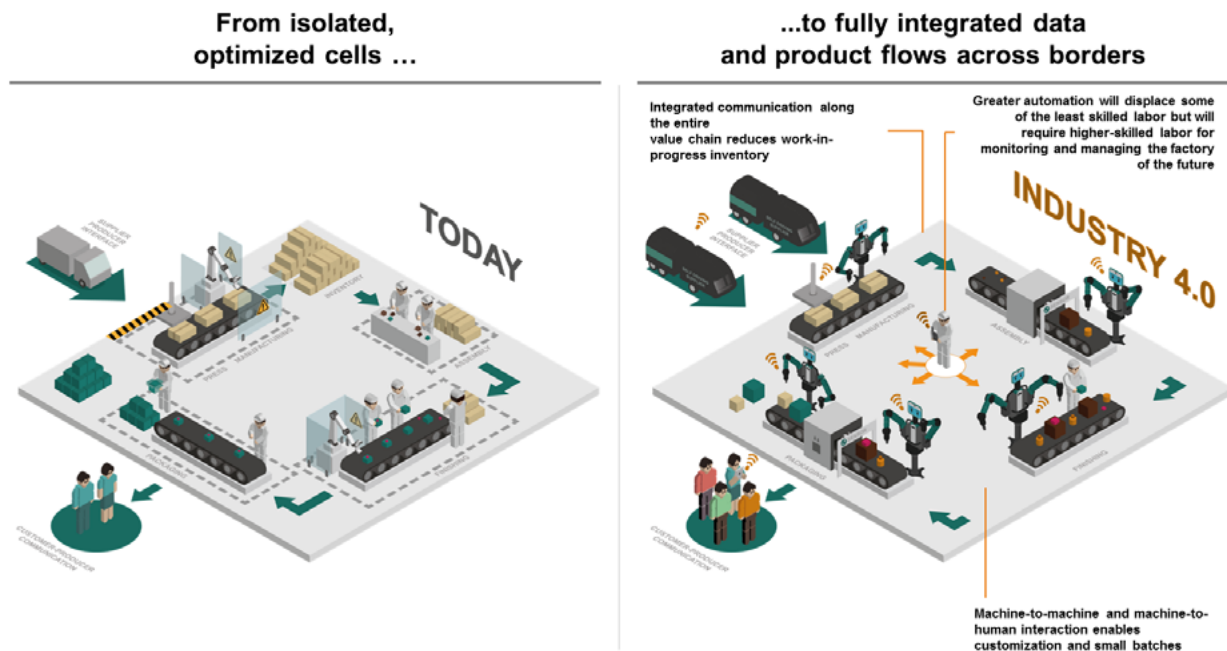
Numerous trends are shaping the future of the world



These trends call for a value chain beyond a single enterprise, in which sensors, machines, work pieces, and IT systems will be connected. These connected systems (also referred to as cyber-physical systems) can interact using standard Internet-based protocols and analyze data to predict failure, configure themselves, and adapt to changes. Industry 4.0 will make it possible to gather and analyze data across machines, enabling faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs. This in return will increase manufacturing productivity, shift economics, foster industrial growth, and modify the profile of the workforce (see Figure 3).

Figure 3: Change of Traditional Production Models through Industry 4.0

Core idea of Industry 4.0:
Integrated, automated and optimized production flow



Source: BCG.

CHAPTER 2

WHY INDUSTRY 4.0
IS POSSIBLE TODAY

2. WHY INDUSTRY 4.0 IS POSSIBLE TODAY

Nine technology drivers are fueling the industrial production of the future (see Figure 4).

Figure 4: Nine technologies that Trigger Industry 4.0



Big Data and Analytics

Analytics based on large data sets emerged only recently in the manufacturing world, optimizing production quality, saving energy, and improving equipment service. In an Industry 4.0 context, the collection and comprehensive evaluation of data from many different sources—such as production equipment and systems, as well as enterprise and customer management systems—to support real-time decision making will become standard.

Industry Example: Infineon Technologies

Semiconductor manufacturer Infineon Technologies has decreased product failures by correlating single-chip data captured in the testing phase at the end of the production process with process data collected in the wafer status phase earlier in the process. In this way, Infineon can identify patterns that help discharge faulty chips early in the production process and improve production quality.

Autonomous Robots

Manufacturers in many industries have long used robots to tackle complex assignments. However, robots are evolving and becoming more autonomous, flexible, and cooperative, while offering lower costs and greater capabilities. Eventually, they will interact with one another and work safely side-by-side with humans while learning from them (see Figure 5).

Figure 5: Autonomous Robots



Industry Example: Kukla and A38

Kukla, a European manufacturer of robotic equipment, offers autonomous robots that interact with one another. These robots are interconnected so that they can work together and automatically adjust their actions to fit the next unfinished product in line. High-end sensors and control units enable close collaboration with humans. Similarly, industrial-robot supplier A38 is launching a two-armed robot called Yum that is specifically designed to assemble products (such as consumer electronics) alongside humans. Two padded arms and computer vision allow for safe interaction and parts recognition.

Simulation

In the engineering phase, 3-D simulations of products, materials, and production processes are already used, but in the future, simulations will be used more extensively in plant operations as well. These simulations will leverage real-time data to mirror the physical world in a virtual model, which can include machines, products, and humans. This allows operators to test and optimize the machine settings for the next product in line in the virtual world before the physical changeover, thereby driving down machine setup times and increasing quality.

Industry Example: Siemens

Siemens and a German machine-tool vendor developed a virtual machine that can simulate the machining of parts using data from the physical machine. This lowers the setup time for the actual machining process by as much as 80 percent.

Horizontal and Vertical System Integration

Most of today's IT systems are not fully integrated. Companies, suppliers, and customers are rarely closely linked; nor are departments such as engineering, production, and service. Functions from the enterprise to the shop floor level are not fully integrated. Even engineering itself, from products to plants to automation, lacks complete integration. But with Industry 4.0, companies, departments, functions, and capabilities will become much more cohesive, as cross-company, universal data-integration networks evolve and enable truly automated value chains.

Industry Example: Dassault Systèmes

Dassault Systèmes and BoostAeroSpace launched a collaboration platform for the European aerospace and defense industry. The platform, AirDesign, serves as a common workspace for design and manufacturing collaboration and is available as a service on a private cloud. It manages the complex task of exchanging product and production data among multiple partners.

The Industrial Internet of Things

Today, only some of a manufacturer's sensors and machines are networked and make use of embedded computing. They are typically organized in a vertical automation pyramid in which sensors and field devices with limited intelligence and automation controllers feed into an overarching manufacturing-process control system. But with the Industrial Internet of Things, more devices— sometimes even unfinished products—will be enriched with embedded computing and connected using standard technologies. This will allow field devices to communicate and interact both with one another and with more centralized controllers, as necessary. It will also decentralize analytics and decision-making, enabling real-time responses.

Industry Example: Bosch Rexroth

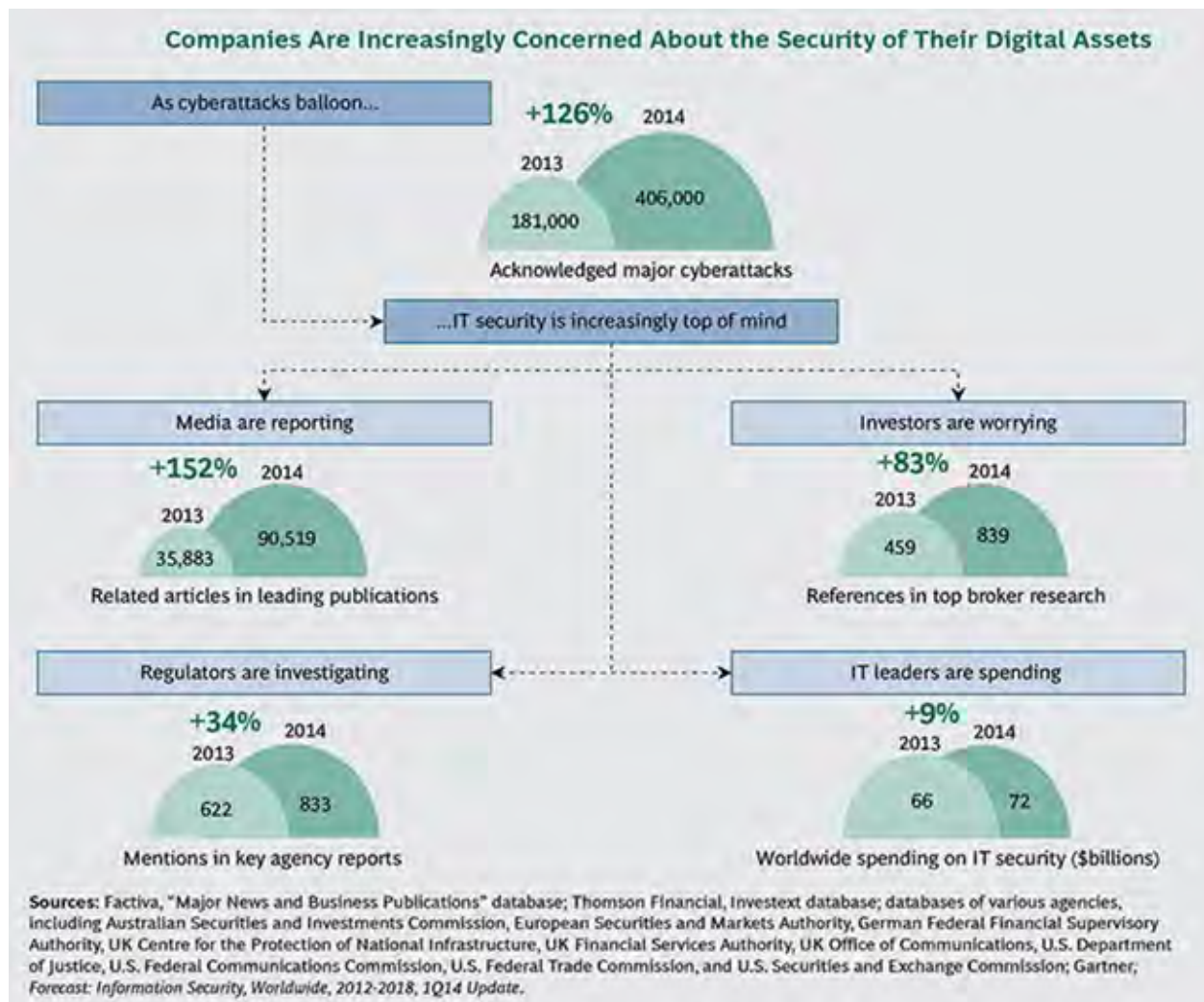
Bosch Rexroth, a drive-and-control-system vendor, outfitted a production facility for valves with a semi-automated, decentralized production process. Products are identified by radio frequency identification codes, and workstations know which manufacturing steps must be performed for each product and can adapt to perform the specific operation.

