THE FOURTH INDUSTRIAL REVOLUTION

EE482 Industrialization: Role of Public and Private Sectors
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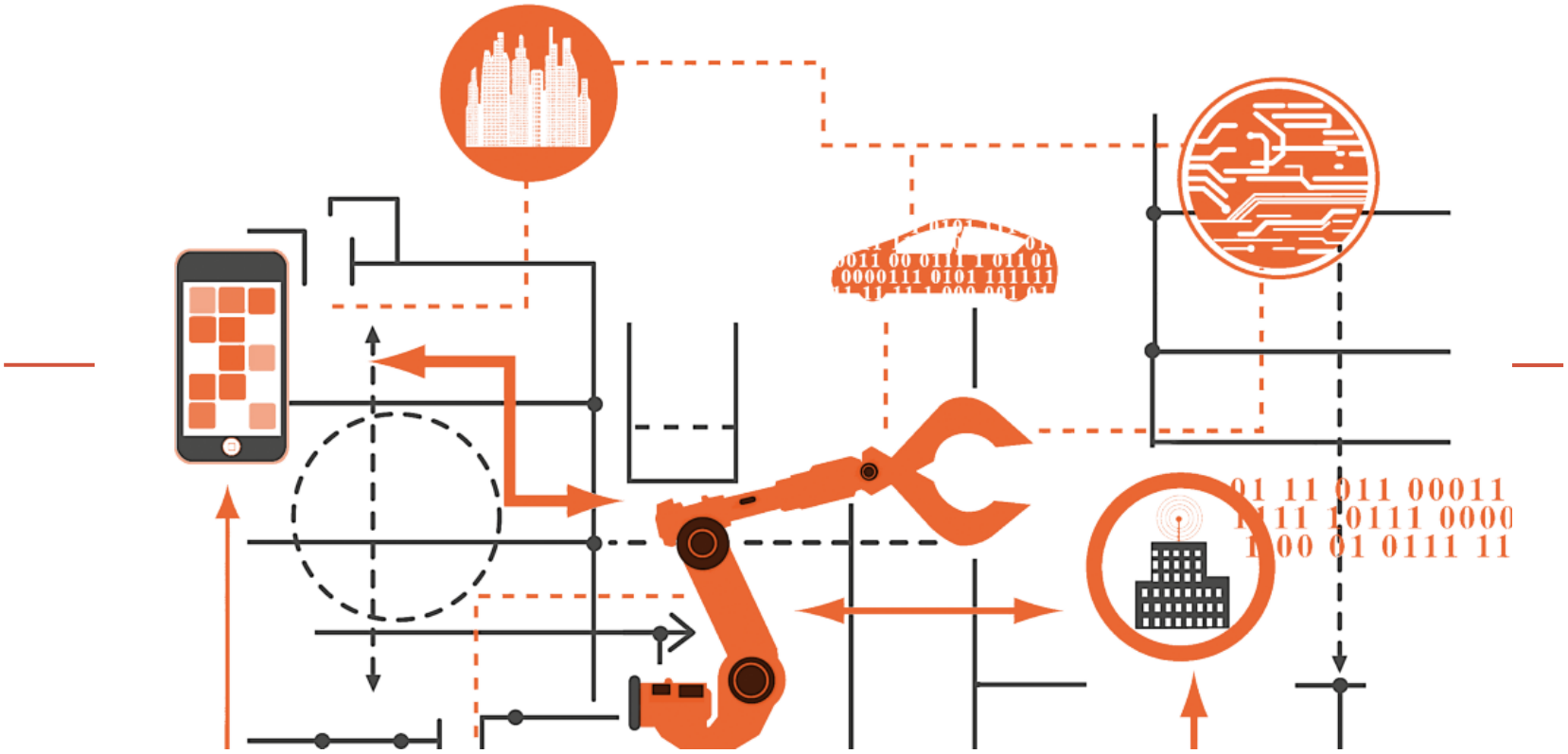
Faculty of Economics, Thammasat University

The Fourth Industrial Revolution

Things to Tighten the Link Between IT and OT



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The Fourth Industrial Revolution

- From 2000 onward, the world has changed radically in a few major steps.
- Moreover, new developments are occurring increasingly rapidly.
- **Social networks, Mobile platforms and apps, advanced Analytics and Big Data, Cloud** and the artificial intelligence of **IBM's Watson**: taken together, these form **SMAC**.
- Now our **Things** are coming to the fore, forming **SMACT** (“smacked”) in a glorious breakthrough.
- Innovation always takes a little longer than anticipated, but miniaturization, cheap sensors, smartphones in the pockets of billions of people, autonomous systems, better batteries, self-steering cars and smart software in the Cloud leave little room for doubt: **SMACT** is already an established Things: Internet of business opportunities was the first reconnaissance.

