INDUSTRY 4.0

Digitalization for Productivity and Growth
The Future of Productivity and Growth in Manufacturing Industries

Industry 4.0 in Turkey as an Imperative for Global Competitiveness: An Emerging Market Perspective
(EU, BCG and TUSIAD Reports, 2016)
Overview

• Technological advances have driven dramatic increases in industrial productivity since the dawn of the Industrial Revolution.

• The steam engine powered factories in the nineteenth century, electrification led to mass production in the early part of the twentieth century, and industry became automated in the 1970s.

• In the decades that followed, however, industrial technological advancements were only incremental, especially compared with the breakthroughs that transformed IT, mobile communications, and e-commerce.
## Industrial Revolutions

<table>
<thead>
<tr>
<th></th>
<th>Time periods</th>
<th>Technologies and capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>1784-mid 19th century</td>
<td>Water- and steam-powered mechanical manufacturing</td>
</tr>
<tr>
<td>Second</td>
<td>Late 19th century -1970s</td>
<td>Electric-powered mass production based on the division of labour (assembly line)</td>
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<tr>
<td>Third</td>
<td>1970s-Today</td>
<td>Electronics and information technology drives new levels of automation of complex tasks</td>
</tr>
<tr>
<td>Fourth</td>
<td>Today-</td>
<td>Sensor technology, interconnectivity and data analysis allow mass customisation, integration of value chains and greater efficiency</td>
</tr>
</tbody>
</table>
What is Industry 4.0?

• Industry 4.0 is a term applied to a group of rapid transformations in the design, manufacture, operation and service of manufacturing systems and products.

• This is the world’s fourth industrial revolution, the successor to three earlier industrial revolutions that caused quantum leaps in productivity and changed the lives of people throughout the world.

• Industry 4.0 is the comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the internet with conventional industry.

• Everything in and around a manufacturing operation (suppliers, the plant, distributors, even the product itself) is digitally connected, providing a highly integrated value chain.

• The term **Industry 4.0** originated in Germany.
Fourth Wave of Technological Advancement

• The rise of new digital industrial technology
• A transformation that is powered by nine foundational technology advances
• In this transformation, sensors, machines, workpieces, and IT systems will be connected along the value chain beyond a single enterprise
• These connected systems (also referred to as cyberphysical systems) can interact with one another using standard Internet-based protocols and analyze data to predict failure, configure themselves, and adapt to changes
Fourth Wave of Technological Advancement

- 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 will increase manufacturing productivity, shift economics, foster industrial growth, and modify the profile of the workforce—ultimately changing the competitiveness of companies and regions.
The Nine Pillars of Technological Advancement

EXHIBIT 1 | Nine Technologies Are Transforming Industrial Production

- Autonomous robots
- Simulation
- Big data and analytics
- Horizontal and vertical system integration
- Augmented reality
- The Industrial Internet of Things
- Additive manufacturing
- The cloud
- Cybersecurity

*Industry 4.0 is the vision of the industrial production of the future*

Source: BCG.
The Nine Pillars of Technological Advancement

• Many of the nine advances in technology that form the foundation for Industry 4.0 are already used in manufacturing

• They will transform production:
  – Isolated, optimized cells will come together as a fully integrated, automated, and optimized production flow
  – Leading to greater efficiencies
  – Changing traditional production relationships among suppliers, producers, and customers—as well as between human and machine
Big Data and Analytics

• Analytics based on large data sets has emerged only recently in the manufacturing world, where it optimizes production quality, saves energy, and improves equipment service.

• In an Industry 4.0 context, the collection and comprehensive evaluation of data from many different sources—production equipment and systems as well as enterprise- and customer-management systems—will become standard to support real-time decision making.
Autonomous Robots

• Manufacturers in many industries have long used robots to tackle complex assignments, but robots are evolving for even greater utility
  • They are becoming more autonomous, flexible, and cooperative
  • They will interact with one another and work safely side by side with humans and learn from them
  • These robots will cost less and have a greater range of capabilities than those used in manufacturing today
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.
Horizontal and Vertical System Integration