Cybersecurity

Many companies still rely on management and production systems that are unconnected or closed; however, an increase in connectivity will come with Industry 4.0. Consequently, secure and reliable communications are essential, along with sophisticated identity and access management of machines, due to the need to protect critical industrial systems and manufacturing lines from cyber security threats (see Figure 6).

As a result, over the course of the past year, several industrial-equipment vendors joined forces with cyber security companies through partnerships or acquisitions.

Figure 6: Cybersecurity



The Cloud

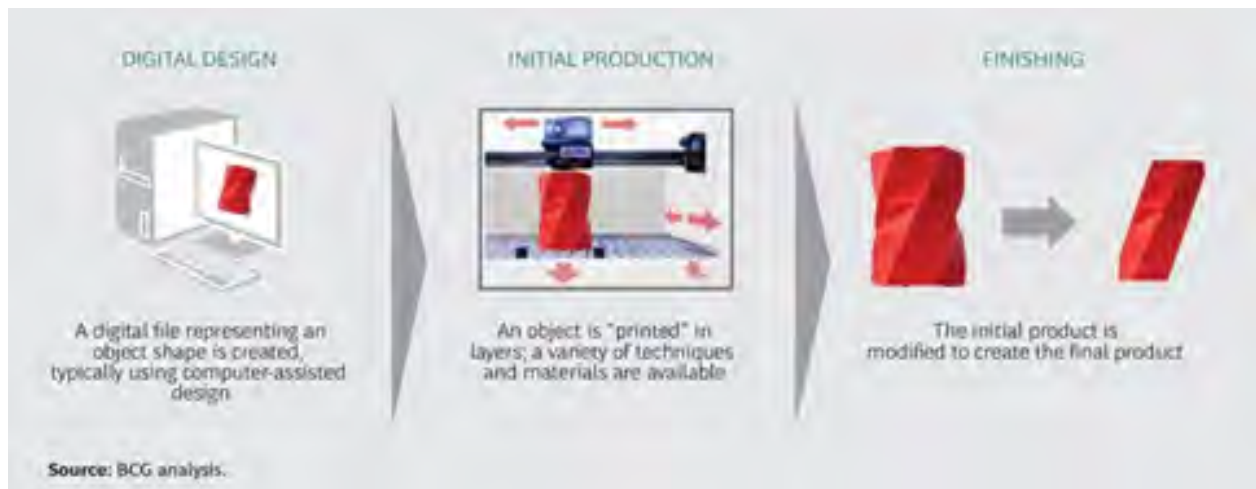
Companies are already using cloud-based software for some enterprise and analytics applications, but with Industry 4.0, more production-related undertakings will require increased data-sharing across sites and company boundaries. At the same time, the performance of cloud technologies will improve, achieving reaction times of just several milliseconds. As a result, machine data and functionality will increasingly be deployed to the cloud, enabling more data-driven services for production systems. Even systems that monitor and control processes may become cloud based.

Vendors of manufacturing-execution systems are among the companies that have started to offer cloud-based solutions.

Additive Manufacturing

Companies have just begun to adopt additive manufacturing, such as 3-D printing, which they use mostly to prototype and produce individual components. With Industry 4.0, these additive-manufacturing methods will be widely used to produce small batches of customized products that offer construction advantages, such as complex, lightweight designs. High-performance, decentralized additive manufacturing systems will reduce transport distances and stock on hand (see Figure 7).

Figure 7: Additive Manufacturing — 3-D Printing



Industry Example: Aerospace companies

Aerospace companies are already using additive manufacturing to apply new designs that reduce aircraft weight, lowering their expenses for raw materials such as titanium.

Augmented Reality

Augmented reality-based systems support a variety of services, such as selecting parts in a warehouse and sending repair instructions over mobile devices. These systems are currently in their infancy, but in the future, companies will make much broader use of augmented reality to provide workers with real-time information to improve decision-making and work procedures (see Figure 8).

Figure 8: Augmented Reality



Augmented Reality Example I: Conceptual example

Workers will receive repair instructions on how to replace a particular part as they are looking at the actual system needing repair. This information may be displayed directly in workers' field of sight using devices such as augmented-reality glasses.

Augmented Reality Example II: Virtual Training Siemens

Siemens has developed a virtual plant-operator training module for its Comos software that uses a realistic, data-based 3-D environment with augmented-reality glasses to train plant personnel to handle emergencies. In this virtual world, operators can learn to interact with machines by clicking on a cyber-representation. They also can change parameters and retrieve operational data and maintenance instructions.

CHAPTER 3

WHY IS INDUSTRY 4.0 VITALLY
RELEVANT FOR TURKEY?

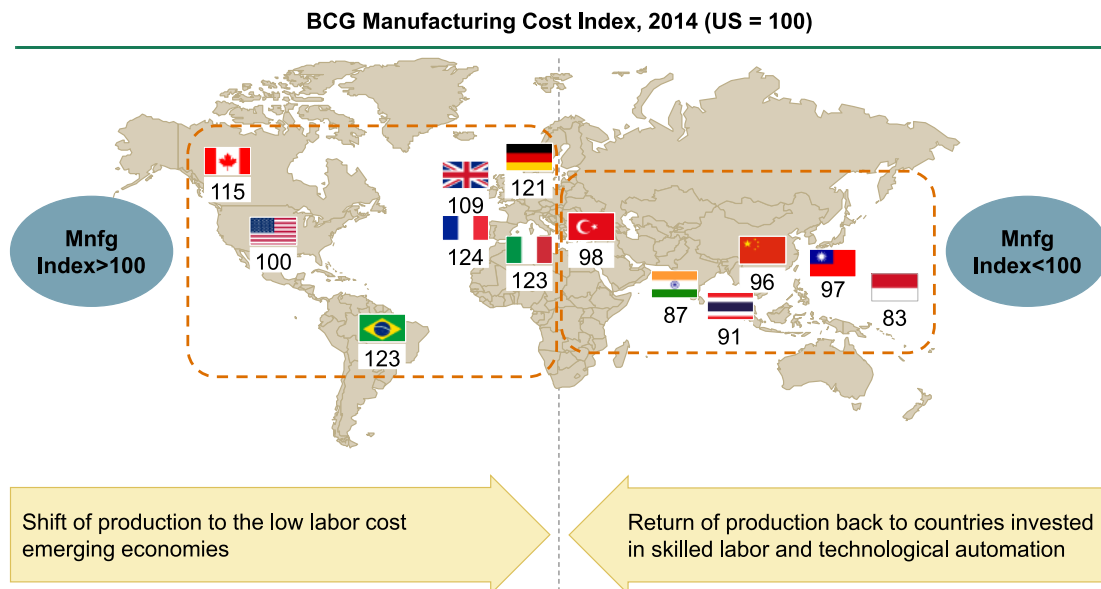
3. WHY IS INDUSTRY 4.0 VITALLY RELEVANT FOR TURKEY?

Trade-off for Turkey: Losing grip on global competitiveness or quantum leap into developed countries league

Turkey has competitively positioned itself along the global value chain by leveraging its geographical location for logistics advantages and providing low at-value labor costs for flexible and cost-efficient production. According to BCG's Global Manufacturing Cost-Competitiveness Index, which develops competitiveness scores based on manufacturing wages, productivity, energy costs, and currency exchange rates compared with the U.S. dollar, Turkey scores 98 vs. the U.S. benchmark score of 100 and Germany of 121. In other words, direct manufacturing costs in Turkey are 23 percent lower than those in Germany and 2 percent lower than the U.S., which creates a competitive edge for Turkey to obtain share from the global value chain and build an export platform (see Figure 9).

Figure 9: Turkey's Position in the Global Value Chain

Turkey positions itself in the global value chain by rather leveraging on its logistical advantage and at value cost labor



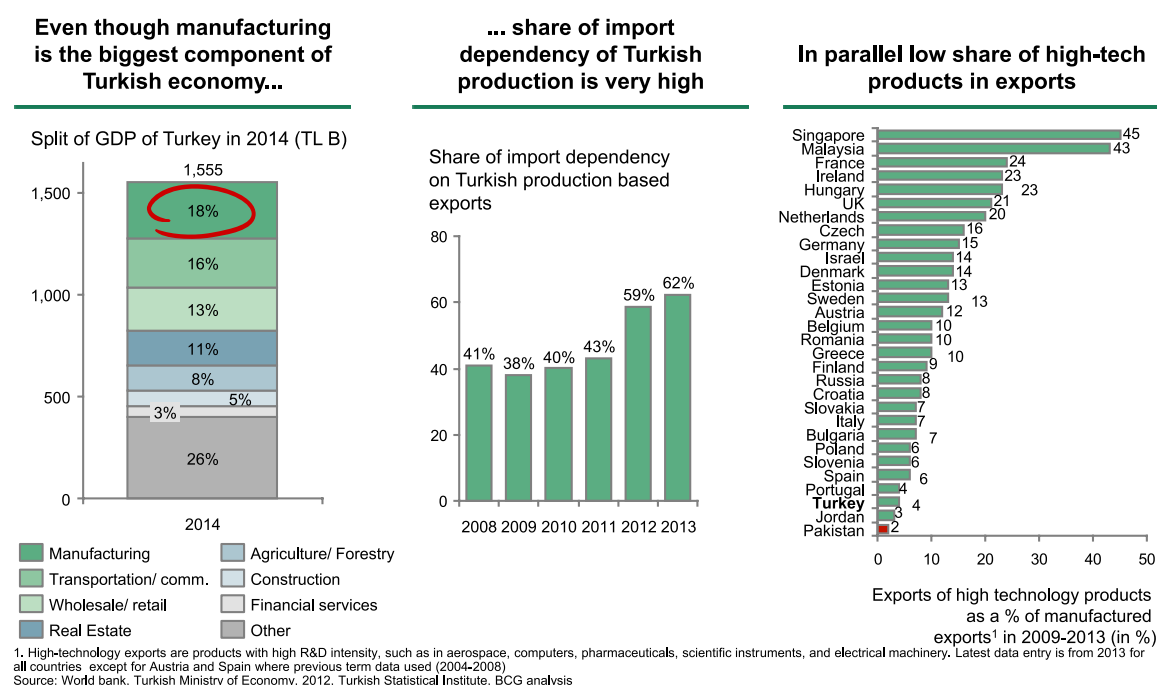
Note: The index covers four direct costs only-No difference is assumed for other costs, such as raw material inputs and machine and tool depreciation. Cost structure calculated as a weighted avg across all industries
Source: US Economic census; US Bureau of Labor statistics; US Bureau of Economic Analysis; International Labour organization; Euromonitor international; Economist intelligence unit; BCG Analysis

However, in the pursuit to maintain and grow its participation in the global value chain, Turkey faces some structural challenges (See Chart 1):

- **High import dependency for exports:** Proportion of imports covered by exports has been consistently high for decades.
- **Low share of value-add products:** Despite rising global demand in value-added products, the share of high-technology products in Turkish manufactured exports is approximately 4 percent.
- **Limited workforce skills/capabilities:** Limited skilled workforce and ecosystems hinder the adaptation to new technologies.
- **High employee turnover:** The shift of workforce from industrial to service sectors leads to high turnover rates in manufacturing sectors.