Source: Bloem et al. (2014)

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- According to the roadmap report of the European Union on the future of the industry, **a new production paradigm** is arising with the advent of **cyber-physical Internet-based systems** to offer innovative capacities that can benefit industry and other economic sectors.
- The leading paradigm is **m2m**: **machine-to-machine communication**, **not only** between **machines in factories** but also between **all conceivable devices and systems**.

Source: Bloem et al. (2014)

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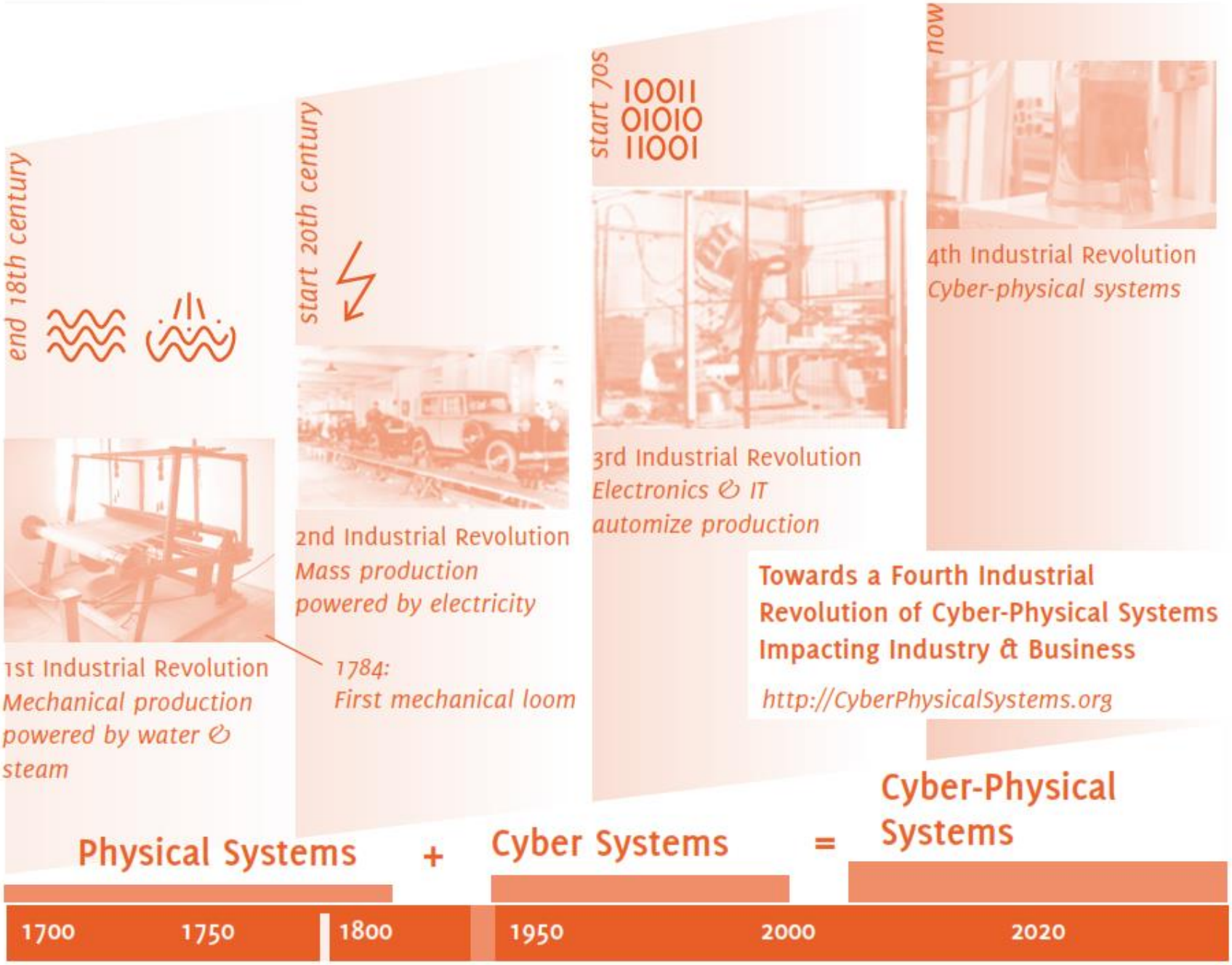
- In this context, one can think of **fleet management** on the basis of **sim cards**, **sensors** and **GPS**.
- The original idea behind the **Industrial Internet**, a term first coined by **General Electric**, is that digital technology will ultimately be **added to and all devices**.
- With more **sensors** in the **engines of planes** and **trains**, GE wishes to make aviation, railway services and healthcare **more efficient and effective.**

Source: Bloem et al. (2014)



Source: Bloem et al. (2014)

