

REVOLUTION TO INDUSTRY 4.0

ปฏิวัติอุตสาหกรรมไทยสู่อุตสาหกรรม 4.0

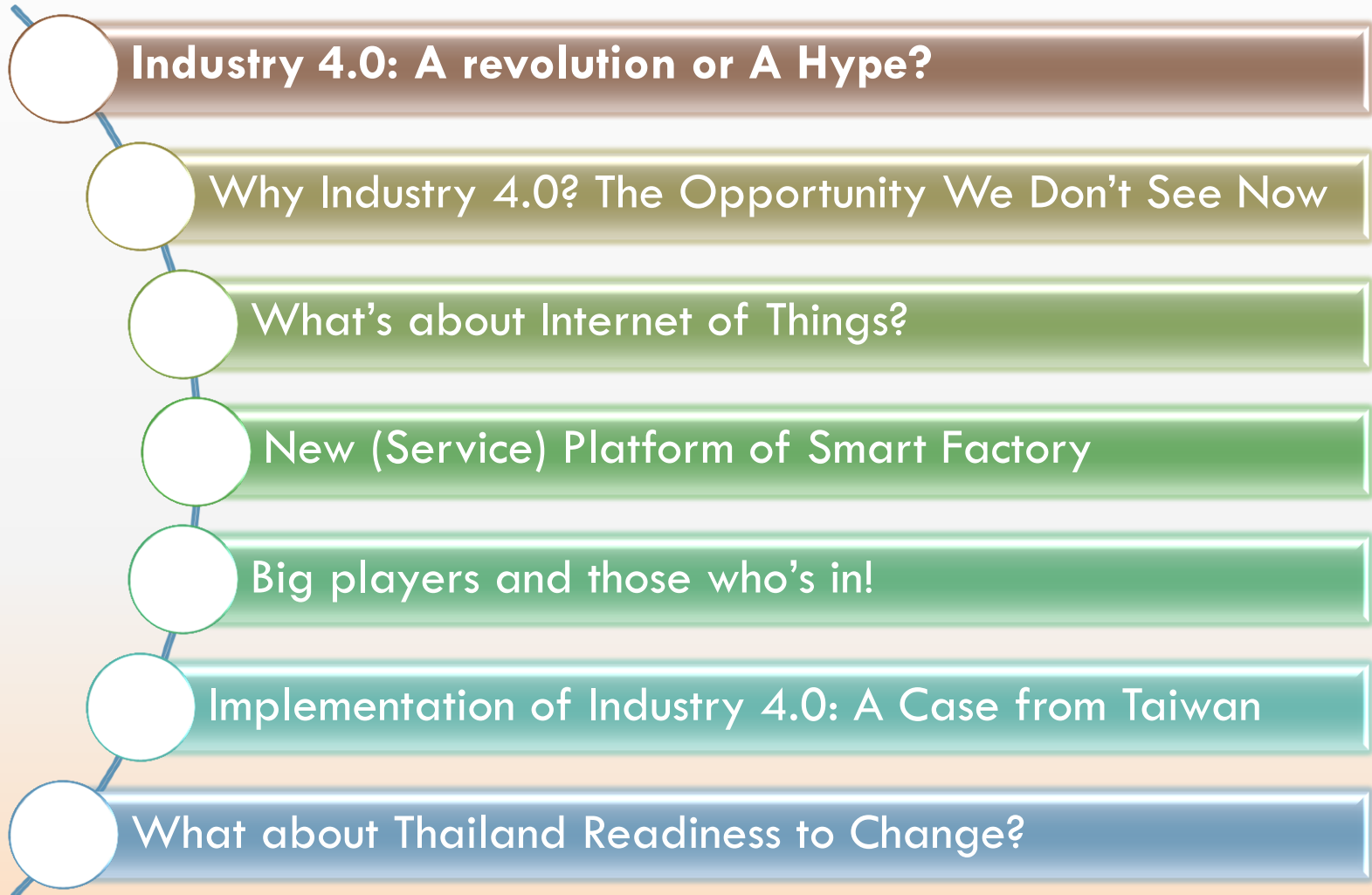
Kamolbhan Sangmahachai

Ph.D. (Information Systems), M.B.A., B.Eng (Industrial Engineering)

Director

Kasetsart Energy and Technology Management Center

Outline



Industry 4.0: A Revolution or A Hype

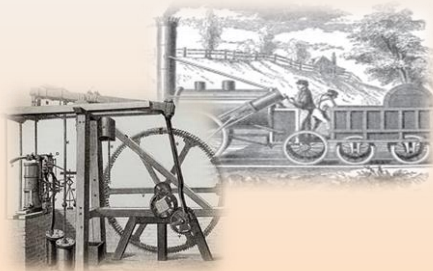
First 

Water and steam power is used to create mechanical production facilities.



