Industry 4.0:
The Fourth Revolution

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Historical Context

➢ Revolution: instantaneous and complete shift

➢ First Shift: from foraging to farming (10,000 years ago)

   ➢ Results: production, transportation, communication

   ➢ Growth in food production, prodding of population growth

➢ Industrial Revolution

   ➢ Developments of new technologies and new approaches

   ➢ Prompts shifts in economic models and social architecture

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Historical Context

➢ First Industrial Revolution

    ➢ During 1760 – 1840

    ➢ Driver: invention of steam engine and construction of railway stimulated the revolution

    ➢ Results: utilization of machines in production

➢ Second Industrial Revolution

    ➢ During the transition from 19th century to 20th century

    ➢ Driver: electricity and assembly line trigged the revolution

    ➢ Results: mass production

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Historical Context

- Third Industrial Revolution
  - Prompted in 1960s
  - Computer or Digital Revolution
  - Driver: production of semiconductor trigged the revolution
  - Results: mainframe, personal computer, and internet

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Fourth Industrial Revolution

➢ Stimulated in 21st century

➢ Proposed to uplift German economy*

➢ Digital Revolution triggered the revolution

➢ Extensive use of ubiquitous and mobile internet

➢ During the revolution, sensors become cheaper, reduced in size, powerful

➢ Extensive use of Artificial Intelligence, Machine Learning, Cyber Physical System (CPS)

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.
Source *: Lu, Y., 2017. Industry 4.0: A survey on technologies, applications and open research issues. Journal of Industrial Information Integration, 6, pp.1-10.

Fourth Industrial Revolution

➤ Computers have become more sophisticated and integrated

  ➤ Results: radical transformation of societies and global economies

➤ Fourth Industrial Revolution is coined as "The second Machine Age"* by Prof. Erik Brynjolfsson, MIT and Andrew McAfee, MIT

➤ Industry 4.0, another synonym of Fourth Industrial Revolution, is coined by Hannover Fair in 2011.

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.
Source *: Brynjolfsson, E. and McAfee, A., 2014. The second machine age: Work, progress, and prosperity in a time of brilliant technologies. WW Norton & Company

Fourth Revolution

➢ Scope of Fourth Revolution:
- ➢ Smart Connected Machines
- ➢ Smart Factories
- ➢ Gene Sequencing
- ➢ Nanotechnology
- ➢ Renewables
- ➢ Quantum Computing

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Profound and Systematic Change

➢ The <u>scale and scope of innovation</u> of Fourth Industrial Revolution defines today's acute <u>disruption</u> and <u>innovation</u>

➢ Airbnb, Uber, Alibaba, etc., disruptors of today, are relatively new

➢ Ubiquitous <u>iPhone</u> launched in 2007 →Billions of smart phones are being <u>mass produced</u> currently

➢ Google announced <u>fully autonomous car</u> in 2010 → <u>AI-based self navigating cars</u> are on the way

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Profound and Systematic Change

➢ Not only the <u>speed of profound change</u>, but <u>scale of profound change</u> is equally staggering

➢ Example *:

  ➢ In 1990, industry giants in Detroit had a combined market of $36 billion capitalization, $250 billion revenues, 1.2 million employee

  ➢ In 2014, industry giants in Silicon Valley had a combined market of $1.09 trillion capitalization, $247 billion revenues, 1,37,000 employee

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.
Source *: Manyika, J. and Chui, M., 2014. Digital era brings hyperscale challenges. Financial Times, 13.

Profound and Systematic Change

➢ With marginal costs, <u>digital business</u> creates unit of today's wealth with fewer workers

➢ Business, providing <u>information goods</u>, has virtually zero transportation and replication cost

➢ In the context of Industry 4.0, Instagram, WhatsApp, etc. do not require much capital to begin with, but it changes the role of capital and scaling business

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Profound and Systematic Change

➢ In the context of Fourth Industrial Revolution

   ➢ <u>Digital fabrication</u> technologies are able to communicate with <u>biological world</u>

   ➢ Designers and architects are, now, combining

      ➢ Computational design

      ➢ Additive manufacturing

      ➢ Material engineering

      ➢ Synthetic biology

   ➢ Results: producing objects that are mutable and adaptable

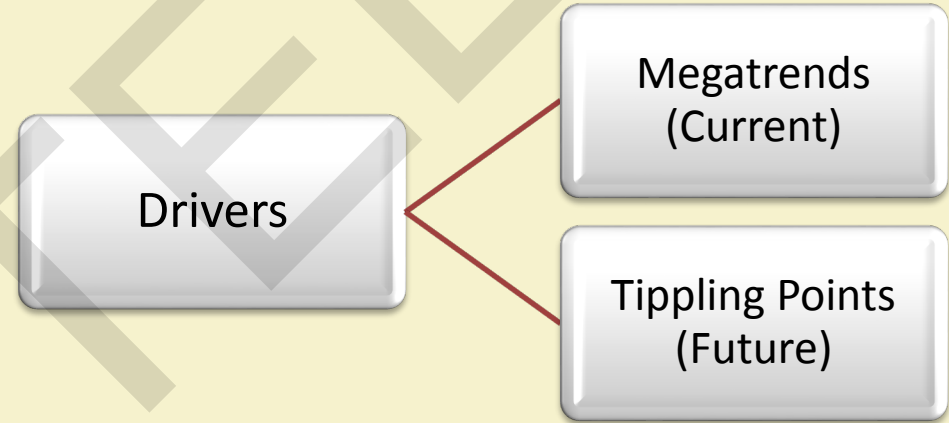Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Profound and Systematic Change

➢ In context of Fourth Industrial Revolution

   ➢ Use of AI

      ➢ Self driving car

      ➢ Virtual assessment

      ➢ Transitional software

      ➢ Discover new drugs

      ➢ Prediction of cultural Interest

   ➢ Application of Siri in Apple is one of the examples of strength of AI (Voice Search) – Also, Cortana for Windows.

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.
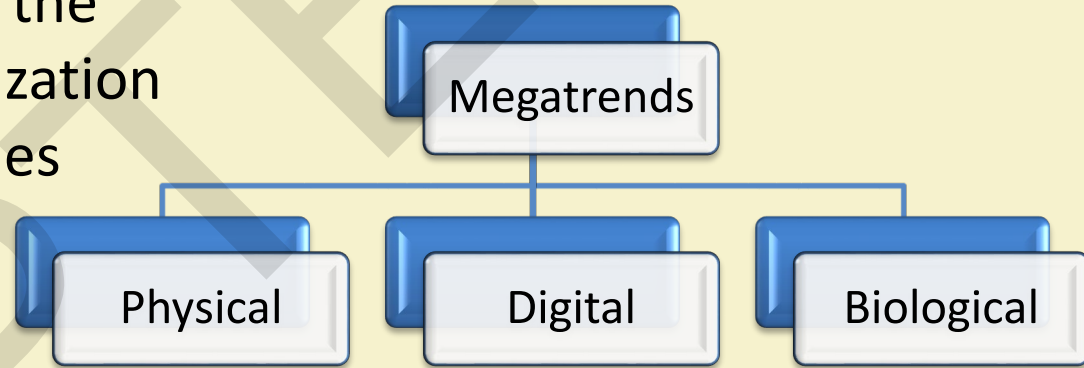
Drivers

➢ Various aspects that drive the fourth industrial revolution

  ➢ Scientific Breakthroughs
  ➢ New Technologies

Drivers

Megatrends (Current)

Tippling Points (Future)