Chart 1: Turkish Manufacturing Sector's Position in the Global Value Chain

Industry is a major driver, however, limited value add remains as a structural issue



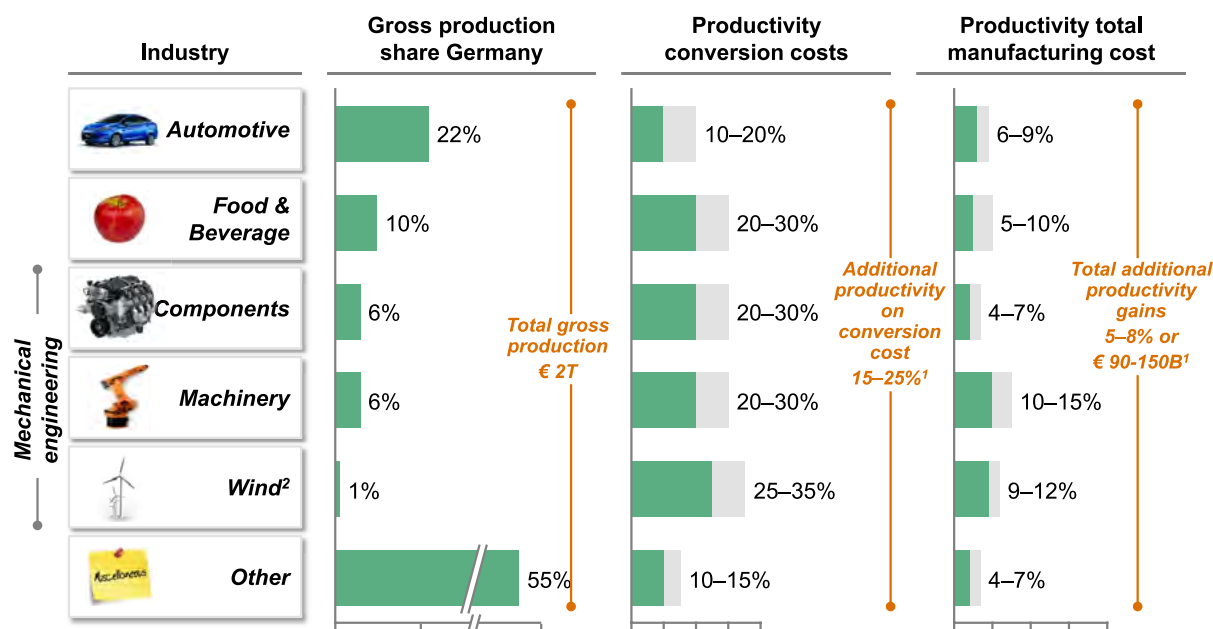
These structural challenges, coupled with potential improvements in other countries' productivity via Industrial 4.0, could hinder Turkey's global manufacturing competitiveness.

Germany as an example of Industry 4.0 transformation

Germany, one of the driving economies of this change, expects significant improvement in its global competitiveness. According to an assessment by BCG, with the adaptation of Industry 4.0, German manufacturing sectors are expected to boost their productivity by €90 billion to €150 billion over the course of the next ten years (see Chart 2). This gain will be achieved through 5 to 8 percent decrease in the total cost of manufacturing. When material costs are excluded, transformation costs are expected to decrease by 20 percent on average. Adapting production processes and systems to incorporate Industry 4.0 will require German producers to invest approximately €250 billion over the next ten years. Increased corporate demand in advanced technologies and consumer demand for customized products will drive additional revenue growth of approximately €300 billion and this growth stimulate will lead to an additional 6 percent increase in employment over the same period.

Chart 2: Potential Benefits of Industry 4.0 Transformation in Germany

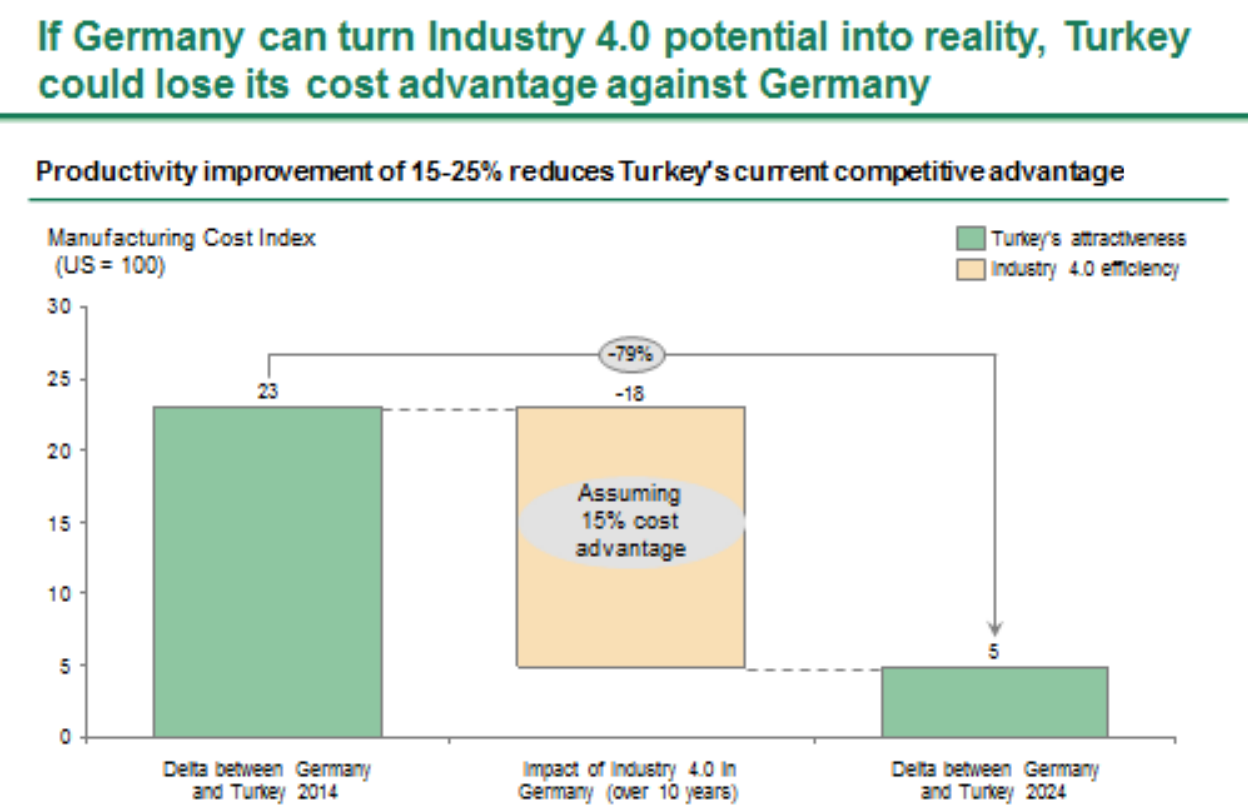
Impact gigantic: Germany - productivity increases for producers of 5–8% on total costs and 15–25% on conversion costs



Note: conversion cost=manufacturing cost excl. material; 1. Additional net effect for manufacturing industries, incl. investments, supplementary to conventional productivity increases 2. Construction of wind power plants included in mechanical engineering (incl. technical components, tower, nacelle); Source: Federal Statistical Office Germany, Expert Interviews, BCG Analysis

The impact of this (r)evolution is groundbreaking due to the absolute numbers associated, shift of labor force structure, and the size of the investments triggered. However, much more importantly, the global balance of cost competitiveness would shift toward industrialized countries adopting the enabling technologies of Industry 4.0. For instance, if Germany were to reduce its transformation costs by 20 percent via successful implementation of Industry 4.0 initiatives, Turkey, maintaining its current competitiveness level, would lose nearly the total of its current cost advantage against Germany. (Chart 3)

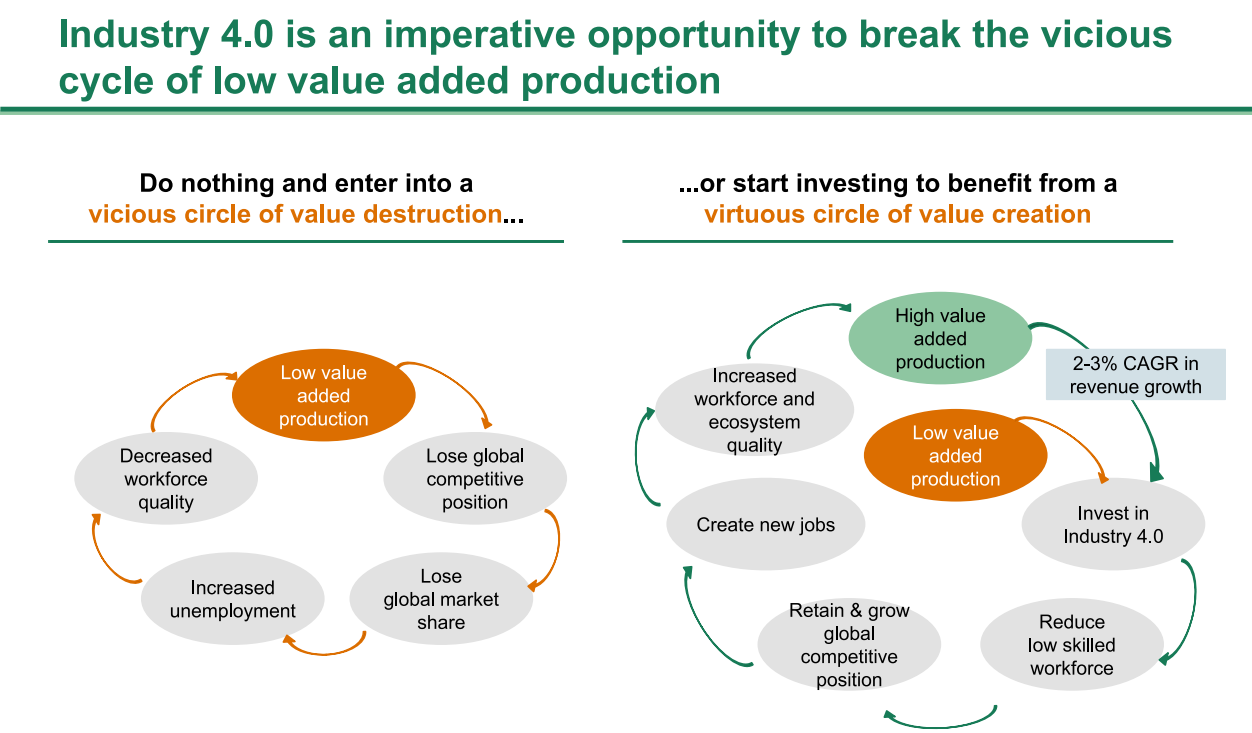
Chart 3: Potential Effect of the German Industry 4.0 Transformation on Turkey