1800

1784: First mechanical loom



Second 

Electricity lets us create a division of labor and mass production.



1900

1870: First assembly line



Third 

IT systems automate production lines further.



2000

1969: First programmable logic controller



Fourth 

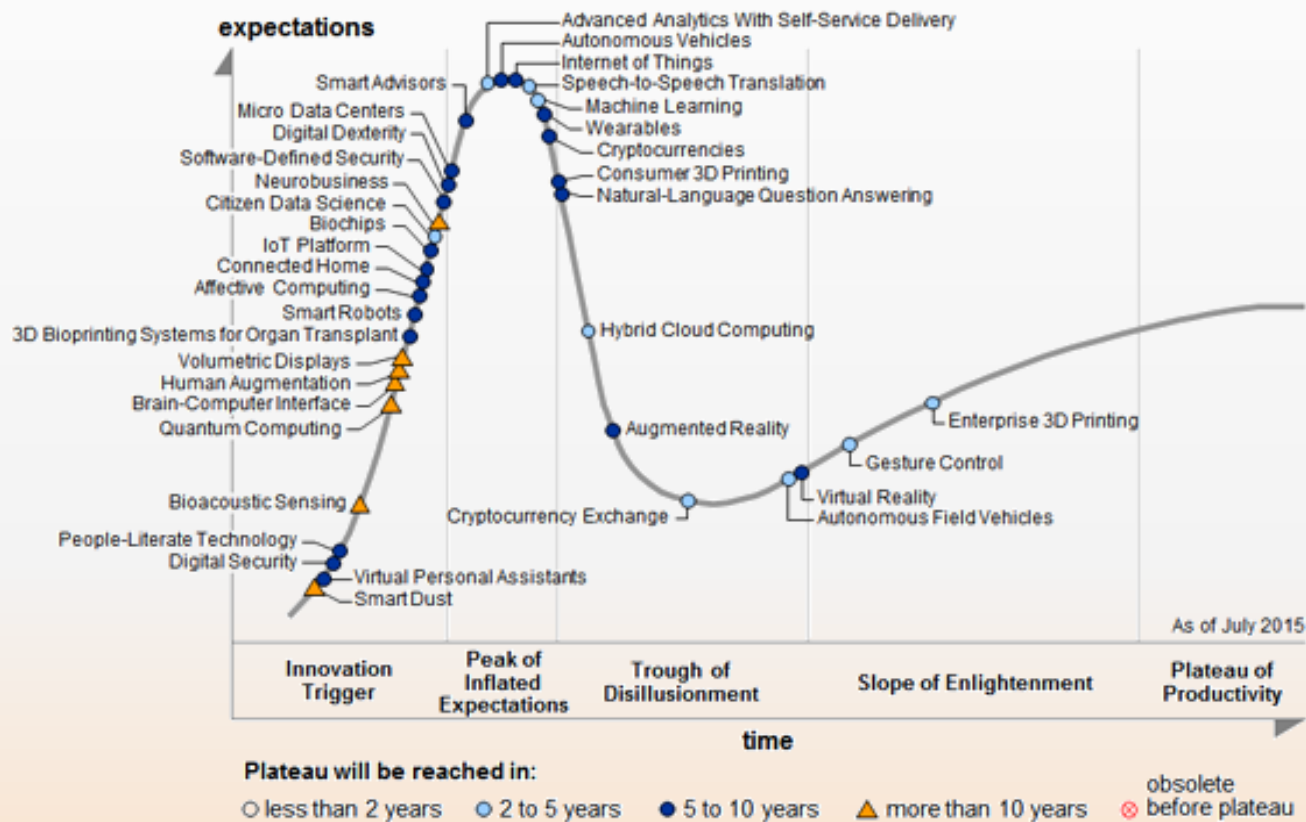
IoT and cloud technology automate complex tasks.