The Fourth Industrial Revolution

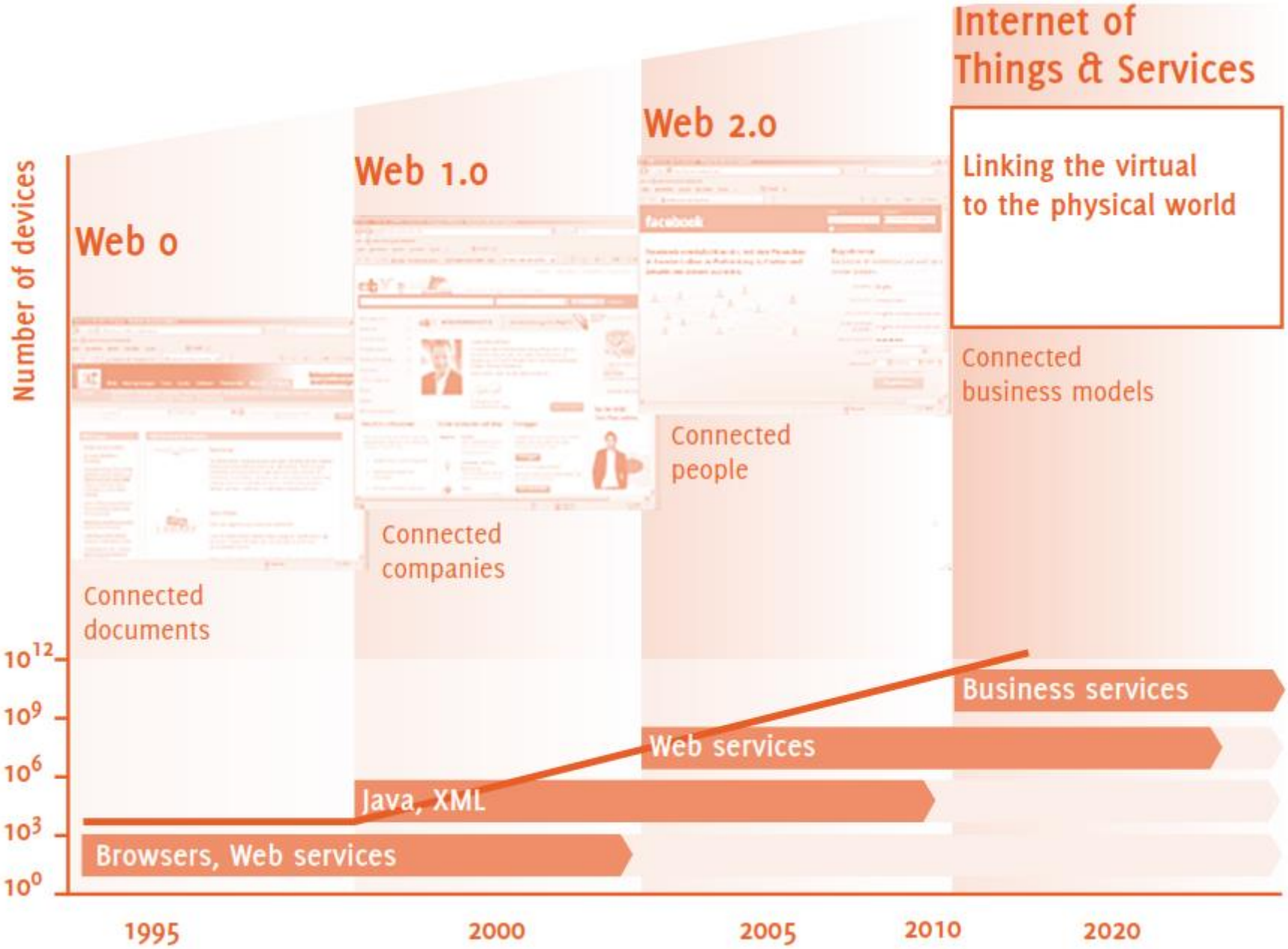
- **The Industrial Revolution** is a concept and a development that has fundamentally **changed our society and economy**.
- The term “development” may seem to indicate some tardiness in the context of a “revolution, ” which really signifies a rapid and fundamental change.
- Industries arose and replaced small-scale workshops and craft studios.
- Textile and pottery factories were the first to recognize the new dawn, and a **new infrastructure** of canals and railway lines enabled **efficient distribution**.
- It was the **transition from industrious to industrial**, and the start of a boom for both.

Source: Bloem et al. (2014)

The Fourth Industrial Revolution

- From the **first mechanical loom**, dating from 1784, exactly 230 years ago, we can **distinguish four stages** in the ongoing process called the **Industrial Revolution**.
- That is the way we currently look at it.
- **The first "acceleration"** occurred toward the end of the 18th century: **mechanical production** on the basis of water and steam.
- We place the **Second Industrial Revolution** at the beginning of the 20th century: the introduction of the conveyor **belt and mass production**, to which the names of icons such as Henry Ford and Frederick Taylor are linked.
- **Number three** is **the digital automation** of production by means of electronics.