This example illustrates that a natural development of further penetration of Industry 4.0 concepts and the evolution of the manufacturing systems in other countries will further intensify the competitive pressures on Turkey in the long term. Consequently, Turkey will face cost pressure from an increasing number of competitors. High-cost production countries will improve their productivity by leveraging the scale of their advanced manufacturing establishments, while low-cost production countries will have the opportunity to further reinforce their position via easier access to new technologies. Furthermore, if Turkey fails to realize Industry 4.0 investments, playing catch up will be much more challenging as entry barriers to participate in the ever-increasing integration of the global value chain will inevitably rise, due to the high entry barriers of technology and human resources developing in the global marketplace.

In sum, the potential deterioration of Turkey’s global competitive position relative to other countries would mean a decrease in global market share leading to a higher unemployment rate with a lower workforce quality. In this case, Turkey would eventually slide into a vicious cycle of underinvested, low value-added production. On the other hand, investing in Industry 4.0 enablers would provide a tectonic shift for Turkey’s global competitiveness and lead to a higher share in the global value chain, creating more jobs with a highly skilled workforce (see Figure 10).

Figure 10: Role of Industry 4.0 for Turkey



CHAPTER 4

POTENTIAL IMPACT OF INDUSTRY 4.0 ON TURKEY

4. POTENTIAL IMPACT OF INDUSTRY 4.0 ON TURKEY

Benefits of Industry 4.0 are multi-fold

New manufacturing methods have the potential to allow Turkey to preempt the above-mentioned global competitive threats and replace the vicious low value-add production cycle with a virtuous high value-add cycle. The benefits to transforming the manufacturing base by implementing Industry 4.0 successfully are expected to be multi-fold.

Increased global competitiveness

- Increased cost competitiveness
- Improved speed and flexibility
- Better quality and reduced scrap rates
- Higher invested technology base, ecosystem, know-how, and human capital

Enhanced and higher value-added share in global value chains

- Resulting efficiencies and capabilities will help companies retain and grow their global competitive ranks and their share in the global value chains

Improved quality and structure of the labor force

- Sophisticated level of integration and connectivity of manufacturing, customer-facing, and administrative functions will create new categories of work and require new job profiles, which can only be executed by a highly-skilled workforce

Quantifying the impact of Industry 4.0 for Turkey

In a joint effort, TÜSİAD and BCG conducted in-depth interviews with 25 Turkish manufacturing companies/groups in Turkey, representing six different sectors. The goals of these interviews was to discuss and challenge the logic of and the high-level potential behind Industry 4.0 in Turkey.

When selecting these six sectors as pilot sectors for this study, manufacturing sectors that have been covered in official policy documents have been taken into account¹.







¹ *The Tenth Development Plan (2014-2018)*
Primary Transformation Program
(GİTES) Input Supply Strategy
Mid-Term Programs
Industry Strategy (2011-2014 and 2015-2018)
Turkish Exporters Assembly, Export Strategy

Additionally, manufacturing sectors that have been evaluated in a 2014 TÜSİAD-Sabancı University REF (Competition Forum) report under indicators such as total factor productivity, labor productivity, share in value-add, share in labor force, R&D expenditure per employee, and export-import ratio have been considered. Finally, after also taking into account criteria such as Industry 4.0 enablers, technology, employment, GDP share, and role in the value chain, the following six sectors were selected as pilots for this report².

- Automotive
- Machinery
- White appliances
- Food and Beverage
- Textile
- Chemical

Chart 4: Pilot Sector

Selection: 6 industry sectors are selected based on their contributions to the Turkish economy

| 6 Industries | Share in Value-added | Share in Employment | Increase in Total Factor Productivity | Dev. Level ratio of exports to imports | Rate of exports meeting imports |
|--|----------------------|---------------------|---------------------------------------|--|---------------------------------|
|  Automotive | 12 % | 6 % | 7 % | 0.9 | 0.9 |
|  White Appliances | 3 % | 1 % | 9 % | 0.9 | 0.7 |
|  Machinery | 5 % | 5 % | 5 % | 0.9 | 0.6 |
|  Textile | 8 % | 13 % | -0.5 % | 1 | 2.4 |
|  Food & Beverage | 10% | 12 % | -4 % | 0.9 | 1.9 |
|  Chemicals | 5 % | 2 % | 1 % | 1 | 0.2 |

² The list above is not exhaustive in terms of sectors and potential levers; levers may differ depending on company context and company starting point. Sectors were selected based on share in the GDP, potential for Industry 4.0 benefits, and representativeness of the production methodology for a broader set of sectors; and based on information derived from sector interviews and expertise of TÜSİAD and BCG teams.

This assessment underlines that the opportunity is real, far beyond conceptual and can be substantial for Turkey.

Industry 4.0 is already in progress

Today, elements of Industry 4.0 are a reality across the Turkish industry. Some concrete actions have already been taken in all sectors interviewed. Companies with various sizes and technological maturities have presented significant elements of implementation (see Chart 5).

Chart 5: Industry 4.0 Applications in Pilot Sectors

Turkey: Industry 4.0 is already our reality for many manufacturers

| Industry 4.0 lever | Company | Examples |
|---|-----------------|---|
| 1 Integrated, automated and optimized production flow | Home appliances | Integrated quality management Tracks products within the manufacturing process and correlates failure data from testing after front-end-production to reduce waste and improve processing |
| | Machinery | Integrated design data Utilizes vertical data integration from design to the end-of-line of its semi-automated manufacturing process for optimization of operations |
| | Home appliances | Horizontal data integration Enabled its suppliers to view selected ERP data to tie them closer to an integrated production process |
| 2 Virtual product design | Automotive | Virtual factory and product design Offers a joint solution to integrate factory and product design to optimize manufacturing through factory simulation based on the actual manufacturing needs |
| 3 Flexible manufacturing | Home appliances | Flexible manufacturing robots Implemented a manufacturing line which communicates with RFID-based smart products and adjusts tools and manufacturing tasks to product type |
| 4 Automated logistics | Automotive | Laser-guided automated guided vehicle (AGV) Operates a laser-guided AGV logistics system, where the host computer controls inventory and schedules, controls deliveries and routes the AGVs |
| 5 Learning and self-optimizing | Chemicals | Self-optimizing process flow Works on an IT algorithm to optimize the quality of the end products process through recognition of disturbances in the basic materials mix |

Source: BCG analysis, company websites, press research

Opportunity is real and massive

The fourth wave of technological advancement will bring benefits in four areas.

Productivity

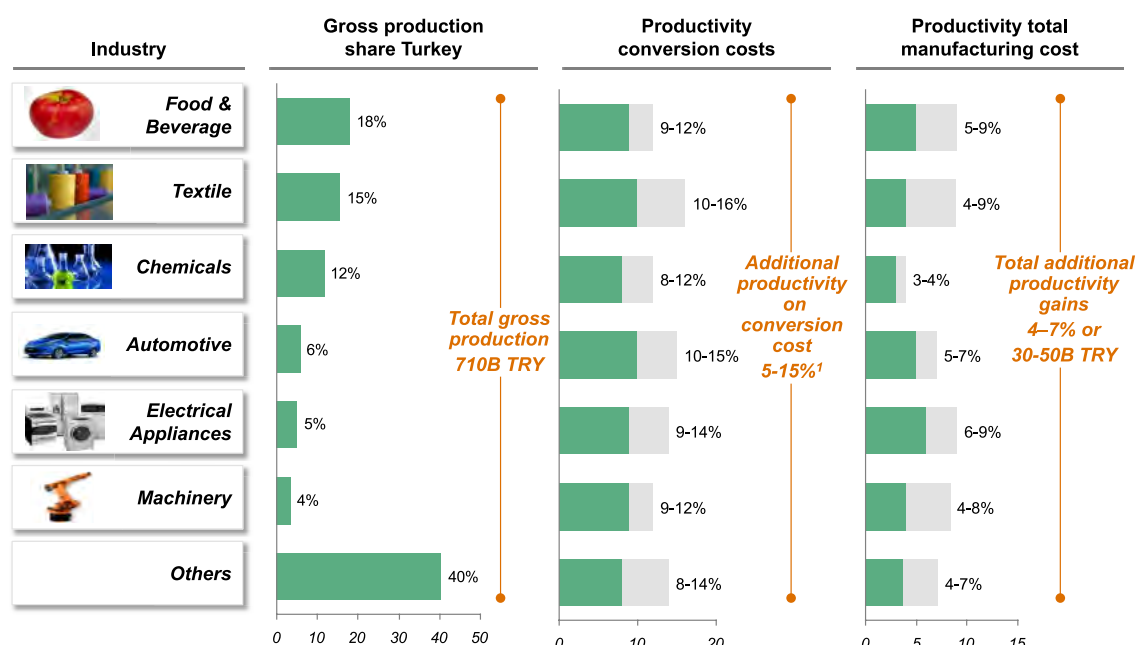
Based on our modeling using Turkish sector data as well as representative company-level inputs and validation, Turkish manufacturing sectors have the opportunity to boost productivity to TL50 billion, provided that Industry 4.0 is adapted successfully.

This is based on expected productivity gains of 4 to 7 percent on an annual basis, with productivity measured against the total cost of production. When the perspective is narrowed down to conversion costs (costs for production excluding material costs), resulting transformation cost efficiency will range from 5 to 15 percent. Some sectors will benefit more than others from productivity improvements.

Depending on the starting point and the dynamics of the sector, each sector and even each company will have substantially differing improvement potential and levers for value creation. In our selected specific sector deep dives, we highlighted some of the relevant levers mentioned by companies from respective sectors (see Chart 6).