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.
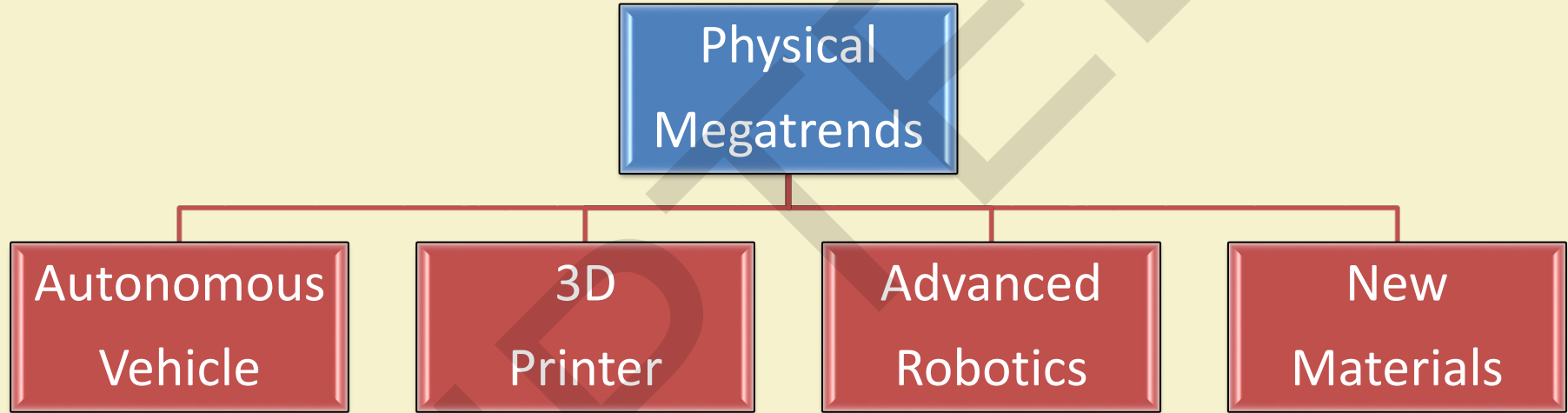
Megatrends

> All recent technologies and development that leverage the pervasive potential of digitization and information technologies

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.
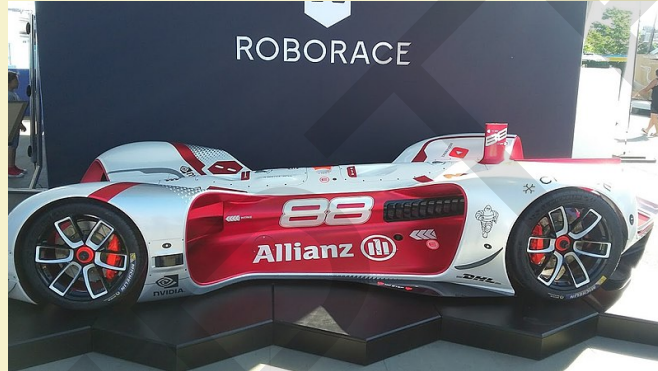
Physical Megatrends

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                    ┌──────────────────┐
                    │     Physical     │
                    │    Megatrends    │
                    └──────────────────┘
         ┌──────────────┬─────────┴────────┬──────────────┐
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│  Autonomous  │ │      3D      │ │   Advanced   │ │     New      │
│   Vehicle    │ │   Printer    │ │   Robotics   │ │  Materials   │
└──────────────┘ └──────────────┘ └──────────────┘ └──────────────┘
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Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Autonomous Vehicle

➢ Driver-less vehicles

    ➢ Trucks

    ➢ Drones

    ➢ Aircrafts

    ➢ Boats

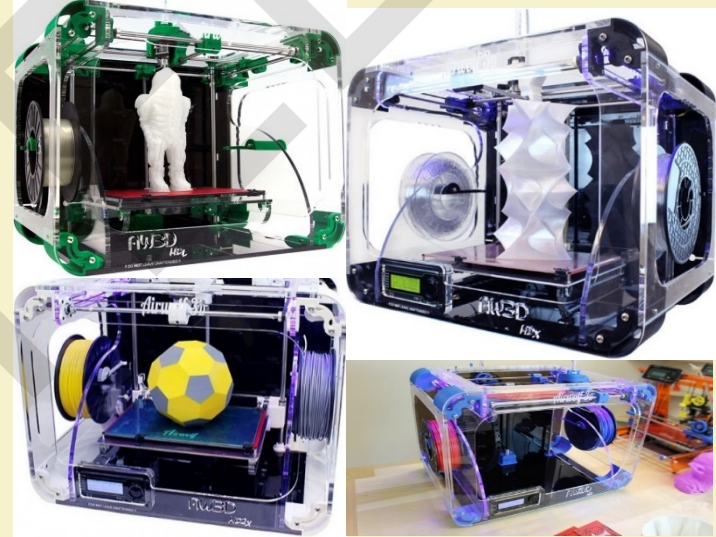Source: Wikipedia, By Dllu, Published: Nov 19, 2017, Online: https://en.wikipedia.org/wiki/Autonomous_car

Source: Wikipedia, By Bcschneider, Published: Jul 16, 2017, Online: https://en.wikipedia.org/wiki/Autonomous_car

3D Printers

➢ Manifesting physical objects based on digital specifications

➢ Application

   ➢ Wind Turbines

   ➢ Medical Implants

Source: Wikipedia, By Tyler Caros, Published: Feb 20, 2015, Online: https://en.wikipedia.org/wiki/Airwolf_3D
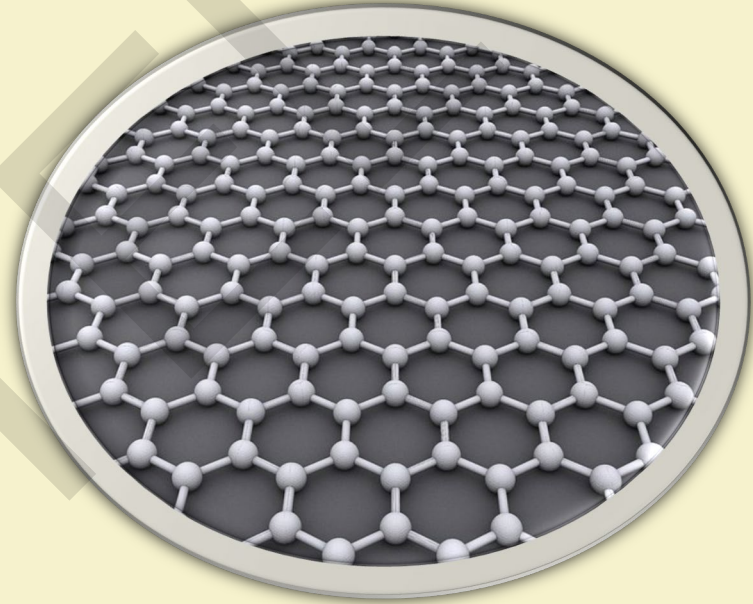
Advanced Robotics

➢ Conventional application of robots: <u>automotive</u>

➢ Recently, robotics are used from precision <u>agriculture</u> to <u>nursing</u>

Source: Wikipedia, By BMW Werk Leipzig, Published: Jul 19, 2005, Online: https://en.wikipedia.org/wiki/Smart_manufacturing

New Materials

➢ Lighter, stronger, recyclable and adaptive

➢ Example: Thermoset plastics, Graphene

Source: Wikipedia, By AlexanderAlUS, Published: Aug 26, 2010, Online: https://en.wikipedia.org/wiki/Graphene

Digital

➢ Internet of Things (IoT)

➢ Application of IoT in Industry

  ➢ RFID

  ➢ Tracking of package delivery

  ➢ Complex supply chain

  ➢ Monitoring systems

➢ Bitcoin (digital currency) and Blockchain (securing bank/government transactions)

➢ Uber model for transportation (car pooling etc.)