Source: Bloem et al. (2014)



Source: Bloem et al. (2014)

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- At present, we find ourselves at the **beginning of this fourth stage**, which is characterized by so-called **“Cyber-Physical Systems” (CPS)**.
- These systems are a consequence of the far-reaching **integration of production**, sustainability and **customer-satisfaction** forming the basis of intelligent network systems and processes.
- **Factory floors** are already teeming with **Internet “things”.**
- But the enormous Internet acceleration of industry comes from the **explosive growth** of **digital devices** from other disciplines.
- Video cameras, RFID readers, tablets, entrance tickets, etc. – all these kinds of Internet devices improve the **quality**, **efficiency** and **security** of **production and process** operations.

Source: Bloem et al. (2014)

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- It is becoming easier to **connect appliances, machines, things, complete factories** and other industrial environments and processes to the Internet.
- The **Industrial IP Advantage consortium** (http://www.industrial-ip.org), established in 2013, is seriously engaged in this domain of expertise.
- Industrial IP aims to enable all **industrial network infrastructures** and applications to benefit from **end-to-end Internet connectivity**.
- In addition to ethernet connected to **Industrial IP**, there is also the **Common Industrial Protocol (CIP)**, which is geared to unified communications.

Source: Bloem et al. (2014)

The Fourth Industrial Revolution

- The **Internet of Things & Services** is responsible for **stage 4**, which is currently beginning to take shape.
- New business services are now being developed on the basis of their **capacity to link the physical and virtual worlds**.
- A marriage is a more romantic depiction, and particularly between Operational Technology – ranging from engines roaring, to people being transported to bread being baked – and Information Technology that supports our business processes.

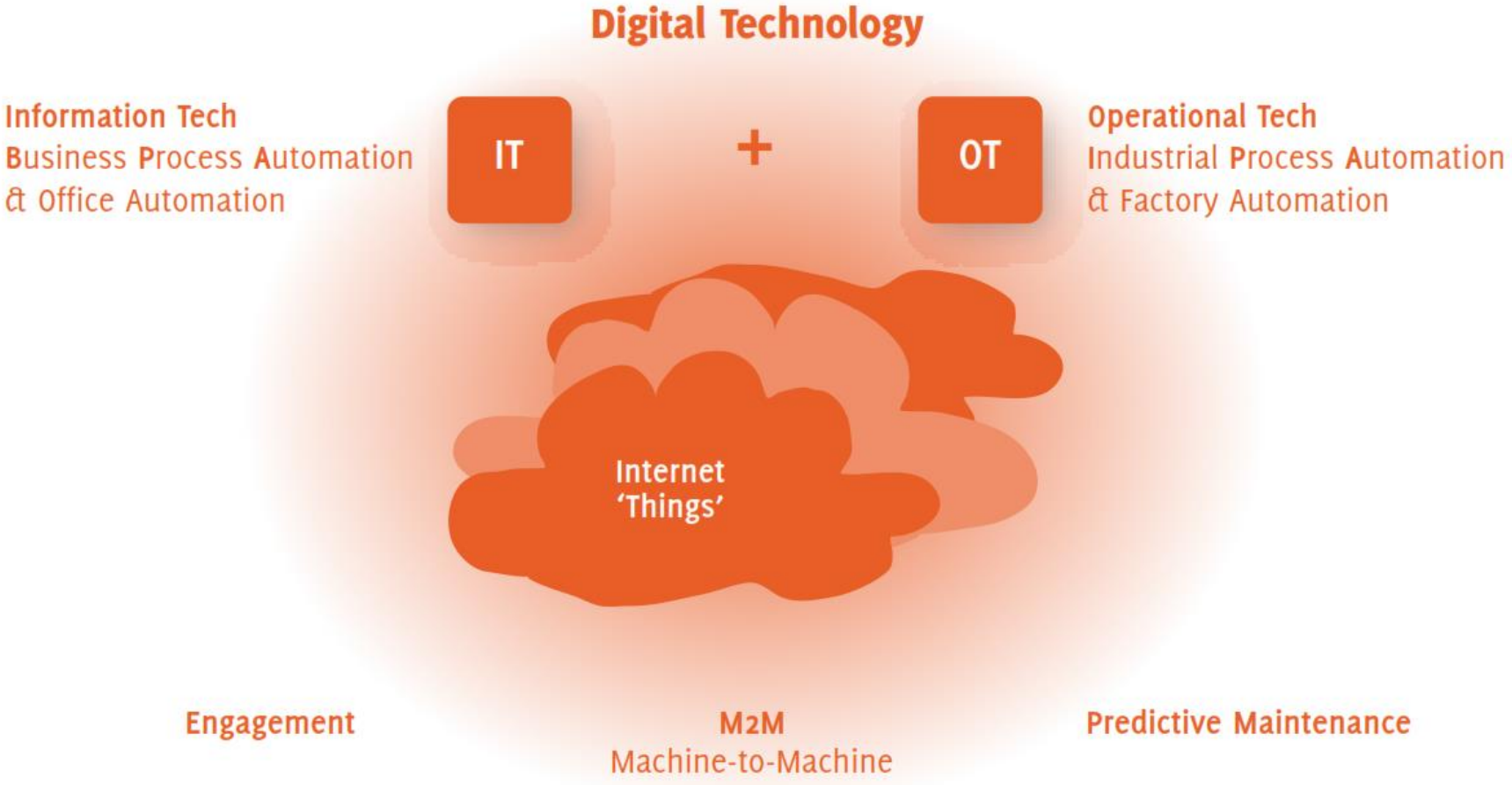
Source: Bloem et al. (2014)