Today



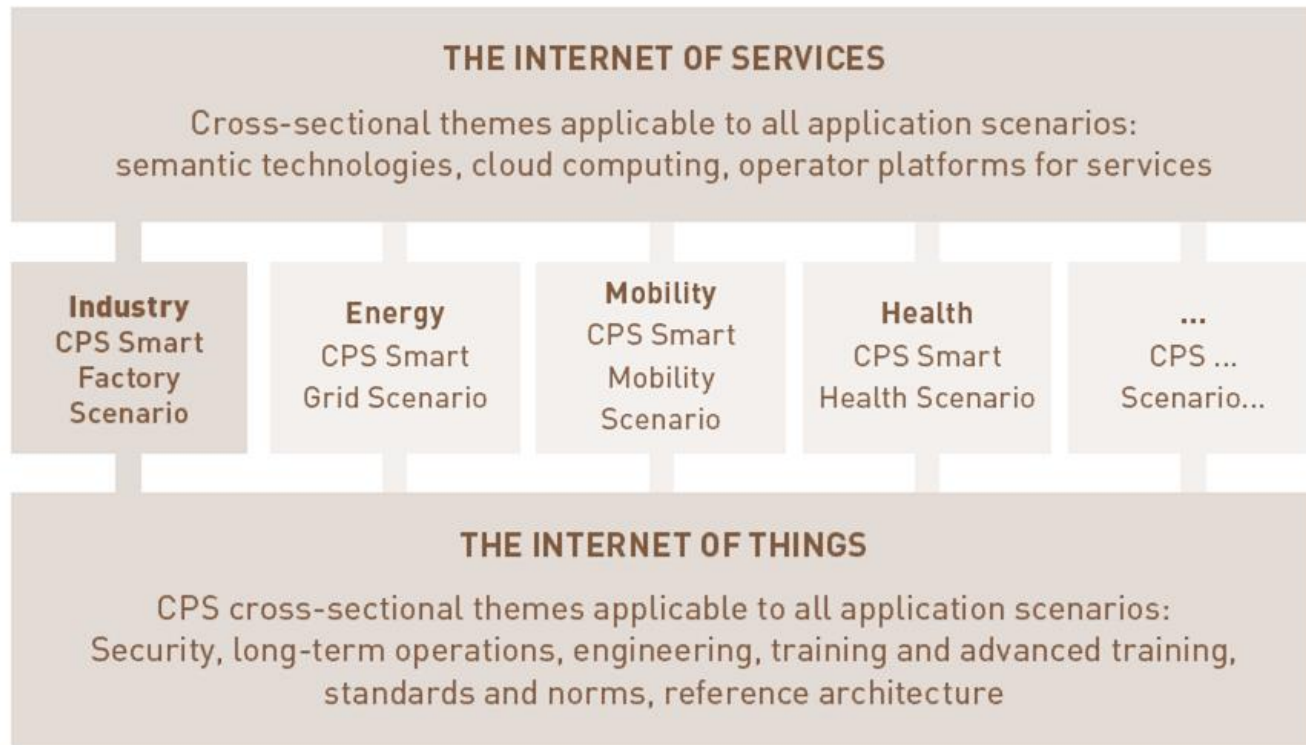
Industry 4.0: A Revolution or A Hype



Hybrid Cloud Computing, Internet of Things (IoT), Machine Learning, People-Literate Technology, Speech-to-Speech Translation, 3D Bioprinting for Life Science, Human Augmentation, Affective Computing, Augmented Reality, Connected Home, Digital Security, Enterprise 3D Printing, Smart Robots, Smart Advisors, Gesture Control, IoT Platform, Machine Learning, Micro Data Centers, Quantum Computing, Software-Defined Security, Speech-to-Speech Translation, Virtual Reality, Volumetric and Holographic Displays, and Wearables. Smart Dust, Smart Robots, Virtual Personal Assistants, Virtual Reality, and Volumetric and Holographic Displays.