- Most of today’s IT systems are not fully integrated
- Companies, suppliers, and customers are rarely closely linked
- Nor 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
- 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
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
• With the Industrial Internet of Things, more devices—sometimes including even unfinished products—will be enriched with embedded computing and connected using standard technologies
• This allows field devices to communicate and interact both with one another and with more centralized controllers, as necessary
• It also decentralizes analytics and decision making, enabling real-time responses
Cybersecurity

• Many companies still rely on management and production systems that are unconnected or closed

• With the increased connectivity and use of standard communications protocols that come with Industry 4.0, the need to protect critical industrial systems and manufacturing lines from cybersecurity threats increases dramatically

• As a result, secure, reliable communications as well as sophisticated identity and access management of machines and users are essential
The Cloud

- Companies are already using cloud-based software for some enterprise and analytics applications.
- **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.
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
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.
Industry 4.0 is expected to have a major effect on global economies

• Industry 4.0 can deliver estimated annual efficiency gains in manufacturing of between 6% and 8%
• The Boston Consulting Group predicts that in Germany alone, Industry 4.0 will contribute 1% per year to GDP over ten years, creating up to 390 000 jobs (6 percent increase in employment)
• Globally, one expert estimates that investment on the Industrial Internet will grow from US$20 billion in 2012 to more than US$500 billion in 2020
• Value added will surge from $US23 billion in 2012 to US$1.3 trillion in 2020
Industry 4.0 is expected to have a major effect on global economies

• The United States has established a National Network for Manufacturing Innovation with a proposed US$1 billion of public funding to bring together national research centers investigating topics such as digital manufacturing and design.

• Companies in the Asia/Pacific region were expected to invest almost US$10 billion in the Industrial Internet of Things in 2012, with that figure rising to nearly US$60 billion by 2020.
What will Industry 4.0 change?

- Smart factories allow *increased flexibility* in production.
- Automation of the production process, the transmission of data about a product as it passes through the manufacturing chain, and the use of configurable robots means that a variety of different products can be produced in the same production facility.
- This *mass customization* will allow the production of small lots (even as small as single unique items) due to the ability to rapidly configure machines to adapt to customer-supplied specifications and additive manufacturing.
- This flexibility also encourages innovation, since prototypes or new products can be produced quickly without complicated re-tooling or the setup of new production lines.
What will Industry 4.0 change?

- The **speed** with which a product can be produced will also improve.
- Digital designs and the virtual modeling of manufacturing process can reduce the time between the design of a product and its delivery.
- Data-driven supply chains can speed up the manufacturing process by an estimated 120% in terms of time needed to deliver orders and by 70% in time to get products to market.
What will Industry 4.0 change?

• Integrating product development with digital and physical production has been associated with large improvements in **product quality** and significantly reduced error rates

• Data from sensors can be used to monitor every piece produced rather than using sampling to detect errors, and error-correcting machinery can adjust production processes in real time

• The rise in quality plays an important role in reducing costs and hence increasing competitiveness: the top 100 European manufacturers could save an estimated €160 billion in the costs of scrapping or reworking defective products if they could eliminate all defects
What will Industry 4.0 change?

- **Productivity** can also increase through various Industry 4.0 effects
- By using advanced analytics in predictive maintenance programmes, manufacturing companies can avoid machine failures on the factory floor and cut downtime by an estimated 50% and increase production by 20%
- Some companies will be able to set up ‘lights out’ factories where automated robots continue production without light or heat after staff has gone home
- Human workers can be used more effectively, for those tasks for which they are really essential
- For example, in the Netherlands, Philips produces electric razors in a ‘dark factory’ with 128 robots and just nine workers, who provide quality assurance
What will Industry 4.0 change?

- **Customers** will be able to be more involved in the design process, even supplying their own modified designs which can then be quickly and cheaply produced.
- The location of some manufacturing operations may also be close to the customer: if manufacturing is largely automated, it does not need to be ‘off-shored’ or located in distant countries with low labor (but high transport) costs.
- European companies may decide to bring some manufacturing capacity back to Europe (‘re-shore’), or to establish new plants in Europe rather than abroad.
What will Industry 4.0 change?