The Fourth Industrial Revolution

- The greatest value of Industrial IP is the possibility it provides to process and analyze significantly **larger information flows** from **production and auxiliary processes**, so that companies can operate in a more flexible and innovative way.
- Despite all the benefits of the Internet, there are still plenty of separate application networks active in the world of Industrial Automation.
- Keeping special networks up, 3 including the hardware needed to enable them to communicate with Internet, costs much time, money and manpower.
- And these three costs increase – along with the complexity of the complete network – as more Internet devices enter the industrial arena.
- A single system – the Internet – seems to be preferable in this context, certainly from a viewpoint of scalability and flexibility.

Source: Bloem et al. (2014)

IT and OT converge



Source: Bloem et al. (2014)

IT and OT converge

- The **Internet of Things** plays a **crucial role** in this development.
- As a matchmaker between **information technology (IT)** and **operational technology (OT),** the IoT has capacities at its disposal that appeal to both partners.
- The **operational machine world** is becoming more human due to **“things**”.
- Moreover, **sensors** are more entrenched in that field.
- But, thanks to these “things,” the it world is becoming **more integrated in the domain of operations**.
- And the opportunities to add value “where the action is” are simply there for the taking: in everyday interaction with appliances and physical products.

Source: Bloem et al. (2014)

IT and OT converge

- This is the amalgamation of **two independent, historical, economical developments** – that of **advanced information technology**, with predictive data analytics, smart-phones and traditional administrative automation, among other things – and that of the **impressive machinery and automation** that have been designed and developed since the start of the industrial revolution.
- In Gartner's definition, **OT** stands for the following:
- **“Operational Technology” (OT)** is hardware and software that **detects or causes a change** through the direct **monitoring and/or control of physical devices**, processes and events in the enterprise. ”

Source: Bloem et al. (2014)

Triple profit

- Industry has **three main reasons** to add networked software to machines and products in the classical industry division of design, production, and product support and services (particularly Maintenance, Repair and Overhaul).
- Networked software, added to products and machines, makes it possible to **gain important benefit** in the fields of:

  (1) **Machine-to-Machine communication**, so that human work can be reduced and important contributions to efficiency and security can be made.

  (2) **Maintenance**, preferably Predictive Maintenance of machines and appliances on the basis of direct status reports and possibly also remote repairs.

  (3) **Engagement or client interaction** via the use of products by consumers or professionals.

Source: Bloem et al. (2014)

1. Machine-to-Machine communication

- **Machine-to-Machine communication** can bring much extra efficiency and extra security in production units ranging from factory halls to cattle stalls.
- Modern m2m applications use **microelectronics and wireless technology**, by means of which embedded **appliances gather and distribute realtime data**.
- In this way, **tens of billions of connections** soon can be accessed at will.
- An m2m system makes use of **sensors and meters** to **communicate "events"** – ranging from temperature, via a communications network (fixed, wireless or hybrid), to application software that **converts the raw data into meaningful information**.
- **Telecom companies** in particular recognize the opportunity to **expand their services** and to **gain access to their clients'** operational aspects.

Source: Bloem et al. (2014)

2. Maintenance and upgrades

- Preferably in the ultimate form of **Predictive Maintenance**, bring **extra reliability and speed** to numerous appliances: from **networked espresso machines** to **sensors in engines and turbines**.
- IBM is one of the firms now capitalizing on this development, through advanced analytics that enable them to take the proper decisions.
- This development is currently being applied to enhance **excavation machinery** in **the mining industry**, for example, which represents an annual market of 5 trillion dollars.