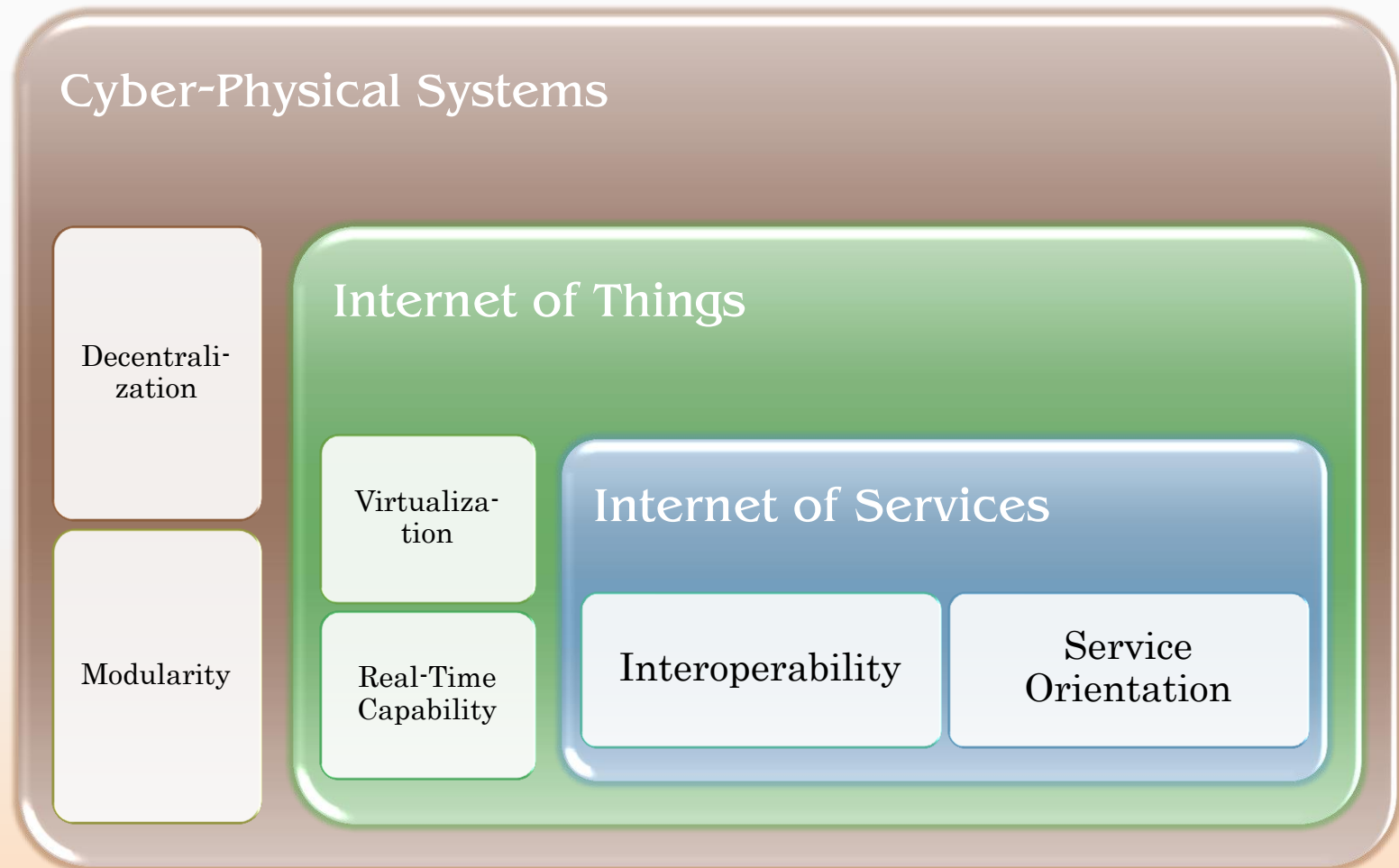
Source: Gartner (August 2015)

Industry 4.0 Architecture



Source: Germany Trade & Invest 2013 (based on "IKT als Innovationsmotor für alle Bedarfsebenen – die Relevanz des »Internets der Zukunft« in „BERICHT DER PROMOTOREN-GRUPPE KOMMUNIKATION – IM FOKUS: DAS ZUKUNFTSPROJEKT INDUSTRIE 4.0 HANDLUNGSEMPFEHLUNGEN ZUR UMSETZUNG“, Forschungsunion 2012)

Industry 4.0 Framework





Principles of i-4

1. The ability to collaborate between man and machine (**Interoperability**) – this era of industry revolution focuses on providing seamless interoperability between man and machine and the interaction between them in the manufacturing process. Both sides rely on communication technology called the Internet of Things (IoT).
2. The production process can be seen clearly from the virtual image of the plant (**Virtualization**) – the virtual image of the plant will be built by simulating the process of linking machines or things via smart sensor devices in the production process. The objective is to keep the production process as much automatically linked together and as clearly visible as possible through a system called Cyber-Physical Systems (CPS).