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Biological

➢ Genetic sequencing

➢ DNA writing

➢ Recommender system (IBM Watson)

➢ Cell Modification

➢ Genetic Engineering (CRISPER)

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

Tipping Points

➢ Tipping points represent the <u>radical changes</u> in that are required in near future

➢ Probable tipping points in 2025

    ➢ Clothes connected to the internet

    ➢ Unlimited and free storage

    ➢ 1 trillion sensors connected to the internet

    ➢ Robotic pharmacist, etc.

Source: Schwab, K., 2017. The fourth industrial revolution. Crown Business.

References

[1] Schwab, K., 2017. The fourth industrial revolution. Crown Business.

[2] Lu, Y., 2017. Industry 4.0: A survey on technologies, applications and open research issues. Journal of Industrial Information Integration, 6, pp.1-10.

[3] Brynjolfsson, E. and McAfee, A., 2014. The second machine age: Work, progress, and prosperity in a time of brilliant technologies. WW Norton & Company.

[4] Manyika, J. and Chui, M., 2014. Digital era brings hyperscale challenges. Financial Times, 13.

[5] Isaiah, D., 2015. Automotive grade graphene. The clock is ticking. Automotive World, 26.

[6] Laskow, S., 2014. The Strongest, Most Expensive Material on Earth. The Atlantic, 23.

Thank You!!

Industry 4.0:
Sustainability Assessment of Manufacturing Industry

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Introduction to Sustainable Industry

➢ Sustainability: means to continue at a fixed rate*

➢ Sustainable Industry provides**:

  ➢ Energy efficiency

  ➢ Conservation of resource

  ➢ Low-waste production

➢ Example: Sustainable Manufacturing Industries

Source*: "Google Defination"
Source **:" Wikipedia"

Sustainability in Industry 4.0

➢ Industry 4.0 proposes inclusion of the characteristics of the <u>previous industry revolution</u> in more <u>sustainable</u> way.

➢ Industry 4.0 or the fourth industrial revolution

    ➢ A <u>comprehensive industrial revolution</u>

    ➢ It incorporates <u>globalization and emerging issues</u>.

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer
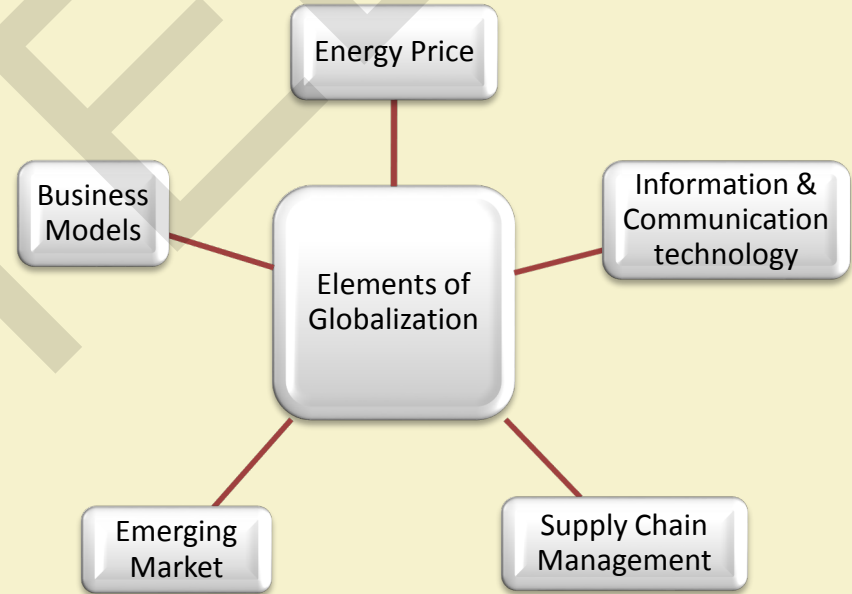
Sustainability Assessment

➢ Manufacturing industry is considered as

  ➢ Base of modern industrialized society

  ➢ Corner stone of world economy

➢ Strong manufacturing base stimulates other aspects of the economy of any country

➢ Evaluation of S/SD or sustainability assessment of manufacturing industry in Industry 4.0 incorporates evaluation of relevant issues and performance metrics

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

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Industry 4.0 and Industrial Internet of Things

Introduction to Globalization Issues

➢ Globalization is one of the drivers of sustainable industries

➢ Globalization issues affect the sustainability of any development/ manufacturing

➢ These issues are one of the most fundamental requirements

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Supply Chain Management (SCM)

➢ Strategic function in manufacturing industry

  ➢ Many different <u>stages</u> including supplier, production system, and customer

  ➢ <u>Sequencing the stages</u> for the whole system

➢ The most important stage in SCM is selection for <u>outsourcing components/parts or raw material</u>

➢ SCM must have <u>environmental concerns</u>: Climate change, contamination and resource consumption

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Information and Communication Technology (ICT)

➢ Main <u>nervous system</u> of any manufacturing industry

    ➢ In absence of ICT, no communication within the enterprise

➢ <u>Share information</u> between customer, producer, and supplier

➢ Examples of ICT

    ➢ Enterprise Resource Planning (ERP)

    ➢ Wireless Communication Technology

    ➢ Global Positioning System (GPS)

    ➢ Radio Frequency Identification (RFID) system

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Energy Prices

Energy → Created → Transferred → Transformed → Consumed

- ➤ For enterprise, <u>less energy consumption</u> brings significant economic advantages
- ➤ Main issues: Energy supply at reasonable price
- ➤ <u>Increase in energy price affects sustainability</u>
- ➤ <u>Reduction in energy consumption</u> form non-renewable sources and increase in <u>energy consumption form renewable</u> will have significant positive effect in sustainability.

Emerging Markets

| Dictatorship Period | → Emerging Market → | Free market and Free Economy |

➢ Markets: able to meet the standards of newly developed, innovative product

➢ Issue: difficult to identify all of the world's emerging markets

➢ Emerging markets are expected to be found in developing countries

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Business Models

➤ **Mass Customization:** incorporates the knowledge including <u>international and local cultures</u>

➤ Business Models ≅ Mass Customization

➤ Business Model:

  ➤ <u>Strategic approach</u>

  ➤ Maximizing economic <u>profits</u> for an enterprises

  ➤ Taking into account <u>competitive benefits</u>, <u>promoting product</u> value

Source Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer

Introduction to Emerging Issues

➢ **Emerging Issues:** changes in manufacturing industries based on the world-wide aggressive competition

➢ Major aspects in case of <u>sustainable development</u> in designing manufacturing industry.

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Technology

➢ One of the important issues in sustainability.