Chart 6: Potential Benefits of Turkey's Industry 4.0 Transformation

Turkey: Productivity increases for producers of 4-7% on total costs and 5-15% on conversion costs



Note: conversion cost=manufacturing cost excl. material. 1. Additional net effect for manufacturing industries, incl. investments, supplementary to conventional productivity increases 2. Construction of wind power plants included in mechanical engineering (incl. technical components, tower, nacelle); Source: Federal Statistical Office Germany, Expert Interviews, BCG Analysis

Revenue Growth

Industry 4.0 will also drive revenue growth. Some of the expected drivers for the additional revenue growth include consumer demand for a wider variety of increasingly customized products, on-time product availability, higher share from the global value chains through more global integration, and higher competitiveness. The quantification of the revenue growth is very complex and for a single company it can mean a significant upward change in trajectory or, in the case of low global competitiveness, a complete

loss of business. Our growth assumption indicates an additional total manufacturing based growth of up to 3 percent per year by capturing more and higher value-add demand. Such an increase would imply an additional 1 percent growth effect on Turkish GDP or, in absolute terms, TL150 billion to 200 billion income. The growth will stem substantially from the indicated factors but will also require an industrial strategy and transformation program beyond pure Industry 4.0.

Investment

We estimate that Turkish producers are required to invest about TL10 billion to 15 billion per year over the next ten years in order to adapt production processes to incorporate Industry 4.0 technologies (about 1 to 1.5 percent of manufacturers' revenues), a significant stimulus for growth and economy. The indicated high level of investment excludes structural investment to revamp underinvested or old/non-competitive production infrastructure, which was not in the scope of this perspective.

Employment

The adoption of Industry 4.0 will initially lead to partial substitution of manual labor with automated systems, particularly of low-skilled employees concentrated in production, quality, and maintenance functions. A 20 to 30 percent effect at some value chain steps could be expected in the long-run.

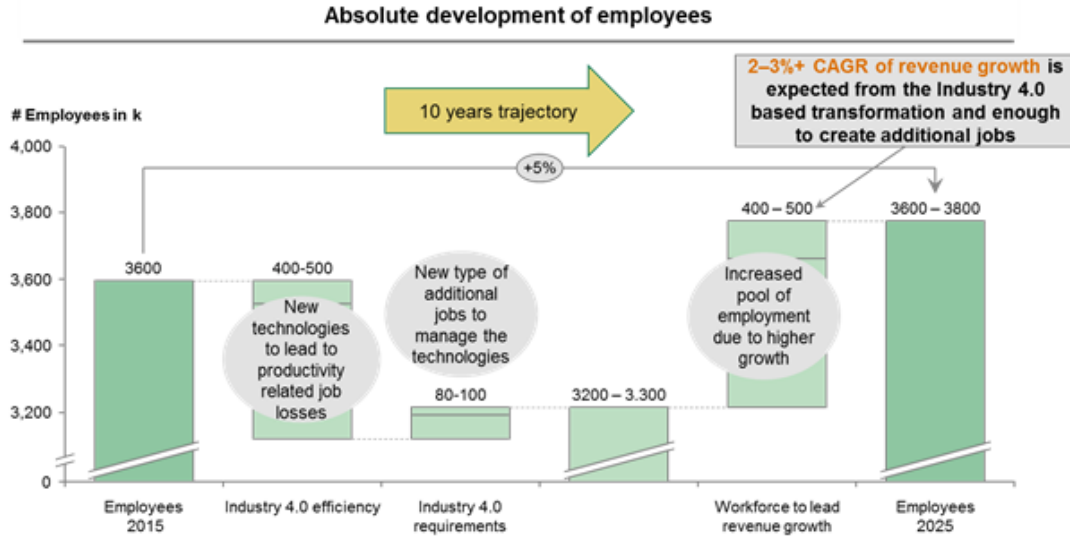
Automated systems will assist workers by providing ergonomic improvements to physically demanding tasks. Assembly line tasks that require physical labor, such as heavy lifting or precise positioning of parts, will be partially or completely executed by robotics. This will free up workers' capacity for more value-added tasks, as well as improve help and safety standards overall. Remote and predictive maintenance will allow technicians to use the extra time on different tasks. Machines, parts, and equipment will be monitored continuously with the help of real-time data collected from operations. This will eliminate the need for physical presence on the shop floor for inspection and diagnoses of issues. With the assistance of augmented reality, a technician can receive remote instructions from an expert, repair the machine, and document the tasks automatically without the need for paperwork. If spare parts have to be ordered for troubleshooting, the technician will not have to wait to get to the site and will be able to focus on more productive tasks.

Two major areas arise as main employment-related discussion topics.

- **Industry 4.0 will shift the required capability set of white and blue collar employees.** In order to manage new production technologies efficiently and grow revenues in a more complex and integrated world, companies will need a more high-skilled workforce. The composition of the workforce will require the expansion of technical functions such as R&D, IT, and automation, and customer-facing functions such as sales and marketing. Specifically, demand for deeper engineering know-how and digital/IT skills will increase. This will enable companies to create new employment opportunities for a more skilled workforce, e.g., “industrial data scientists” will be a new role. IT systems will integrate enterprise, manufacturing, and product lifecycle management system and generate large sets of data collected from networks of business operations. Industrial data scientists will organize the collected data, conduct advanced analytics, and apply their findings to continuously improve the operations. Candidates for this role will have to demonstrate a combined understanding of network systems, statistical analysis, and programming.
- **Higher global competitiveness and higher share in value-added manufacturing for Turkey is expected to significantly fuel growth and thus employment levels.** Over the next ten years, we expect that lower-skilled employment needs will decline, leading to a loss of 400,000 to 500,000 jobs. On the other hand, the need for high-skilled employment, coupled with the additional growth stimulated, will create a total of 400,000 to 500,000 jobs. Based on modeling of the Turkish manufacturing sector, an additional growth of 2 to 3 percent per year is expected to deliver enough stimuli to compensate for the efficiency-based employment losses, leading to 5 percent absolute increase in employment versus a steady-state scenario over the next ten years. In parallel, the significantly higher-skilled labor force structure is expected to raise the income pyramid and prepare a stronger know-how base for Turkey (see Chart 7).

Chart 7: Employment Projection for Turkey

Vision for Turkey: In the long run a better skilled labour force with increasing absolute employment



The real challenge evolves into availability of enough qualified employees

Impact expected in different sectors

Different sectors and companies show varying levels of implementation and potential.

- Companies that are already integrated in global value chains and exposed to global competition have higher maturities, higher awareness levels, and higher short-term potential.
- Larger companies will have a greater ability to justify required investments.
- Büyük ölçekli şirketler aynı zamanda, karşılaştırmalı olarak küçük şirketlere kıyasla Sanayi 4.0'dan daha çok faydalanır. Çoğu Türk şirketi gelişmiş ülkelerdeki rakiplerine kıyasla daha küçük olduğu için, Türkiye için Sanayi 4.0'ın mutlak kazançları nispeten daha düşük olacaktır.
- Current levels of technological maturity may curtail the scope of implementation. Some companies will require capex-heavy investments to replace outdated machine parks that are still in operation although fully amortized on the balance sheet a decade ago. Other companies will have to invest in technologies that will enable and foster connectivity among parts, machines, and humans—although these companies own newer plants and equipment, they still lack integration and connectivity between enterprise and manufacturing applications.

Different levels of labor costs in countries lead to varying levels of absolute improvement potential

- The relatively low cost of labor in Turkey reduces the potential impact of new technologies on productivity. This is mainly due to the smaller share of labor costs among the total cost of production. Essentially, the same rate of productivity improvement yields less cost improvement in Turkey compared to countries with higher labor costs

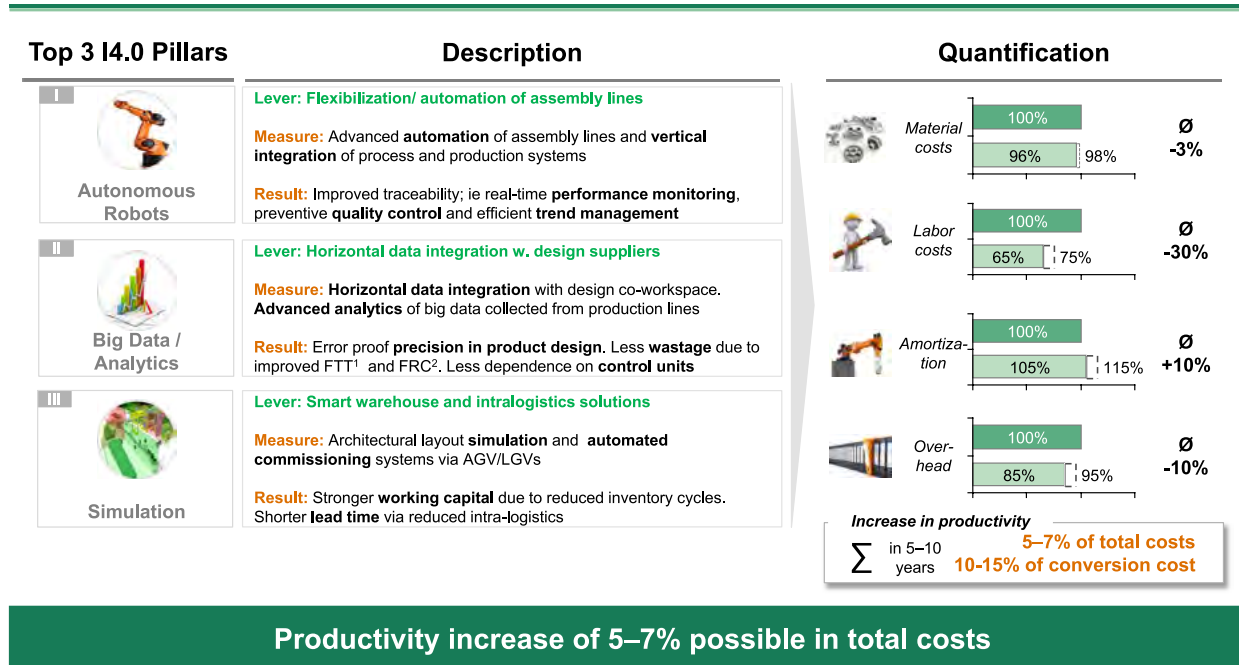
A deeper look into the selected sectors indicates major paths for value creation through Industry 4.0

Automotive (see Chart 8)

- **An increase in flexibility and automation of assembly lines** will develop small-batch capabilities of producers. Advanced automation of assembly lines through cooperative and autonomous robots will develop flexible production lines where multiple models with different parts and designs can be produced using the same line.