Principles of i-4

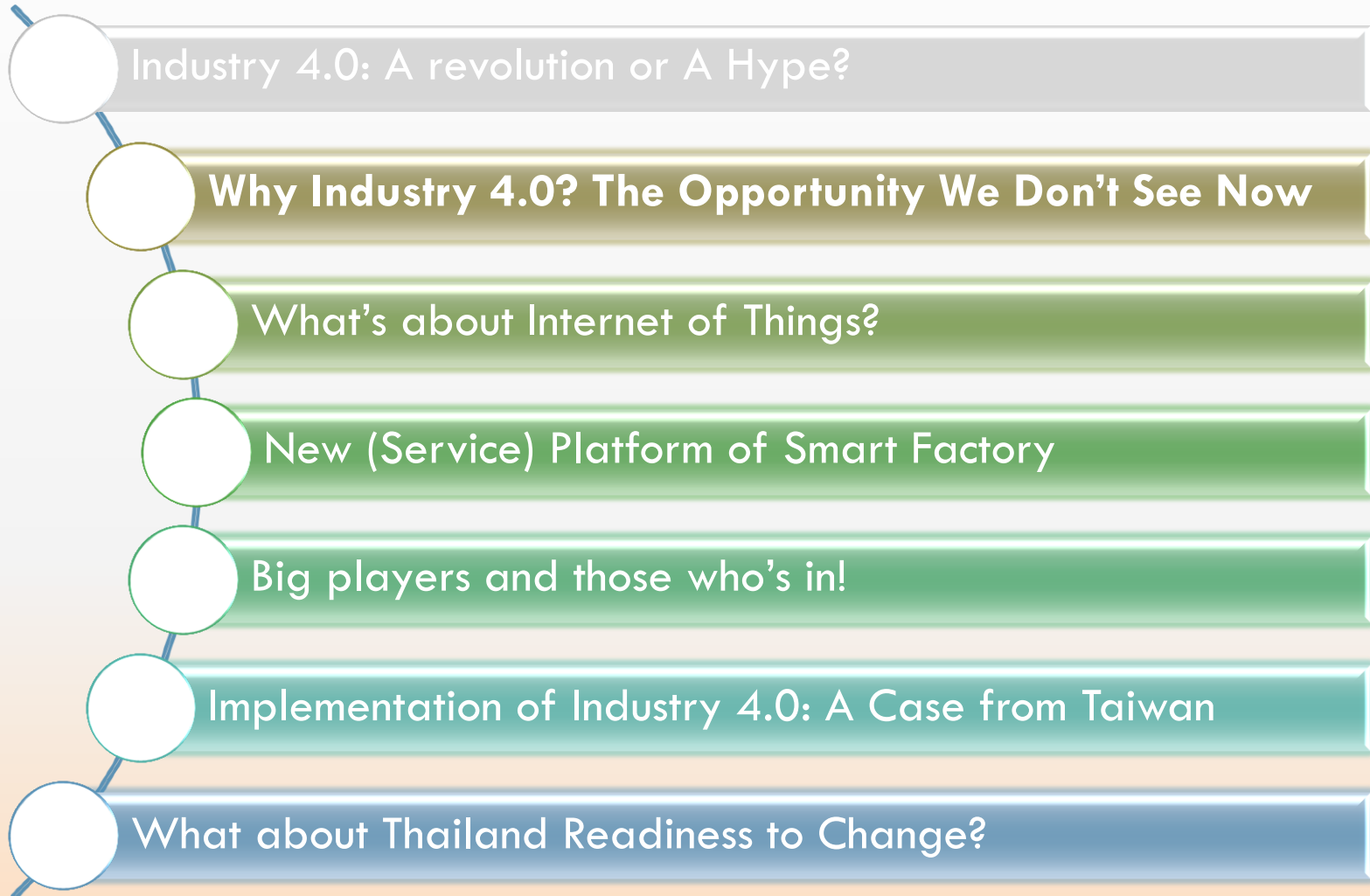
3. Decentralized control scheme (**Decentralization**) – the capability of CPS that enables staff in the factory can make decisions quickly. The objective is to decentralized decision making in machine control and resolving problems quickly and accurately.
4. **Real-Time Capability** is focusing on the capability of manufacturing processes that makes instant decisions through the communication system via the network backbone. This enables the industry to reduced inventories or work-in-process materials required during the process, as well as waste and down time of the machine.