➢ Advancement in technology facilitates manufacturing with

  ➢ High <u>quality</u> products

  ➢ Low-<u>cost</u> products

  ➢ Reduces manufacturing <u>time</u>

➢ Role of technology advancement in global market

  ➢ Converting from <u>traditional system</u> to <u>automated system</u>

  ➢ Introducing more <u>agility</u> and <u>flexibility</u>

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Government Regulation

➢ Necessary to protect public and private sector

➢ It consists of Enterprise Requirements for achieving government purpose such as demands for better services and low cost goods

➢ Government Regulation

   ➢ Prevents the manufacturing industry from <u>unfair competition</u>

   ➢ Enact laws to provide <u>suitable environments for the employees</u>

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Government Regulation

- Employment
- Advertising
- Labor
- Environmental
- Safety And Health
- Privacy

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Government Regulation

- Employment & Labor rules represents laws
  - Concerning wages/salaries
  - Benefits (e.g. retirement plans)
  - Compliance with health and safety issue
  - Proper working condition
  - Expatriate employee issue (e.g. Visas)
  - Equal opportunity in employment (including promotion)
  - Provisioning of Authority or High ranking position

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Government Regulation

➢ Advertisement Regulation focuses on

    ➢ Protection of customers

    ➢ Firm honesty about a product

    ➢ Information regulation publicly

    ➢ Transparency on distribution and manufacturing process

Government Regulation

- Environmental rules
  - Maintained by Environmental Protection Agencies(EPA)
  - Maintains clean air, reduction of chemical effects in soil, river
- Privacy Regulations
  - Safety procedure to <u>sensitive information</u> collected during hiring process
  - Information includes ID card, names, personal information, personal history, health condition, and banking information
  - Inappropriate disclosure of this information risks legal issues

Government Regulation

➢ Safety and Health regulations

    ➢ Ensures healthy working environment

    ➢ Enterprise must distribute information on maintaining a healthy workplace to avoid dangerous events

    ➢ Need to update safety regulation information due to yearly changes in Governments

Population Growth

➢ Monitoring population growth is important for manufacturing industry

➢ It affects

   ➢ Industry growth

   ➢ Food supplies

   ➢ Fertility

   ➢ Sociology

   ➢ Economics

   ➢ Politics

   ➢ Industry Location

   ➢ Use of Available lands

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Population Growth

➢ Three different category of countries based on population growth

  ➢ Developed

  ➢ Emerging

  ➢ Developing

➢ Population growth of countries (developing and disadvantaged) > Population growth of countries (developed and advantaged)

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Population Growth

➤ Based on the United Nations (UN) report, population growth from1950 to 2050

   ➤ Reduced between 32 to 13 % in developed countries

   ➤ Increased between 8 to 20 % in emerging and developing countries

➤ Economic view on population growth

   ➤ Pessimistic

   ➤ Optimistic

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Population Growth

➤ <u>Pessimistic view</u> of population growth
  - ➤ Hinders the economic growth
  - ➤ Consumes most of the economic investments in safety, need for schools, hospitals, universities

➤ <u>Optimistic view</u> of population growth
  - ➤ Dissemination of knowledge and information
  - ➤ Increases globalization issue such as trade and commerce

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Population Growth

- ➢ Despite the advantages of population growth, if there is no plan to control it, it would turn out to be <u>disaster for any developing country</u>

- ➢ Human capital and respective skills are one of the most important aspects of manufacturing industries.

- ➢ Example: A location of manufacturing industry requires politics and skill level provided by the local population

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Economic Crisis/Recession and Depression

- Economic crisis takes place over a duration not more than a few months

- Recession: exponential decline in economic activity
  - Commence after economic crisis arrives at the activity peak
  - Completion after economy arrives at its trough
  - Duration: more than few months but not more than two years
  - Observable on gross domestic product (GDP), actual income, employment, industrial production, and wholesale-retail sales

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Economic Crisis/Recession and Depression

➢ Depression: extremity of recession

  ➢ Observed by exponential unemployment increase

  ➢ Reduction in available credit

  ➢ Significant reduction in trade and commerce

  ➢ Huge number of bankruptcies

  ➢ Volatility in currency value

  ➢ Duration: more than two years

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503
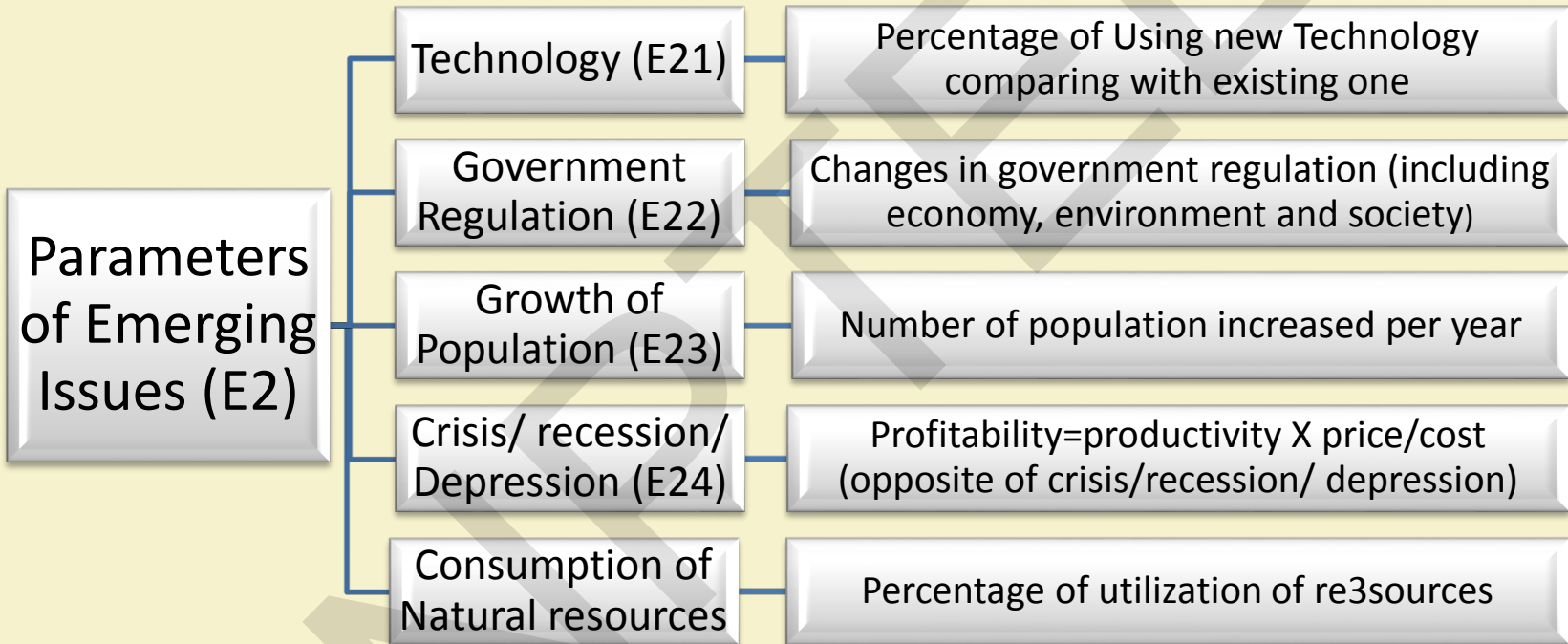
Economic Crisis/Recession and Depression

➢ An economic crisis and recession ➔ observing <u>reduction in prices</u> of few major commodities

➢ <u>Increasing productivity</u> and <u>reduction in cost</u> is one of the solution

➢ Applying same solution, it takes more time to recover form depression

➢ Example of avoiding crisis➔ The main economy of manufacturing location should not be based only one resources

Consumption of Natural Resources

➢ One of the biggest issues in contrast of <u>economically sustainable development</u>

➢ As <u>natural resources</u> are <u>main source of revenue</u> in developing countries, it is one of the major source of social conflicts