Chart 8: Potential Productivity Increase in Automotive Sector

Automotive: Potential productivity increase of 10–15%



Source: BCG analysis, expert interviews
 1. First Time True 2. First Run Capability

Now Industry 4.0 Range

- Vertical integration of process and production systems will allow engineering of multiple product life cycles and models. Big data collected from these vertically integrated systems will significantly improve traceability, and advanced analytics will increase both accuracy and complexity of real-time performance monitoring, preventive quality control, and efficient trend management units.
- **Horizontal data and system integration with suppliers** will create co-working spaces. Timely collaboration through standardized processes will generate error-proof precision in product design, which means less wastage for the carmakers due to improved performance in terms of FTT¹ and FRC²

Suppliers will also benefit from this integration, as they will be able to maximize their potential in just-in-time logistics by streamlining their operations on the basis of new orders from the producers. This change will reduce the costs of logistics and operations.

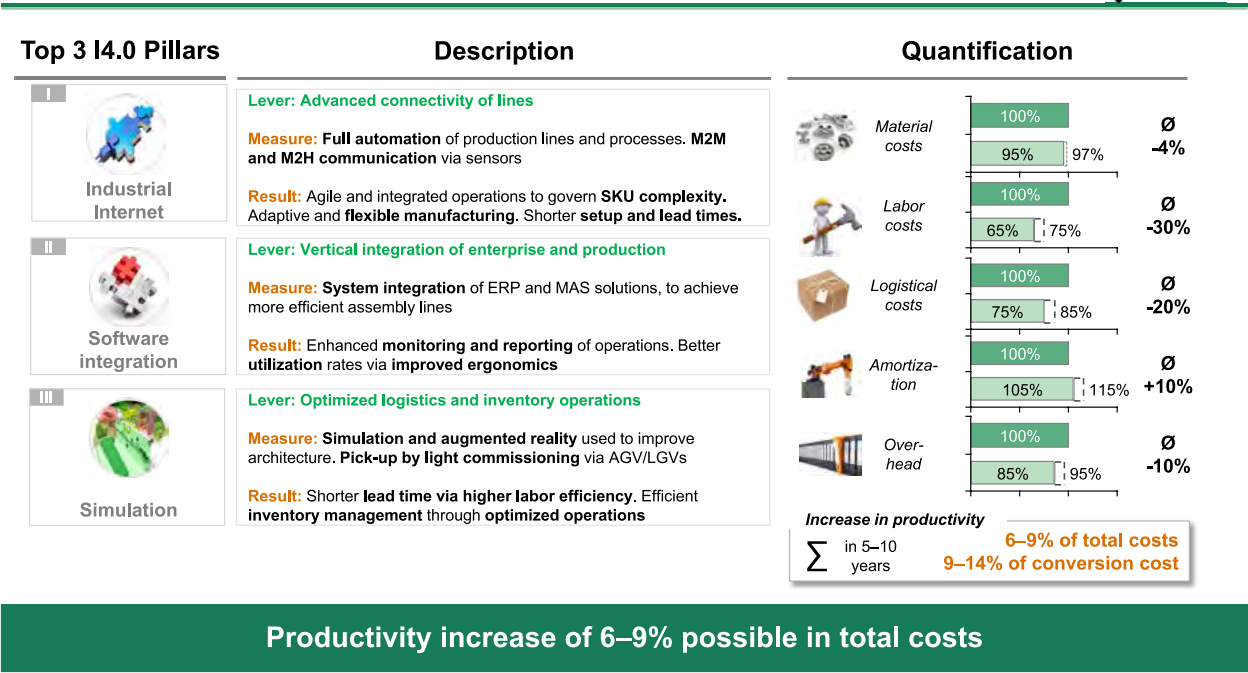
- **Smart warehouse and intra-logistics solutions**, will become a competitive edge for producers. Simulation applications will help create flexible architectural layouts optimized for logistics operation. Augmented reality glasses will bring logistics and manufacturing data in workers' field of vision, helping employees choose the correct part for the incoming step in logistics process. Both advancements will lead to stronger working capital due to reduced inventory cycles and shorter lead times due to less time spent for intra-logistics.

White Appliances (see Chart 9)

- **Sensors embedded in parts, lines and equipment** will enable Machine-to-Machine (M2M) and Machine-to-Human (M2H) communication systems. Further automation and connectivity of end-to-end processes will increase agility and adaptability of the production lines. This will allow companies to govern the increasing SKU complexity more effectively and expand their engineering to multiple product cycles. Increased utilization and flexibility of production lines will make mass customizations possible.
- **Vertical integration of internal systems** will lead to more efficient production. Enterprise resource planning (ERP) systems will work in integration with product lifecycle management (PLM) and manufacturing execution and operation systems (MES/MOS). This will enhance monitoring and reporting capabilities at the granular level and allow companies to take faster actions by using detailed data collected from all three systems.

Chart 9: Potential Productivity Increase in White Appliances Sector

White Apps : Potential productivity increase of 9–14%



Source: BCG analysis, expert interviews

Now Industry 4.0 Range

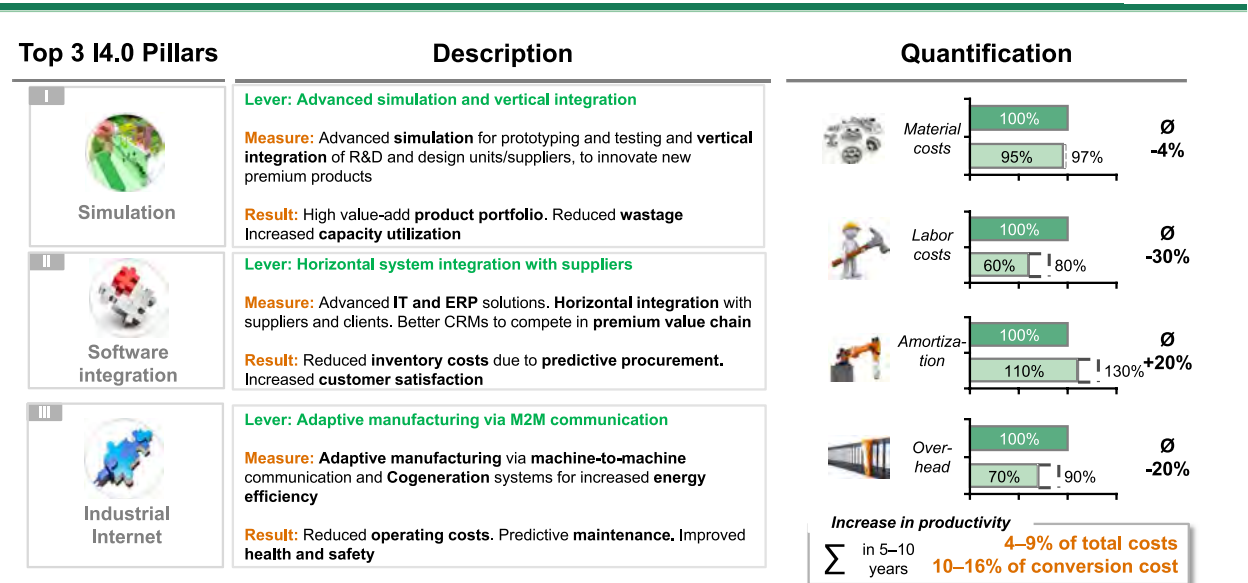
- Labor productivity on the factory floor** will increase due to autonomous transport vehicles and consignment robots. These vehicles and equipment will work together to adjust interval delivery of parts and materials to the destination in time, using the real-time data collected from ongoing operations. Transport vehicles will be able to navigate the production floor using laser-precision guidance and communicate with other vehicles using wireless networks. Consignment robots will automatically find and select the proper materials for upcoming production processes.

Textile (see Chart 10)

- Further use of advanced simulation** for prototyping and vertical data integration of R&D with internal product development units will elevate the level of collaboration and help companies innovate new premium products faster. Companies will not only enjoy a high value-add product portfolio but will also reduce waste and defect ratios due to enhanced precision and accuracy in product designs..

Chart 10: Potential Productivity Increase in Textile Sector

Textile: Potential productivity increase of 10–16%



Productivity increase of 4–9% possible in total costs

Source: BCG analysis, expert interviews

Now Industry 4.0 Range

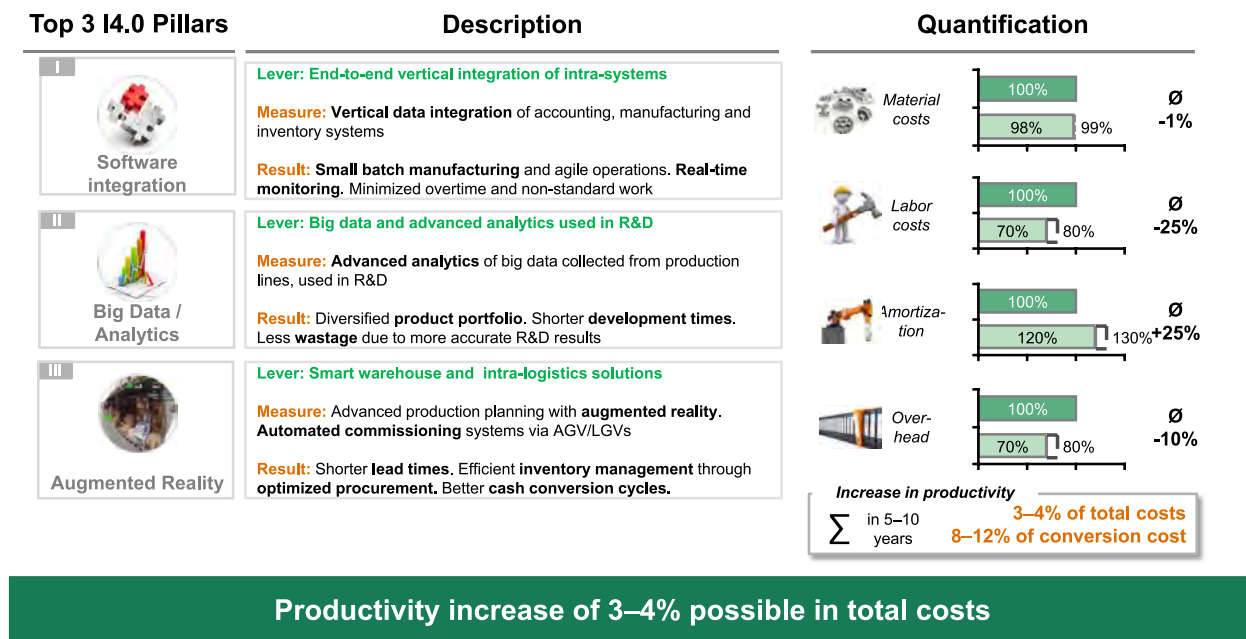
- **Horizontal integration of ERP solutions with suppliers and clients** “will result in better customer relationship management performance required to compete in premium value chain. The integration will also allow companies to predict their procurement cycles more accurately and reduce inventory costs.
- **Adaptive manufacturing via M2M communication** will allow machine operators to predict potential downtime in the production line and start maintenance efforts before the problem kicks in. This will minimize the downtime and allow continuity in the operations.