Source: Bloem et al. (2014)

2. Maintenance and upgrades

- To companies such as Thiess, which manages and hires out 700 models of mining equipment, a day's outage means a loss of 1.8 million dollars.
- Nowadays, **sensors** send all kinds of **user data** via the Internet to central systems.
- This data sharing provides around **10% productivity profit**, according to calculations by IBM, because timely interventions can be made.
- The aim is to realize zero unplanned downtime and peak productivity, by progressing from **Corrective Maintenance** (repairs) to **Predictive Maintenance**, so that significantly less downtime is necessary and no bottlenecks or defects, resulting in irreparable damage to the systems, can occur.

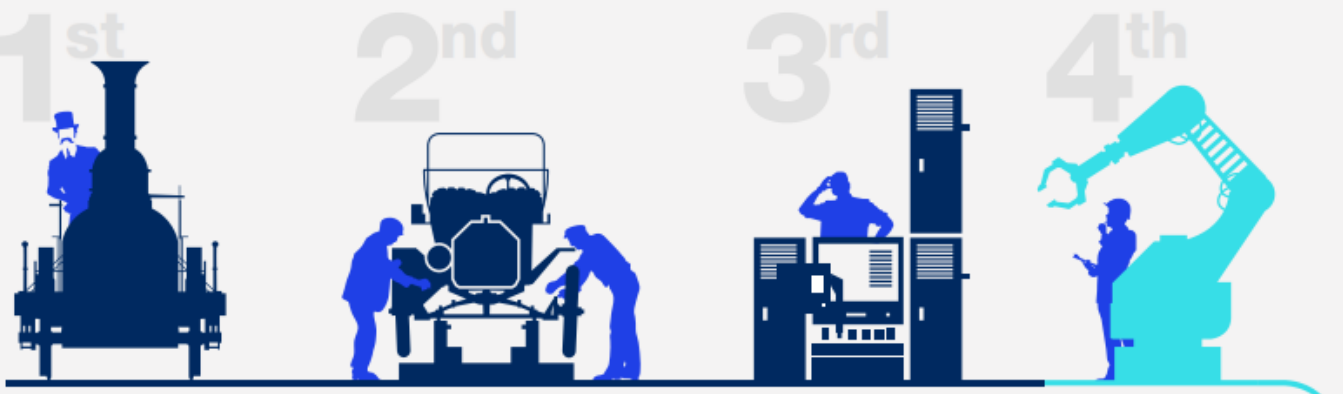
Source: Bloem et al. (2014)

3. Engagement

- With **engagement**, or **customer interaction**, we can share, via all kinds of domestic appliances – refrigerators, toothbrushes, televisions, vacuum cleaners – **user data** in order to **create new value** and to shape service provisioning.
- The **client** can be the **professional worker** who always has to be **completely up to date in his operations**, and prefers to be supported by modern screen devices or Google Glass-like portable aids.
- But this applies equally to the **end user** who would much appreciate **improved service** in the facilities he wishes to use, such as a combination of data from the traveler's digital train ticket (IT) and rail traffic (OT).

Source: Bloem et al. (2014)

In the fourth industrial revolution, digital analytics enables a new level of operational productivity.



Maturation of new cyber physical technologies (artificial intelligence, 3-D printing, robotics)