    ➢ Mining

    ➢ Oil and Gas extraction

    ➢ Demography shifts

    ➢ Difficult economic situations

    ➢ Negative societal behavior

    ➢ Politics

    ➢ Technology

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Consumption of Natural Resources

Renewable
- Naturally Available
- Source: Solar, Air, Water, Wind etc.
- Renewable energies can be generated easily

Non-renewable
- Usage is selective based on the type of the industry
- Source: Coal, Oil, Gas, etc.
- Can not be recycled

Source: Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503

Sustainability Assessment of Emerging Issues

Parameters of Emerging Issues (E2)

Parameter	Description
Technology (E21)	Percentage of Using new Technology comparing with existing one
Government Regulation (E22)	Changes in government regulation (including economy, environment and society)
Growth of Population (E23)	Number of population increased per year
Crisis/ recession/ Depression (E24)	Profitability=productivity X price/cost (opposite of crisis/recession/ depression)
Consumption of Natural resources	Percentage of utilization of re3sources

Sustainability Assessment of Emerging Issues

➢ Sustainability/Sustainable development

  ➢ $S/SD_{E2} = f(E21, E22, E23, E24, E25)$

  ➢ $S/SD_{E2} = \left(I_{E21}^{Y_{E21}} \cdot I_{E22}^{Y_{E22}} \cdot I_{E23}^{Y_{E23}} \cdot I_{E25}^{Y_{E24}} \cdot I_{E25}^{Y_{E25}}\right)$

  ➢ Where $I_{E2i} = S_{E2i}/E2i$,

  ➢ S_{E2i} = The change towards the sustainability

  ➢ Y_{E2i} = Exponent of the change towards sustainability (S_{E2i}) of $E2i$

References

[1] Garbie, I.H., 2013. DFSME: Design for sustainable manufacturing industries (an economic viewpoint). International Journal of Production Research, 51(2), pp.479-503.

[2] Garbie, I.H., Parsaei, H.R. and Leep, H.R., 2008. A novel approach for measuring agility in manufacturing firms. International Journal of Computer Applications in Technology, 32(2), pp.95-103.

[3] Garbie, I., 2016. Sustainability in manufacturing industries: Concepts, analyses and assessments for industry 4.0. Springer.

Industry 4.0:
Lean Production System

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What is Lean Production System?
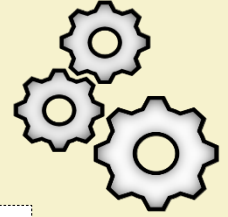
Finishing good inventories through <u>eliminating wastes</u> from processes

➤ Developed by **Toyota motor corporation**
➤ It is mainly focusses on **customer's need**

Source: Toyota Production System or Lean Manufacturing
URL: https://www.slideshare.net/haiggg/lean-production-system-tps

Lean in simple term

Lean Approach	Other Approach
⬇	⬇
Looks from customers perspective	Looks from tasks and production perspective

Source: The Origin of Lean Manufacturing
URL:https://www.coursera.org/lecture/lean-manufacturing-services/the-origins-of-lean-manufacturing-TKEXN
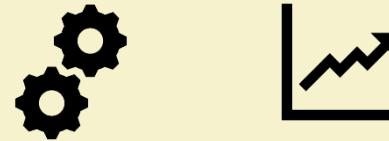
Lean production system established on…

JIDOKA

- **When there is a problem, stop production and stop producing defective products**

JUST-IN-TIME

- **Each process produces what is needed by the next process in a continuous flow**

Source: Toyota Production System or Lean Manufacturing
URL: https://www.slideshare.net/haiggg/lean-production-system-tps

7 Types of wastes

➢ **Transportation** – Excessive movements of people for materials or information
➢ **Waiting** – Period of inactivity of people for material or information
➢ **Motion** – Non value-added movement of people
➢ **Inventory** – Cost of inventory such as raw materials, work in process, finished goods

Source: The 7 Types of Waste, Lean U
URL: https://www.youtube.com/watch?v=8gExNBPzSJk

7 Types of wastes (Contd..)

➢ **Over-processing** – Doing more work in product than customer values

➢ **Defects** – Defects can be in products or paper works

➢ **Overproduction** – Producing more product sooner than the customers ready for

Source: The 7 Types of Waste, Lean U
URL: https://www.youtube.com/watch?v=8gExNBPzSJk

Value streams in Lean

Value streams - All the actions required for a product from order to delivery

It can be done by simply walking through the lifecycle of the product

3 types of works to be noticed ➡ Value-added → Incidental → Pure Waste

Source: Lean U - Value Streams
URL: https://www.youtube.com/watch?v=U985dxED7e4

5 steps of walk in value streams

➢ Focus on single value stream
➢ Build a leadership team
➢ Schedule date and time
➢ Walk it – Discuss value, walk together, list and prioritize ideas
➢ Schedule follow up

Source: Lean U - Walking a Value Stream
URL: https://www.youtube.com/watch?v=P3v5EI6EEog
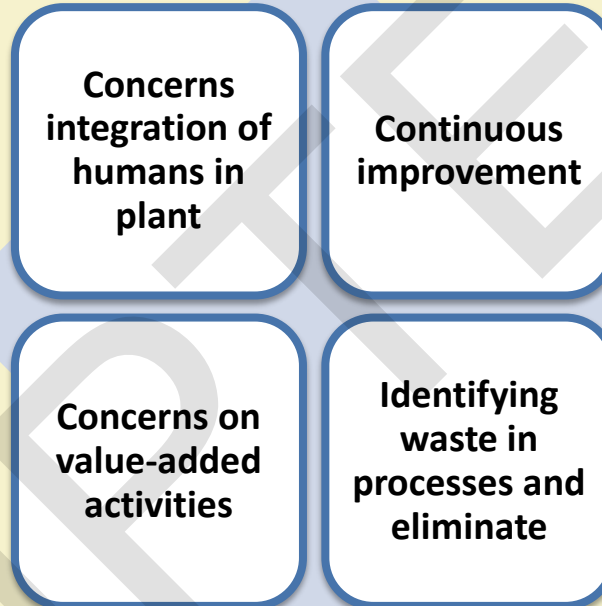
Lean production in Industry 4.0

Concerns integration of humans in plant

Continuous improvement

Concerns on value-added activities

Identifying waste in processes and eliminate

Source: Mrugalska B, Wyrwicka MK. Towards lean production in industry 4.0. Procedia Engineering. 2017 Jan 1;182:466-73.

Impacts of Lean production system

Through the elimination of waste in processes, it provides best quality, lowest cost, shortest lead time

Source: Lean Production System - TPS
URL: https://www.slideshare.net/haiggg/lean-production-system-tps

Implementation of Lean implies

Implementation of lean → implementation of full manufacturing system

➢ It does not only focus on <u>lean tools</u>
➢ In addition it focuses on <u>four main areas</u> such as business requirements, operation improvement, people management, performance governance

Implementation of Lean implies (Contd...)

1. Business Requirements
- ➢ Set right objectives
- ➢ Clear about strategy
- ➢ Clear about contributions

Business Requirement

Implementation of Lean implies (Contd...)

2. Performance Management

➢ Refers to people management

➢ Should have clear **KPI** (**K**ey **P**erformance **I**ndicator) structure

➢ Top-down management

➢ Key topics to be covered-
Productivity, **Q**uality, **C**osts, **D**elivery, **S**afety

Performance Management

Implementation of Lean implies (Contd...)

3. Operation Improvement

➢ Company should have clear
   knowledge about all tools of toolbox
➢ Should not have massive toolbox
   with unnecessary tools

Operation Improvement

Implementation of Lean implies (Contd...)