Chemicals (see Chart 11)

- **End-to-end vertical data integration of** accounting, manufacturing, and inventory systems will help small batch manufacturing and agile operations. Advanced planning and real-time monitoring of the production lines will minimize overtime and non-standard work.

Chart 11: Potential Productivity Increase in Chemicals Sector

Chemicals: Potential productivity increase of 8–12%



Source: BCG analysis, expert interviews

Now

Industry 4.0

Range

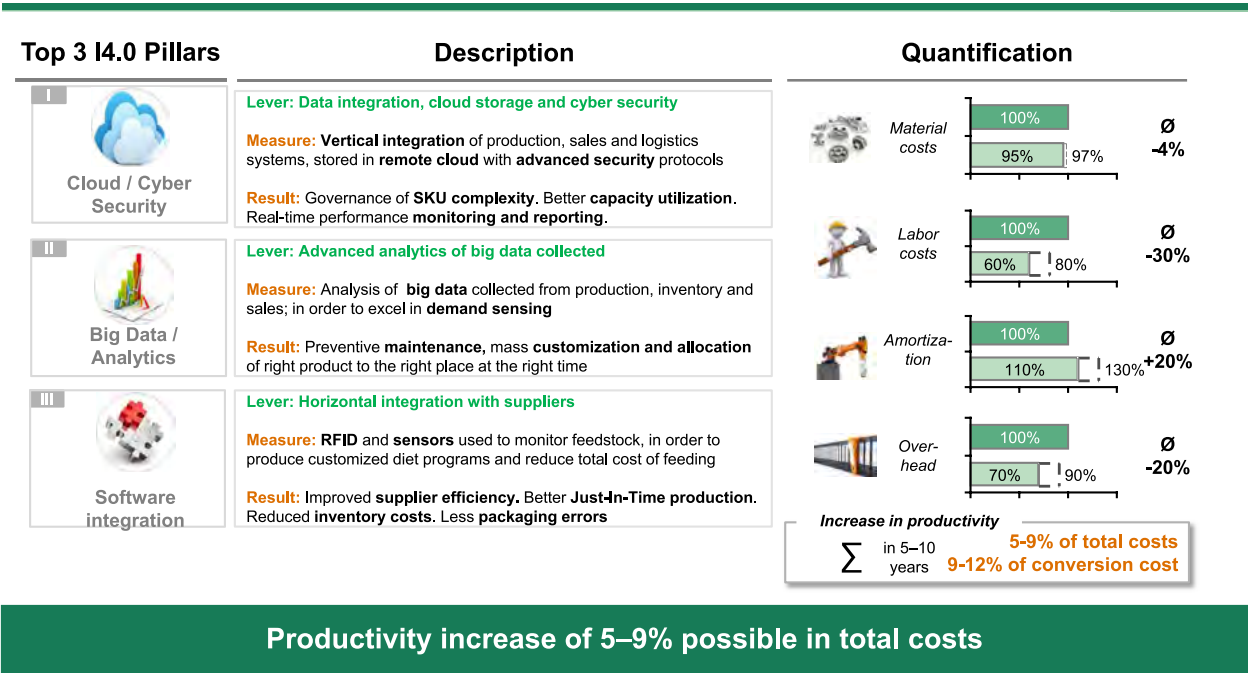
- **Advanced analytics of big data** collected from production lines and used primarily for R&D purposes will foster innovation of new products and improvement of manufacturing systems and processes. More accurate R&D results will lead to less waste and shorter development times.
- **Smart warehouse and intra-logistics solutions** will enable advanced end-to-end production planning. Automated commissioning systems via AGV/LGVs will shorten lead times and improve efficiency in inventory management through optimized procurement. This will eventually improve working capital levels due to better cash conversion cycles.

Food & Beverage (see Chart 12)

- **Advanced analytics of big data collected** from production, inventory, and sales systems will help companies predict market demand with greater accuracy. This will allow companies to allocate the right product to the right place at the right time. Geographical improvements in demand projections will enable the optimization of logistics planning and thus will reduce the transportation costs of light-weight food products.

Chart 12: Potential Productivity Increase in Food and Beverage Sector •

Food & Bvg: Potential productivity increase of 9–12%



Source: BCG analysis, expert interviews

Now Industry 4.0 Range

- **Horizontal integration with suppliers through RFID and sensors** will be used to monitor feedstock in order to produce customized diet programs and reduce total cost of feeding. Improved supplier efficiency will improve just-in-time production, reduce inventory costs, and minimize packaging errors.
- **Vertical integration of production, sales, and logistics systems** will produce big data, which will be stored in remote cloud structures with advanced security protocols. Analytics of this data will improve capacity utilization and allow real-time performance monitoring and reporting.

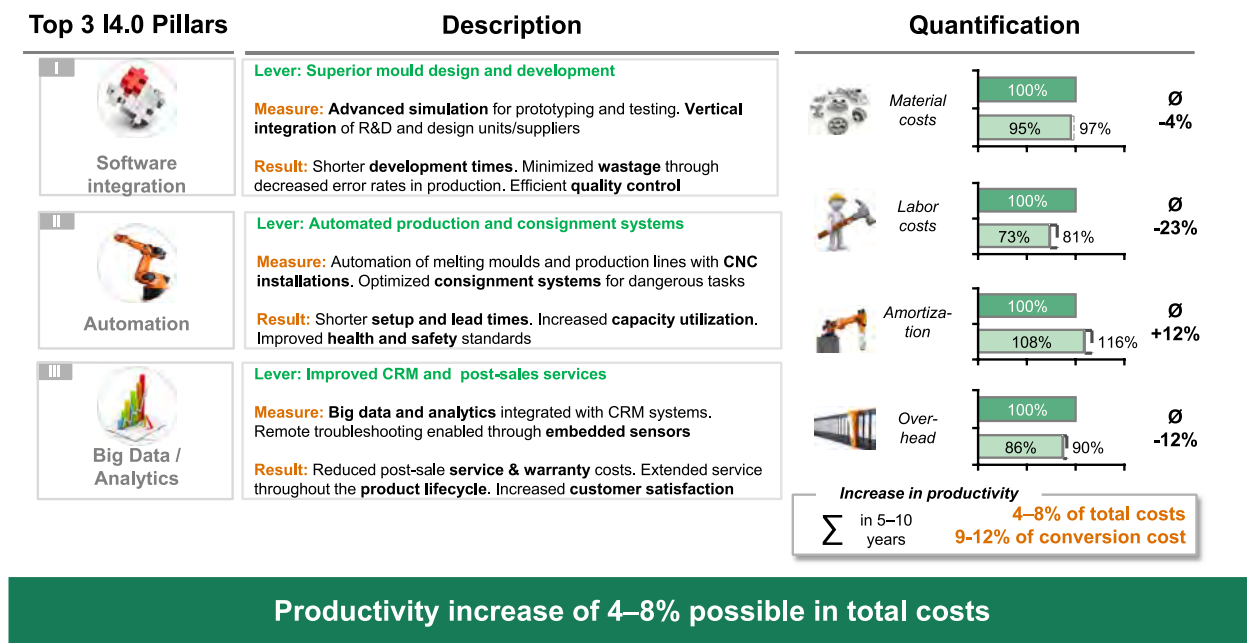
Machinery (see Chart 13)

- **Advanced simulation used in prototyping and testing systems** will lead to superior processes in mold design and development. Effective virtual co-working spaces for R&D, design and manufacturing units will shorten product development times and minimize the dependency on quality control mechanisms due to reduced defect rates.

- **Automation of melting molds and production lines with CNC installations** will shorten setup/lead times and increase capacity utilization. Optimized consignment systems for dangerous tasks will improve health and safety standards for the workers.

Chart 13: Potential Productivity Increase in Machinery Sector

Machinery : Potential productivity increase of 9–12%



Source: BCG analysis, expert interviews

Now Industry 4.0 Range

data and analytics integrated with CRM systems will improve both pre-sales and post-sales services. Remote troubleshooting enabled via embedded sensors will further reduce the cost of post-sales operations and warranty costs. Extended service throughout the product lifecycle will increase customer satisfaction.

- **Simulation and augmented reality** will be used to improve plant and warehouse architecture and enable smart inventory management. Pick-up by light commissioning via auto- and laser-guided vehicles will shorten lead times and will improve labor utilization rates and ergonomics.

CHAPTER 5

CONCLUSION: A ROADMAP FOR TURKEY

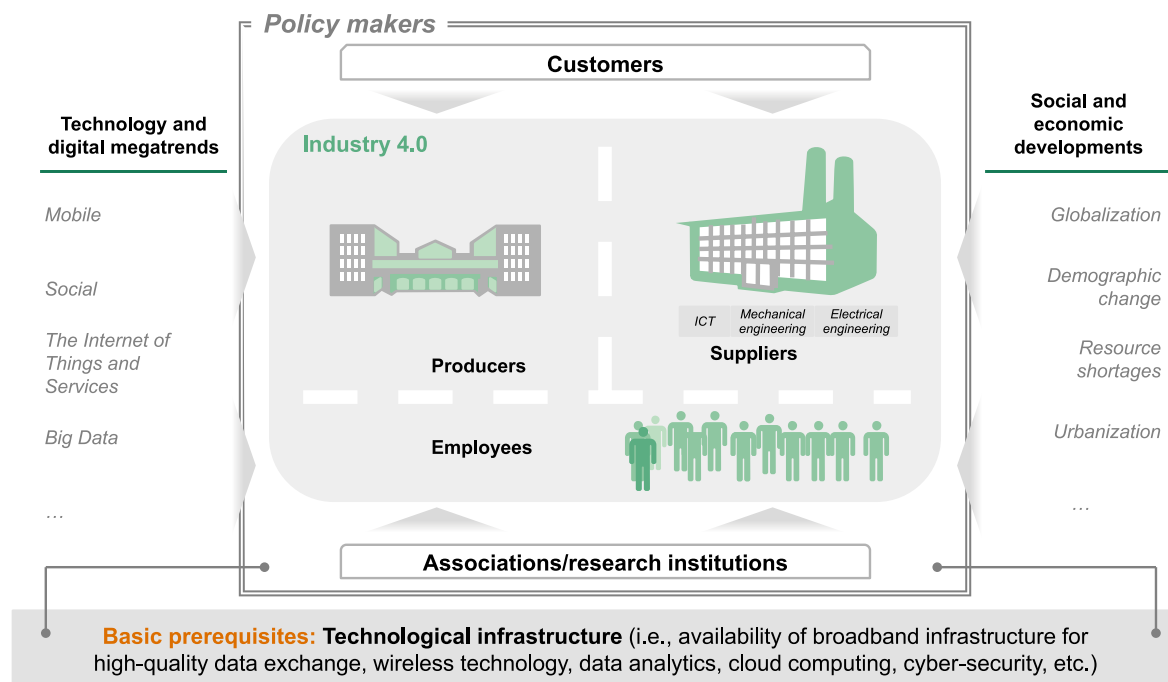
5. CONCLUSION: A ROADMAP FOR TURKEY

Globally, industries and countries will embrace Industry 4.0 at different rates and in different ways. Industries with a high level of product variants, such as automotive and food and beverage industries, will benefit from a greater degree of flexibility that can generate productivity gains. Industries that demand a strict focus on quality, such as semiconductors and pharmaceuticals, will benefit from data-analytics-driven improvements that reduce error rates. Countries with high-cost skilled labor will be able to capitalize on the higher degree of automation combined with increased demand for more highly skilled labor.