• Industry 4.0 will also provoke changes in **business models**

• Rather than exclusively competing on cost, European companies can compete on the basis of innovation (the ability to deliver a new product rapidly), on the ability to produce customer-driven customized designs (through configurable factories), or on quality (the reduction of faults due to automation and control)

• Some companies may take advantage of the data created as ‘smart’ products are created and used, and adopt business models based on selling services not products
• 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 the automotive and food-and-beverage industries, will benefit from a greater degree of flexibility that can generate productivity gains, for example, and industries that demand high 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 the increased demand for more highly skilled labor
• Many emerging markets with a young, technology-savvy workforce might also jump at the opportunity and might even create entirely new manufacturing concepts
Challenges for Industry 4.0

Investment and change

- Building a complex value network that can produce and distribute products in a flexible fashion means business leaders must accept to change and partner with other companies – not only suppliers and distributors of a product, but technology companies and infrastructure suppliers such as telecoms and internet service providers
- Large investments are needed if enterprises are to make the move to Industry 4.0
Challenges for Industry 4.0

Data ownership and security

• With the large quantities of data being collected and shared with partners in the value network, businesses need to be clear about who owns what industrial data and to be confident that the data they produce will not be used by competitors or collaborators in ways that they do not approve

• A single set of rules on privacy, data storage and copyright, that balances trust and data protection, is considered by some to be a necessary step to ensuring competitiveness
Challenges for Industry 4.0

Legal issues
• Advanced manufacturing also raises a variety of legal questions including employee supervision, product liability and intellectual property
  – Data from a ‘smart glove’ that guides and records the movements of workers might be used to monitor or evaluate employees
  – If an autonomous manufacturing system that links different value networks produces a defective or dangerous product, how should the courts determine who in the network is responsible?
  – If a customer requests an individualized product, who owns the intellectual property (IP) rights to the design?
Challenges for Industry 4.0

Standards

• Standards are essential to ensure the exchange of data between machines, systems and software within a networked value chain

• If data and communication protocols are proprietary or only recognized nationally, only the equipment of one company or group of companies will be compatible; competition and trade can be expected to suffer and costs rise

• Independent, commonly agreed, international standard communication protocols, data formats and interfaces can ensure interoperability across different sectors and different countries, encourage the wide adoption of Industry 4.0 technologies
Challenges for Industry 4.0

Employment and skills development

• The nature of manufacturing work has been shifting from largely manual labor to programming and control of high performance machines
• Employees with low skill levels risk becoming replaceable unless they are retrained
• Workers able to make the transition to Industry 4.0 may find greater autonomy and more interesting or less arduous work
• Employers need personnel with creativity and decision-making skills as well as technical and ICT expertise
Turkish Manufacturing Sector’s Position in the Global Value Chain

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

Even though manufacturing is the biggest component of Turkish economy...

Split of GDP of Turkey in 2014 (TL B)

- 1,555
- 1,500
- 1,000
- 500
- 0

2014

18%
16%
13%
11%
8%
5%
3%
26%

... share of import dependency of Turkish production is very high

Share of import dependency on Turkish production based exports

- 80
- 60
- 40
- 20
- 0

2008 2009 2010 2011 2012 2013

41% 38% 40% 43% 59% 62%

In parallel low share of high-tech products in exports

- Singapore: 45%
- Malaysia: 24%
- France: 23%
- Ireland: 21%
- Hungary: 20%
- UK: 16%
- Netherlands: 16%
- Czech: 15%
- Germany: 14%
- Israel: 14%
- Denmark: 13%
- Estonia: 13%
- Sweden: 12%
- Austria: 10%
- Belgium: 10%
- Romania: 10%
- Greece: 9%
- Finland: 8%
- Russia: 8%
- Croatia: 8%
- Slovakia: 7%
- Italy: 7%
- Bulgaria: 7%
- Poland: 6%
- Slovenia: 6%
- Spain: 6%
- Portugal: 4%
- Turkey: 3%
- Jordan: 2%
- Pakistan: 4%

Exports of high technology products as a % of manufactured exports in 2009-2013 (in %)
Role of Industry 4.0 for Turkey

Industry 4.0 is an imperative opportunity to break the vicious cycle of low value added production

Do nothing and enter into a vicious circle of value destruction...