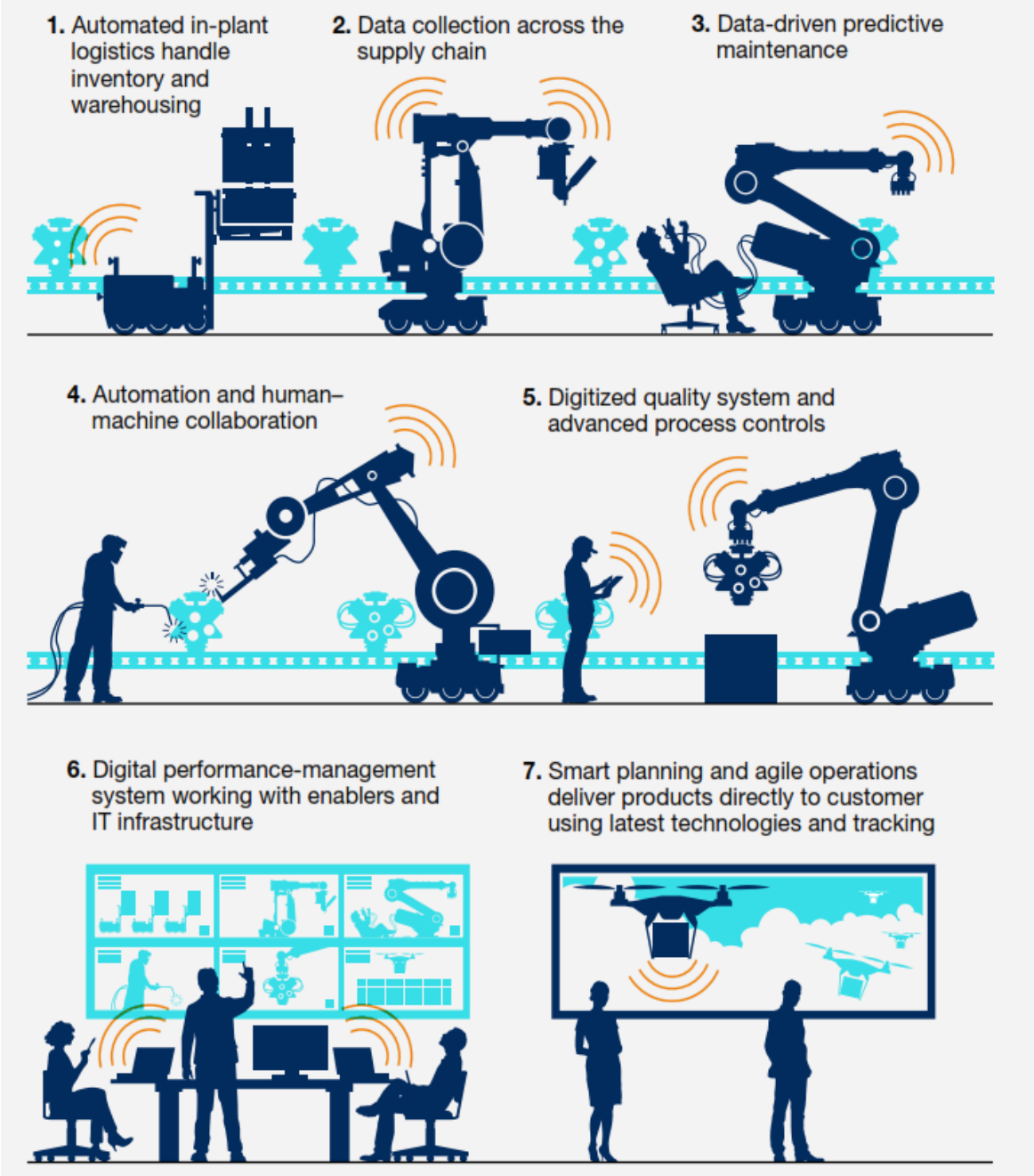
Data analytics driving efficacy and new business models

Pervasive sensing and actuation

Ubiquitous connectivity throughout the supply chain

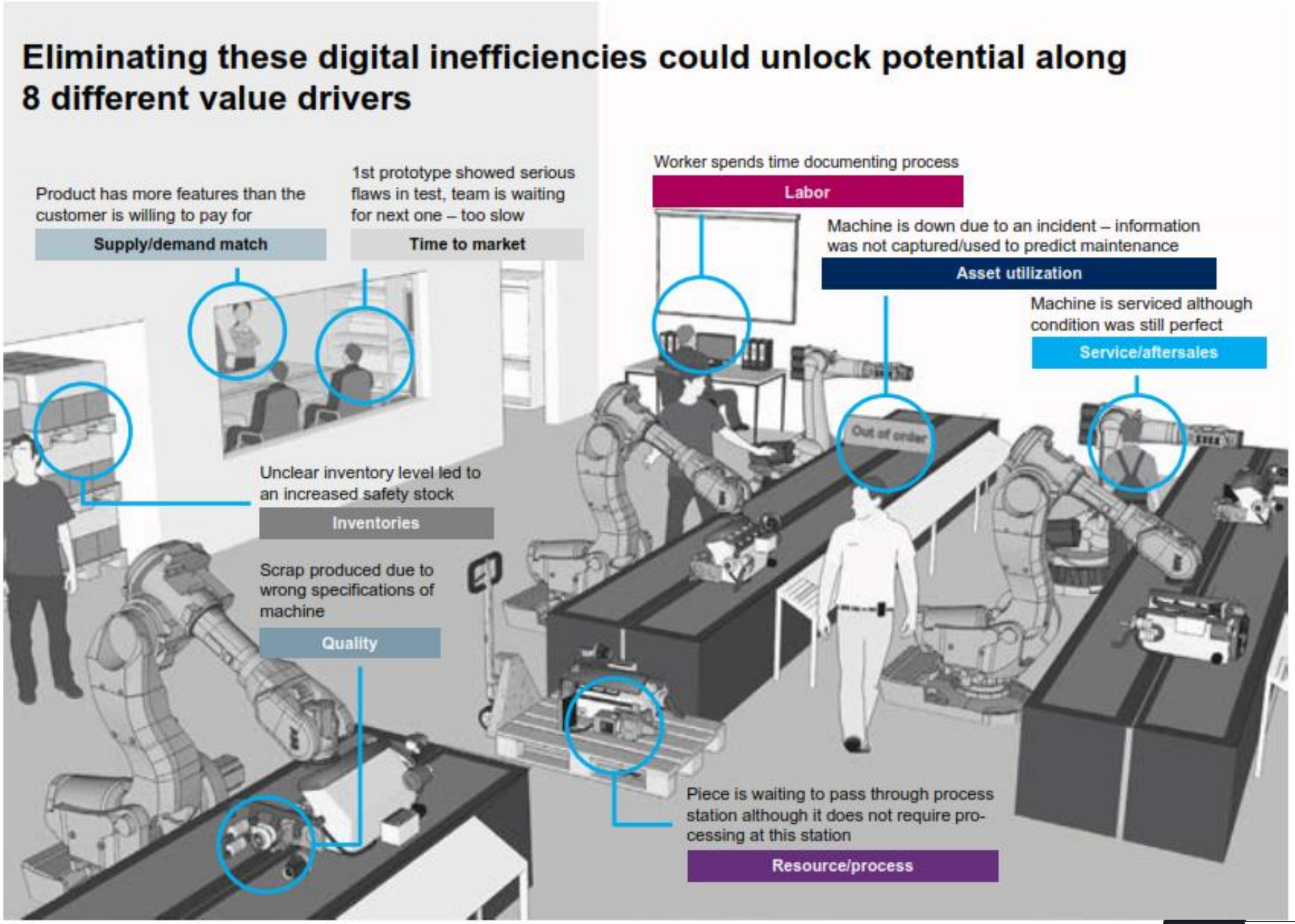
Unprecedented levels of data and increased computing powers