4. People Engagement

➢ Develop right capabilities

➢ Should follow **L**earn, **D**o, **T**each

   Learn – Clear knowledge about tools

   Do – Perform all tools

   Teach – Move into role of teacher to teach about tools

People Engagement

Why company should decide to implement lean?

Company should implement lean motivated by three drivers; **Cost**, **Time**, **Quality**

Cost ▸ Time ▸ Quality

This leads to company's continuous improvement

Source: How Lean delivers impact in manufacturing; Coursera
URL: https://www.coursera.org/lecture/lean-manufacturing-services/how-lean-delivers-impact-in-manufacturing-S32fw?authMode=signup

References

[1] Source: Toyota Production System or Lean Manufacturing

URL: https://www.slideshare.net/haiggg/lean-production-system-tps

[2] Source: The Origin of Lean Manufacturing

URL:https://www.coursera.org/lecture/lean-manufacturing-services/the-origins-of-lean-manufacturing-TKEXN

[3] Source: The 7 Types of Waste, Lean U

URL: https://www.youtube.com/watch?v=8gExNBPzSJk

[4] Source: Lean U - Value Streams

URL: https://www.youtube.com/watch?v=U985dxED7e4

[5] Source: Lean U - Walking a Value Stream

URL: https://www.youtube.com/watch?v=P3v5EI6EEog

References (Contd..)

[6] Source: Mrugalska B, Wyrwicka MK. Towards lean production in industry 4.0. Procedia Engineering. 2017 Jan 1;182:466-73

[7] Source: Lean Production System - TPS
URL: https://www.slideshare.net/haiggg/lean-production-system-tps

[8]Source: The lean manufacturing system; Coursera
URL: https://www.coursera.org/lecture/lean-manufacturing-services/the-lean-manufacturing-system-mqbGU

Thank You!!

Industry 4.0:
Smart and Connected Business Perspective

Dr. Sudip Misra
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Why smart and connected products?

➢ Connecting the physical objects.

➢ Sharing the data between physical objects.

➢ Increasing the <u>resource efficiency</u>.

➢ Increasing the <u>productivity</u>.

Source: "Industry 4.0:Managing The Digital Transformation", Springer.

Benefits of smart and connected products

➢ Faster.

➢ Cheaper.

➢ Better usage of product.

➢ Improved recall process of product.

➢ Decreased environmental impact.

➢ Smart supply chain.

Source: "Why Your Products Must be Smart and Connected ", TCS.

Medium of getting smart and connected

- ➢ Embedded Systems.
- ➢ Cloud computing.
- ➢ Internet of things (IOT).
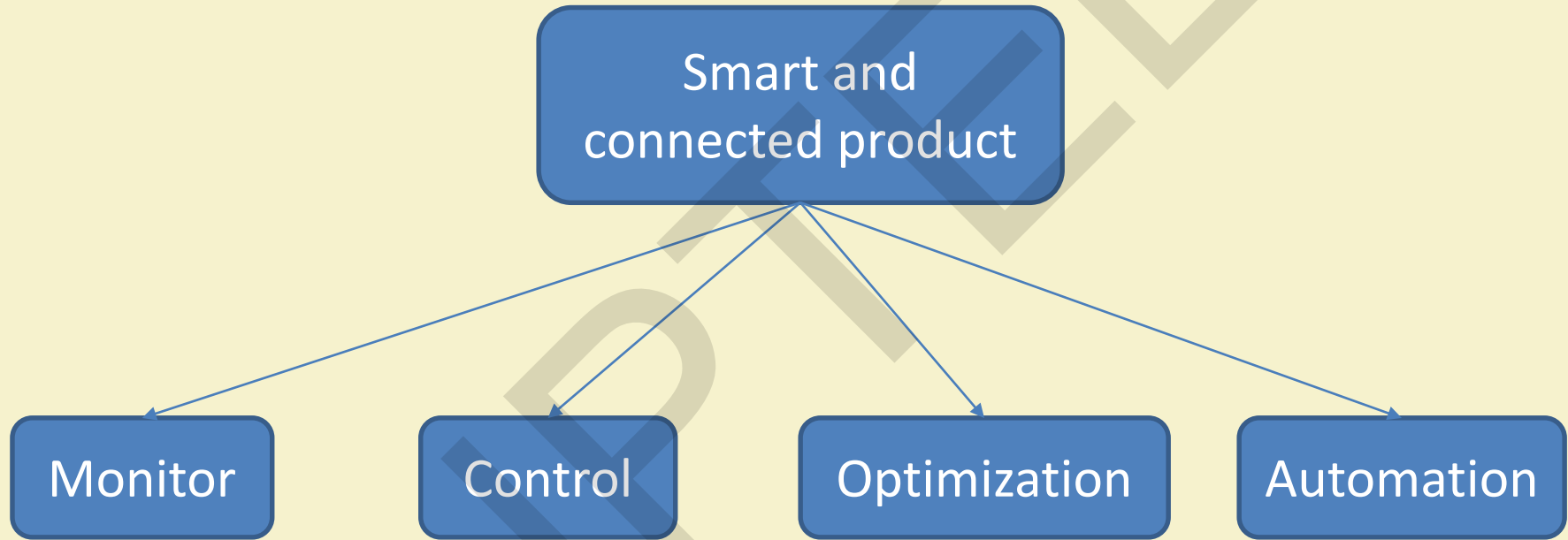- ➢ Sensors.

Source: "Industry 4.0:Managing The Digital Transformation", Springer.

Fundamental building blocks

➤ Customer values.

➤ Blueprint of profits.

➤ Key resources.

➤ Key processes.

Categorization

Monitor

- **Resource:**
  - Sensors.
  - External data sources.

- **Effects :**
  - Health monitoring of products.
  - Generating alerts.
  - Taking action against the odds.

Control

➢ **<u>Resource</u>**:
  ➢ Custom software.

➢ **<u>Effects:</u>**
  ➢ Controlling the products.
  ➢ Personalization.

Optimization

➢ **Resource:**

  ➢ Optimization algorithms.

➢ **Effects:**

  ➢ Enhances the performance.

  ➢ Enables remote services.

  ➢ Assists in repairing the product.

Automation

- ## Resource:
    - Monitor, control, and optimization capabilities.
    - Software algorithms.
- ## Effect:
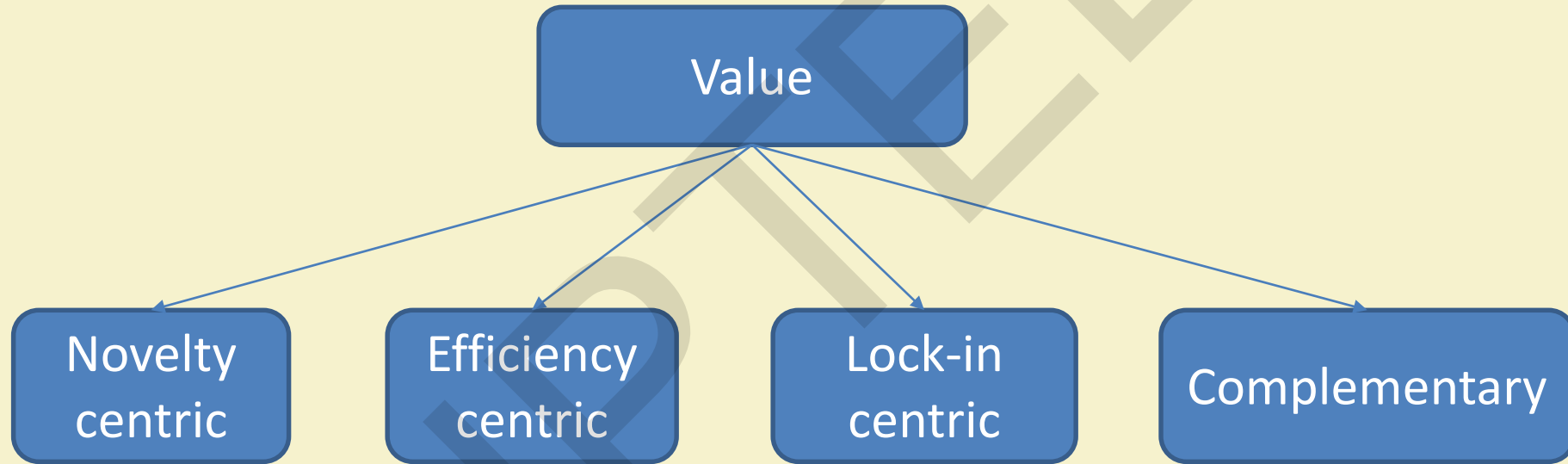   - Autonomous performance of products.