As demonstrated in previous sections, Industry 4.0 presents tremendous opportunities for Turkey. A focused, coordinated, and well-designed approach by all stakeholders is imperative. To actively shape the transformation, producers, system suppliers, infrastructure providers, policy-makers, and academics must take decisive action to embrace the nine pillars of technological advancement (see Figure 11).

Figure 11: Major Components and Stakeholders of Industry 4.0

At the center of Industry 4.0 – the production of the future – are the producers, suppliers, and employees



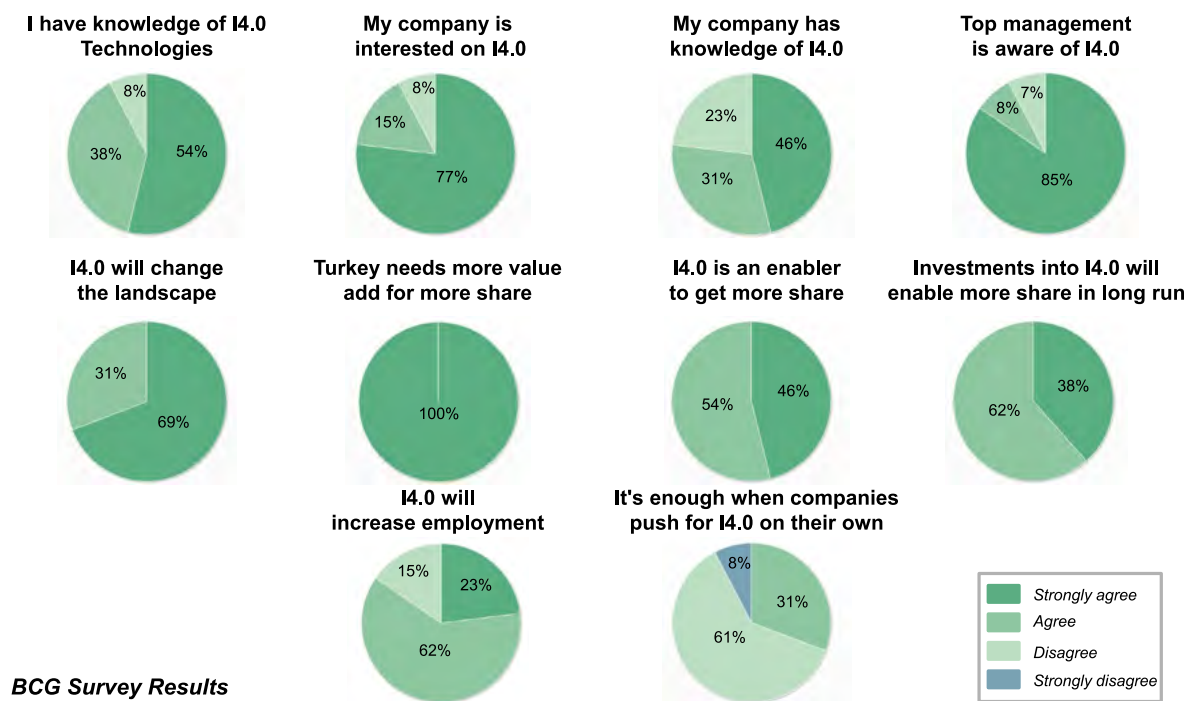
Looking at the results of a survey we conducted among 45 executives from 25 firms representing six sectors,³ some key insights emerge about the Turkish case of Industry 4.0 transformation.

3 Forty-five executives from 25 companies operating in six selected sectors were asked to participate in a survey that explored Turkish industry's awareness of Industry 4.0.

As unanimously acknowledged by the Turkish industrial stakeholders, Turkey needs more value-add for larger global market share (see Chart 14).

Chart 14: Results of Industry 4.0 Awareness Survey

Industry 4.0 is regarded as a key priority for the future, but need to be complemented by other factors –Survey results



There is significant awareness and interest in Industry 4.0 technologies and the alignment on competitive advantages it may bring. More than 90 percent of the respondents indicated that they and the top management have knowledge of Industry 4.0 technologies and that they believe Industry 4.0 will change the landscape. More importantly, all participants agreed that required investments will enable Turkey to increase its share in the global value chain in the future.

Another significant outcome of the survey was that companies' efforts and investments to implement Industry 4.0 alone will not be sufficient to reap benefits: approximately 70 percent of the executive respondents disagreed that it is enough when companies push for Industry 4.0 on their own. The transformation requires a holistic and aligned approach by all stakeholders, specifically government and non-governmental organizations. The need to adapt the appropriate infrastructure and education emerge as clear enablers for the transformation.

Issues related to workforce structure

- Structurally cheap labor costs lengthen the break-even period of return on investments, yielding less incentive to invest in advanced capex intensive systems.⁴
- Limited skilled workforce and ecosystems curtail the adaptation of new technologies. High turnover rate, fuelled by the shift of workforce from industrial to service sectors, impair the chance to build a robust, experienced workforce.

Issues related to technology and corporate structure

- Lack of integration between enterprise applications and factory/equipment and silos prevent connectivity and data collection.
- Relatively small size and scale of companies limit the potential benefits from Industry 4.0 compared to those in developed countries.
- Lack of supplier sophistication and relatively small company sizes limit the possibility of triggering the required investments for Industry 4.0 and inhibit end-to-end integration across supply chains.
- Moreover, the large scale of solution providers' and engineering partners' involvement will be required for integration of industrial 4.0 technologies across the value chain, which is currently provided by international markets. Building the local know-how and support eco-system will be a critical enabler for adaption.

Issues related to investment horizon

- Investors' expectations are usually limited to two years for investment returns, challenging the appetite for Industry 4.0 expenditures that are expected to yield gains in longer periods.

Therefore, it is crucial that all stakeholders, especially the public sector and NGOs, work in a holistic and harmonious manner to realize an industrial transformation. Specifically, the necessary infrastructure and education system are the major factors that will enable such transformation.

Producers have to set priorities among their production processes and enhance their workforce's competencies, as follows:

⁴ *It is important to note that labor costs in Turkey have been on an upward trend as well; as Turkey moves up the development ladder, this trend will continue, making Industry 4.0 transformation ever more crucial.*

- Identify key areas for improvement, such as flexibility, speed, productivity, and quality. Then, consider how the nine pillars of technological advancement can drive improvement in the designated areas. Avoid becoming stuck in incremental approaches; instead, consider more fundamental changes enabled by a combination of the nine technologies
- Analyze the long-term impact on the workforce and conduct strategic workforce planning. Adapt roles, recruiting, and vocational training to prepare the workforce with the additional IT skills that will be required.

While these improvements already hold significant potential for existing industries, emerging fields could use Industry 4.0 technology to disrupt existing standards using innovative factory layouts and production processes. To build these offers, they must put the right foundations in place:

- Define which business model to leverage for their enhanced or new offers
- Build the technological foundation, such as the tool base for analytics
- Build the right organization structure and capabilities
- Develop partnerships that are essential in the digital world
- Participate in and shape technological standardization
- Nurture a supplier ecosystem for new technologies

Policy-makers and the public sector should adapt the infrastructural, educational, regulatory and investment framework. This is best addressed through a combined effort involving government, industry associations, and businesses to achieve the following:

- Upgrade technological infrastructure, such as fixed- and mobile-broadband services. Infrastructure must be rendered fast, secure, and reliable enough for companies to depend on for near real-time data.
- Adapt school curricula, training, and university programs and strengthen entrepreneurial approaches to increase the IT-related skills and innovation abilities of the workforce.
- A stimulus approach will be also fundamental to enabling not only large but also small- and medium-sized enterprises to realize the investments required for new technologies, new ways of manufacturing and working, and a skilled labor force.

In addition to the aforementioned stakeholders, it is possible to make important deductions for the service sector as well. Value chains that develop within the framework of Industry 4.0 will naturally also trigger a transformation in the service sectors. In this regard, finance, logistics, and software and system integration, which are production solution partners, are also important areas:

- Strengthening the logistic sectors' integration in value chains with regard to Industry 4.0
- Keeping manufacturing sectors' solution partners up-to-date in terms of innovation needs and competencies required
- Adapting financial institutions to new risk assessment needs due to changing balance sheet structures

Turkey is a young country with an internalized technology and a growing workforce, on the threshold of an opportunity to achieve a huge transformation that will change its role in the global economy. It is urgent and imperative that all stakeholders focus and work within the framework of a joint national plan and objective to join the Industry 4.0 (r)evolution that we believe will be a very fundamental factor in and opportunity to enhancing the development and competitiveness of Turkish industry and allowing the country to take its place among the leading nations. Turkey must identify what is required to make this opportunity a reality and outline a roadmap to success. Implementation of this roadmap in cooperation with all stakeholders should be one of the most central items on the national agenda for the next ten years.

There is, therefore, a need for a platform in which every aspect of the Industry 4.0 approach can be addressed, and both the strategic and operational needs and applications can be discussed in depth with the participation of all of the actors responsible for transforming our industrial sectors.

This report has been prepared by TUSIAD and BCG cooperation. Some chapters of this report had been published in “Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries” report in 2015, by The Boston Consulting (BCG). That report may have been reached from www.bcgperspectives.com.

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