Source: McKinsey. (2018). Analytics Comes of Age.



Source: McKinsey. (2018). Analytics Comes of Age.

Eliminating these digital inefficiencies could unlock potential along 8 different value drivers

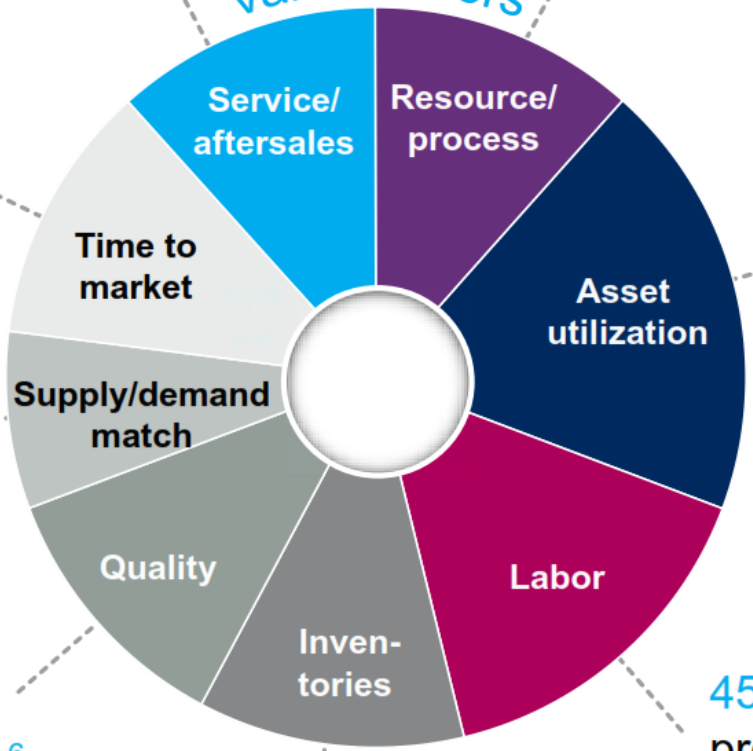


Source: McKinsey. (2015). Industry 4.0: How to navigate digitization of the manufacturing sector

Indicative quantification of value drivers

10 - 40% reduction of maintenance costs[1]

Productivity increase by 3 - 5%[5]



20 - 50% reduction in time to market[1]

30 - 50% reduction of total machine downtime[2]

Forecasting accuracy increased to 85+%[3]

Costs for quality reduced by 10 - 20%[6]

45 - 55% increase of productivity in technical professions through auto- mation of knowledge work[4]

Costs for inventory holding decreased by 20 - 50%[3]

1 Cf. McKinsey Global Institute: Big data: The next frontier for innovation, competition, and productivity 2 McKinsey analysis
3 McKinsey analysis 4 Cf. McKinsey Global Institute: Disruptive Technologies 5 See, for example, ABB case study
6 Cf. T. Bauernhansl, M. ten Hompel, B. Vogel-Heuser (Hrsg.): Industrie 4.0 in Produktion/Automatisierung/Logistik (2014)

Source: McKinsey. (2015). Industry 4.0: How to navigate digitization of the manufacturing sector