Why smart business model?

➢ Make the current process less costly.

➢ Make the process efficient.

➢ Meet the expected revenue.

Key attributes of smart business model

➢ Value proposition.

➢ Revenue streams.

➢ Technologies.

Value creation in smart business model

Value centric business model

➢ New market.

➢ New services.

➢ Innovation.

Efficiency centric business model

Efficiency makes the transaction –

➢ Faster.

➢ Simple.

➢ Transparent.

➢ Eliminating the errors.

Lock-in centric business model

➢ Prevents the customer migration.
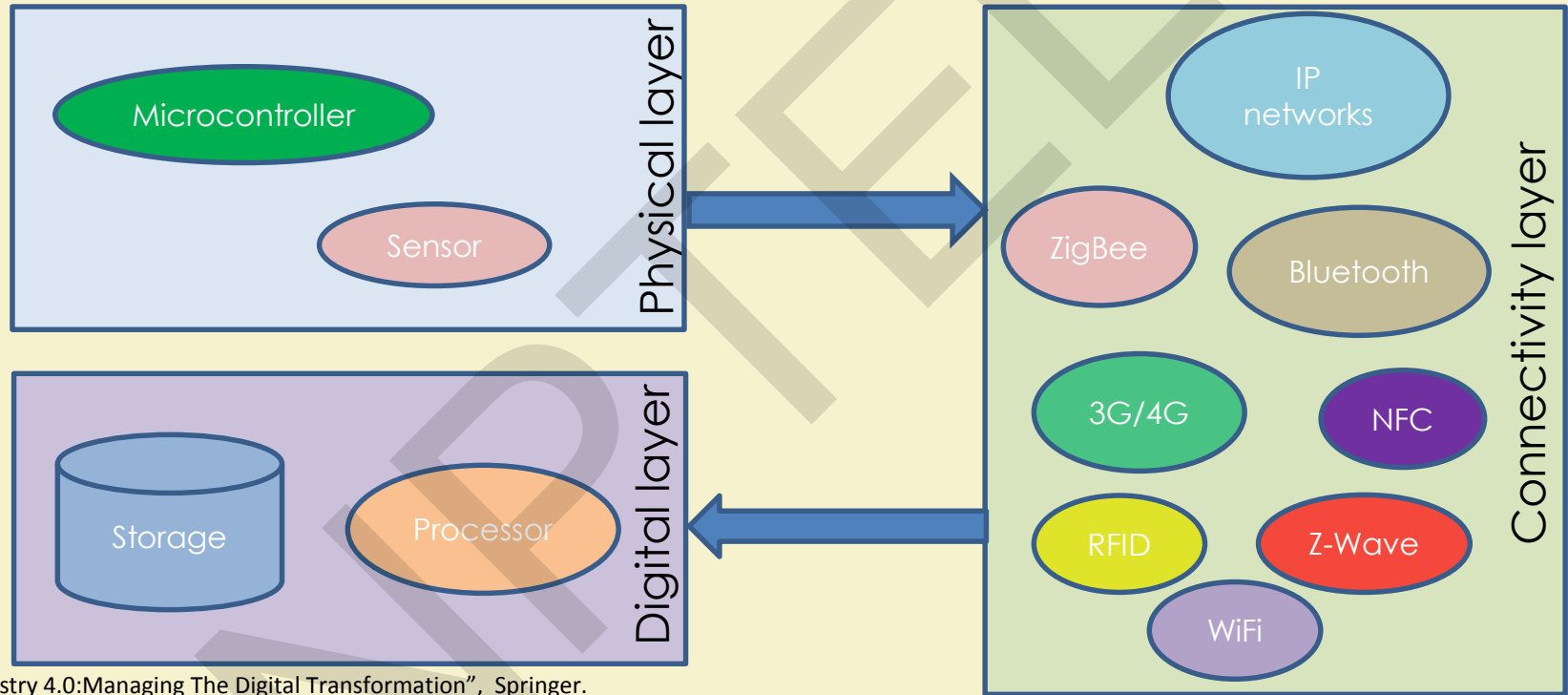
➢ Switching cost.

➢ Building trust.

Complementary business model

➢ Product and services.

➢ On-line and off-line assets.

➢ Technologies.

➢ Activities.

Layers and technologies for creating values

➢ Physical layer.

➢ Connectivity layer.

➢ Digital layer.

Architecture

Physical layer
- Microcontroller
- Sensor

Digital layer
- Storage
- Processor

Connectivity layer
- IP networks
- ZigBee
- Bluetooth
- 3G/4G
- NFC
- RFID
- Z-Wave
- WiFi

Source: "Industry 4.0:Managing The Digital Transformation", Springer.

Physical layer

➢ Responsible for collecting and acquiring data from object or environment.

➢ Equipped with micro-controllers and sensors.

Connectivity layer

➢ Connects smart devices, servers.

➢ Equipped with different communication technology including IP networks, ZigBee, NFC, Bluetooth etc.

Digital layer

➢ Stores the data.

➢ Analyzes the data.

➢ Processes the data

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Examples of smart and connected business model

Product	Value proposition	Revenue streams	Physical layer	Connectivity layer	Digital layer
Amazon's dash button	Lock-in	Low cost	WiFi enabled embedded device	WiFi	Connected through mobile application
Semios	Efficiency	Yearly subscription, 24/7 monitoring and assistance	Sensor for soil moisture, insect, disease, climate monitoring	Cellular connectivity	Mobile application.

Source: "Industry 4.0:Managing The Digital Transformation", Springer.

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[1] Ustundag, A., & Cevikcan, E (2018). Industry 4.0:Managing The Digital Transformation. Springer.

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[3] Amit, R., & Zott , C. (2001). Value Creation in E-Business. In Strategic Management Journal (pp. 493-520). Wiley Volume 22.

Industry 4.0:
Smart Factories

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What is smart factory?