- Decreased workforce quality
- Low value added production
- Lose global competitive position
- Lose global market share
- Increased unemployment

...or start investing to benefit from a virtuous circle of value creation

- High value added production
- Increased workforce and ecosystem quality
- Create new jobs
- Retain & grow global competitive position
- Reduce low skilled workforce
- 2-3% CAGR in revenue growth

Invest in Industry 4.0
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.

• The following six sectors were selected as pilots for this report:
  ✓ Automotive
  ✓ Machinery
  ✓ White appliances
  ✓ Food and Beverage
  ✓ Textile
  ✓ Chemical
## Pilot Sectors and Their Contribution to the Turkish Economy

<table>
<thead>
<tr>
<th>6 Industries</th>
<th>Share in Value-added</th>
<th>Share in Employment</th>
<th>Increase in Total Factor Productivity</th>
<th>Dev. Level ratio of exports to imports</th>
<th>Rate of exports meeting imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive</td>
<td>12%</td>
<td>6%</td>
<td>7%</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>White Appliances</td>
<td>3%</td>
<td>1%</td>
<td>9%</td>
<td>0.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Machinery</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Textile</td>
<td>8%</td>
<td>13%</td>
<td>-0.5%</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>Food &amp; Beverage</td>
<td>10%</td>
<td>12%</td>
<td>-4%</td>
<td>0.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Chemicals</td>
<td>5%</td>
<td>2%</td>
<td>1%</td>
<td>1</td>
<td>0.2</td>
</tr>
</tbody>
</table>
## Industry 4.0 Applications in Pilot Sectors:

Industry 4.0 is already in progress

<table>
<thead>
<tr>
<th>Industry 4.0 lever</th>
<th>Company</th>
<th>Examples</th>
</tr>
</thead>
</table>
| 1                 | 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 |
| 1                 | 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 |
| 2                 | Home appliances| Horizontal data integration
Enabled its suppliers to view selected ERP data to tie them closer to an integrated production process |
| 2                 | 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                 | 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                 | 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                 | 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 |
Potential Benefits of Turkey’s Industry 4.0 Transformation

<table>
<thead>
<tr>
<th>Industry</th>
<th>Gross production share Turkey</th>
<th>Productivity conversion costs</th>
<th>Productivity total manufacturing cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food &amp; Beverage</td>
<td>18%</td>
<td>9-12%</td>
<td>5-9%</td>
</tr>
<tr>
<td>Textile</td>
<td>15%</td>
<td>10-16%</td>
<td>4-9%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>12%</td>
<td>8-12%</td>
<td>3-4%</td>
</tr>
<tr>
<td>Automotive</td>
<td>6%</td>
<td>10-15%</td>
<td>5-7%</td>
</tr>
<tr>
<td>Electrical Appliances</td>
<td>5%</td>
<td>9-14%</td>
<td>6-9%</td>
</tr>
<tr>
<td>Machinery</td>
<td>4%</td>
<td>9-12%</td>
<td>4-8%</td>
</tr>
<tr>
<td>Others</td>
<td>40%</td>
<td>8-14%</td>
<td>4-7%</td>
</tr>
</tbody>
</table>

Total gross production 710B TRY

Additional productivity on conversion cost 5-15%

Total additional productivity gains 4-7% or 30-50B TRY
Potential Benefits of Turkey’s Industry 4.0 Transformation

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

• 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.

• 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).
Potential Benefits of Turkey’s Industry 4.0 Transformation

Main challenge: 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

• 20 to 30 percent effect at some value chain steps could be expected in the long-run

• Industry 4.0 will shift the required capability set of white and blue collar employees
Potential Benefits of Turkey’s Industry 4.0 Transformation

- 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, lower-skilled employment needs will decline, leading to a loss of 400,000 to 500,000 jobs.
- The need for high-skilled employment, coupled with the additional growth stimulated, will create a total of 400,000 to 500,000 jobs.
- 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.
The Real Challenge: High Skilled Labor Force

Absolute development of employees

2–3% CAGR of revenue growth is expected from the Industry 4.0 based transformation and enough to create additional jobs.