➢ According to Deloitte University Press –

"The smart factory is a flexible system that can self-optimize performance across a broader network, self-adapt to and learn from new conditions in real or near-real time, and autonomously run entire production processes. "

Source : "The smart factory", Deloitte

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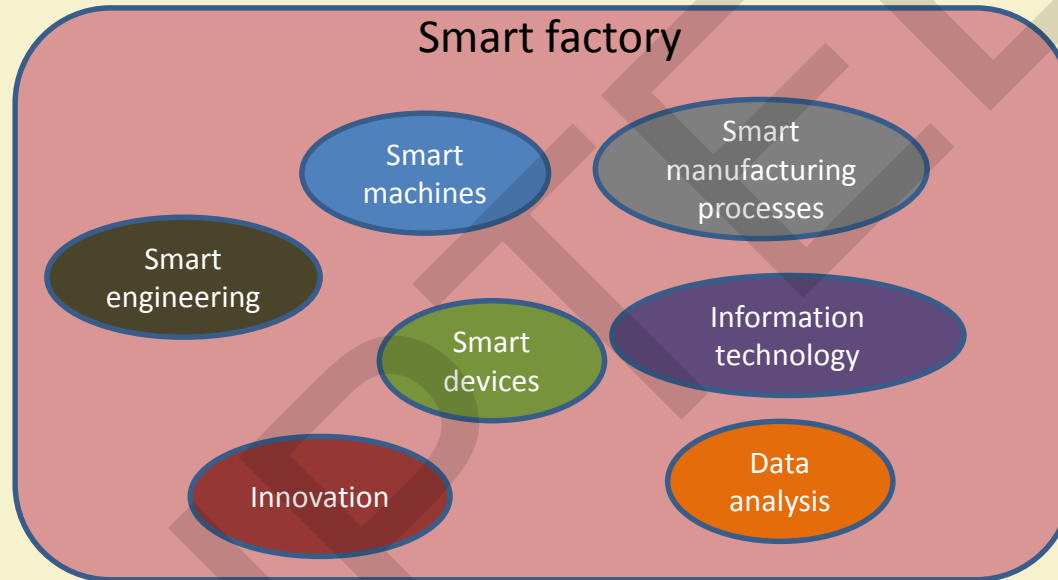NPTEL

Why do we need smart factories?

- ➢ Evolution of technologies.
- ➢ High competitive market.
- ➢ High amount of production within minimum timeline.
- ➢ Reduce risk of failure.

Advantages of running smart factories

➢ Reducing cost.

➢ Increasing efficiency.

➢ Improving quality.

➢ Improving predictability.

➢ Improving safety.

Components of smart factory

Source: "Smart factories in Industry 4.0: A review of the concept and of energy management approached in production based on the Internet of Things paradigm. **",** IEEE ICIEEM.

Smart machines

➢ Communicate with other machines.

➢ Communicate with other smart devices.

➢ Communicate with humans.

Smart devices

➢ Connected with smart devices including
  ➢ Field devices.
  ➢ Mobile devices.
  ➢ Operating devices.

Smart manufacturing process

➢ Dynamic.

➢ Automation.

➢ Real-time.

➢ Efficient.

Smart engineering

➢ Smart design of product.

➢ Smart development of product.

➢ Smart planning.

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Information technology

➢ Smart software application.

➢ Monitoring.

➢ Control.

➢ Smart management process.

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Characteristics of smart factories

- ➢ Connection.
- ➢ Optimization.
- ➢ Transparent.
- ➢ Proactivity.
- ➢ Agility.

Connection

➢ Connected smart devices.

➢ Connected smart machines.

➢ Connected with data.

➢ Connected processes.

Optimization

➢ Optimizing the task scheduling.

➢ Optimizing the use of energy.

➢ Optimizing the cost of production.

➢ Optimizing the tracking.

➢ Optimizing the throughput.

➢ Optimizing the reliability.

Transparent

- ➤ Real-time monitoring.
- ➤ Taking required action on time.
- ➤ Generating alert messages.
- ➤ Real-time tracking.

Proactivity

- ➢ Predicting the quality issues.
- ➢ Improving safety.
- ➢ Forecasting the future outcomes.
- ➢ Predicting the future challenges.

Agility

➢ Flexibility.

➢ Adaptation.

➢ Self-configuration.

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Supporting technologies for smart factories

➢ Big Data.

➢ Cloud computing.

➢ Smart grid.

Use of Cloud computing in smart factories

➢ Provides the capability of high-performance computing.

➢ Easy access for product designing software and tools.

➢ Easy access for present and past data for analyzing.

➢ Scalability provides freedom in terms of computing and data storage.

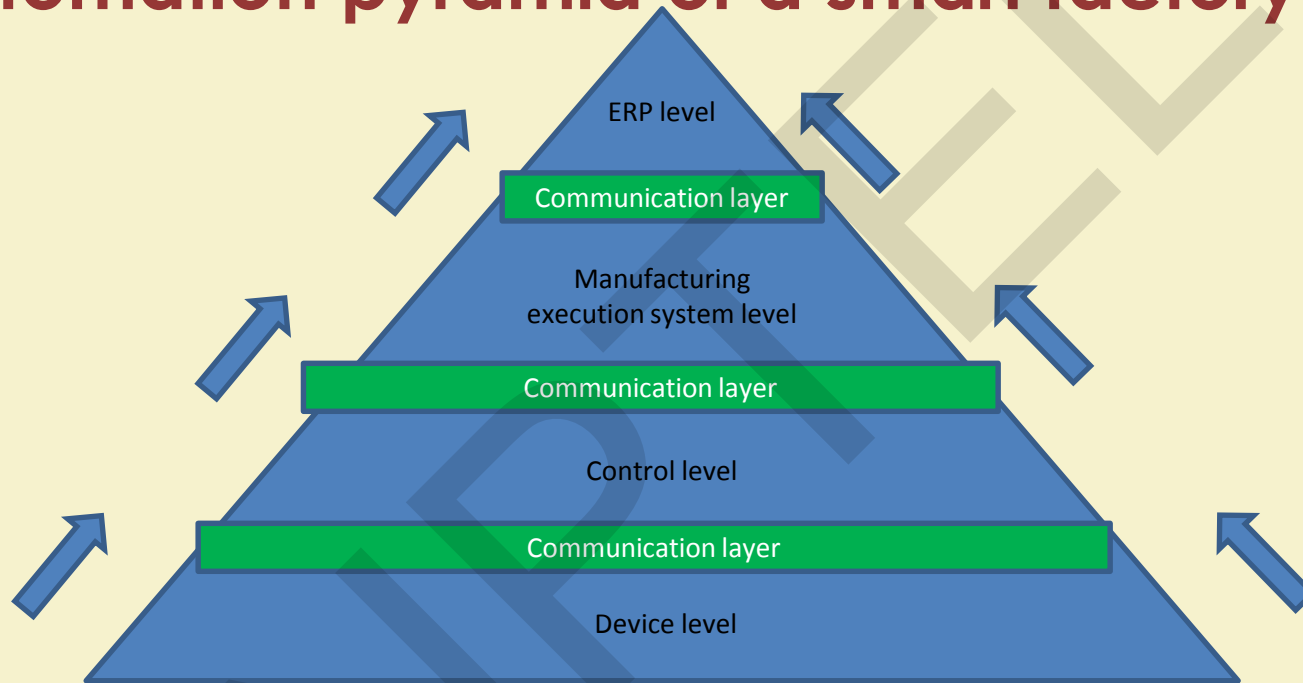# Use of Big Data analytics in smart factories

➢ Generating knowledge.

➢ Improving value streams.

➢ Future prediction.

➢ Key Performance Indicator (KPI).

Use of smart grid in smart factories

➢ Persistence in energy consumption.

➢ Load balancing.

➢ Reduction of energy consumption cost.

➢ Increase the life cycle of electronic equipment.

Automation pyramid of a smart factory

Use of augmented reality in smart factories

➤ Operate instruments from remote.

➤ Providing precision.

➤ Providing safety especially for radio active zones.

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