- New types of additional jobs to manage the technologies
- New technologies to lead to productivity-related job losses
- Increased pool of employment due to higher growth

Employees 2015: 3600
Industry 4.0 efficiency: 400-500
Industry 4.0 requirements: 80-100
Workforce to lead revenue growth: 3200-3300
Employees 2025: 3600-3800

10 years trajectory
Potential Productivity Increase in Textile Sector

Textile: Potential productivity increase of 10–16%

<table>
<thead>
<tr>
<th>Top 3 I4.0 Pillars</th>
<th>Description</th>
<th>Quantification</th>
</tr>
</thead>
</table>
| I                  | **Lever:** Advanced simulation and vertical integration  
|                    | **Measure:** Advanced simulation for prototyping and testing and vertical integration of R&D and design units/suppliers, to innovate new premium products  
|                    | **Result:** High value-add product portfolio. Reduced wastage increased capacity utilization |
|                    | ![Image](image1.png)  
|                    | Material costs  
|                    | ![Image](image2.png)  
|                    | Labor costs  
|                    | ![Image](image3.png)  
|                    | Amortization  
|                    | ![Image](image4.png)  
|                    | Overhead  
|                    | ![Image](image5.png)  
|                    | **Increase in productivity**  
|                    | ![Image](image6.png)  
|                    | **4–9% of total costs**  
|                    | ![Image](image7.png)  
|                    | **10–16% of conversion cost**  

Productivity increase of 4–9% possible in total costs

Source: BCG analysis, expert interviews
## Potential Productivity Increase in Automotive Sector

### Automotive: Potential productivity increase of 10–15%

<table>
<thead>
<tr>
<th>Top 3 L4.0 Pillars</th>
<th>Description</th>
<th>Quantification</th>
</tr>
</thead>
</table>
| **I** | Autonomous Robots | **Lever:** Flexibilization/ automation of assembly lines  
**Measure:** Advanced automation of assembly lines and vertical integration of process and production systems  
**Result:** Improved traceability; i.e., real-time performance monitoring, preventive quality control and efficient trend management |  
Material costs: 100% ↓ 96% ↓ 98% ↓ -3%  
Labor costs: 100% ↓ 65% ↓ 75% ↓ -30%  
Amortization: 100% ↓ 105% ↓ 115% ↓ -10% |
| **II** | Big Data / Analytics | **Lever:** Horizontal data integration w. design suppliers  
**Measure:** Horizontal data integration with design co-workspace. Advanced analytics of big data collected from production lines  
**Result:** Error proof precision in product design. Less wastage due to improved FTT¹ and FRC². Less dependence on control units |  |
| **III** | Simulation | **Lever:** Smart warehouse and intralogistics solutions  
**Measure:** Architectural layout simulation and automated commissioning systems via AGV/LGVs  
**Result:** Stronger working capital due to reduced inventory cycles. Shorter lead time via reduced intra-logistics |  |

**Productivity increase of 5–7% possible in total costs**
Policy Measures in Tenth Development Plan

The Tenth Development Plan (2014-2018) identifies four strategic pillars:

1. qualified people, strong society;
2. innovative production, stable and high growth;
3. livable places, sustainable environment;
4. international cooperation for development
Latest Policy Decree from Supreme Council of Science and Technology (Decree 2016/101, February 2016)

Transition of Turkish industry for increasing international competitiveness in technology production:

- Developing an **implementation and monitoring model** for smart manufacturing in coordination with all stakeholders

- Increasing **goal-oriented R&D efforts in critical and pioneering technology areas** (cyber-physical systems, AI/sensor/robotics, IoT, big data, cyber security, cloud techs, etc.)

- Designing **support mechanisms for manufacturing infrastructures** to develop critical and pioneering technologies
TUBITAK’s Call Topics in Industry 4.0: 2016-17

Advanced Manufacturing Technologies
- Multilayer additive manufacturing
- Rapid prototyping and 3D printing technologies
- CAD/CAM, simulation & modeling software
- Robotics and mechatronics
- Flexible manufacturing

Internet of Things
- Sensors and sensing systems
- Virtualization
- M2M communication
- Cloud computing