Principles of i-4

5. Model that emphasizes service (**Service Orientation**) – the innovative service model of information system called Internet of Services (IoS) is used to control the monitoring and analysis of data collected from the smart sensor devices. The service focuses on the system's ability to produce products to meet the needs of individual consumers. That is the Flexible manufacturing process has been created.
6. The ability to separate (**Modularity**) – is a unique feature of the flexible manufacturing system. The production process can be separated from each other to overcome the complexity of a system or a long-line production process. Long-line or continuous production process is broken down to make management easier. The ability to separate also means the plant is able to modify the machines or manufacturing process to meet the diverse needs of consumers more quickly.

Outline



Contribution of Industry to the Success of Economies

Industry GDP of each country



Industry Value Added, % of GDP	2011	2014
China	46.1	42.6
Germany	30.5	30.7
France	19.8	19.4
India	33.1	30.1
Indonesia	44.8	42.9
South Korea	38.4	38.2
Thailand	43.0	42.0
United States	20.6	N/A
Vietnam	37.9	38.5

Source: World Bank, 2015

Demand Side of Growth

- World population
 - 1950 2.5 billion
 - 2013 7.0 billion
 - 2025 7.9 billion
- Expansion of Consumption
 - 1990 1.2 billion who have purchasing power
 - 2025 4.2 billion who have purchasing power
- Market development
(Developed vs. Developing Economies)



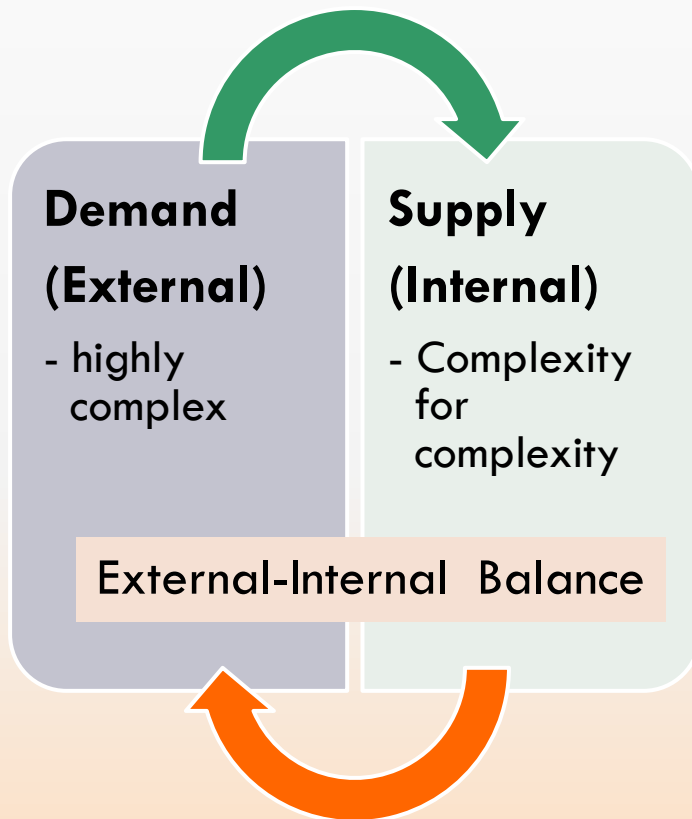
- Urbanization
 - 60-70 percent of people will live in cities



Supply Side of Growth

- Energy demand
 - Doubled by 2050
 - Transition from fossil fuel to renewable energy and energy efficiency
- Factor of production
 - Energy
 - Skilled labor (global problem on waste of human resource)
 - Capital (link between financial market and real economy)
- ICT is an enabler of factor of production
 - For example, smart grid, EV, ...

Industry 4.0 : A Balance between Demand and Supply

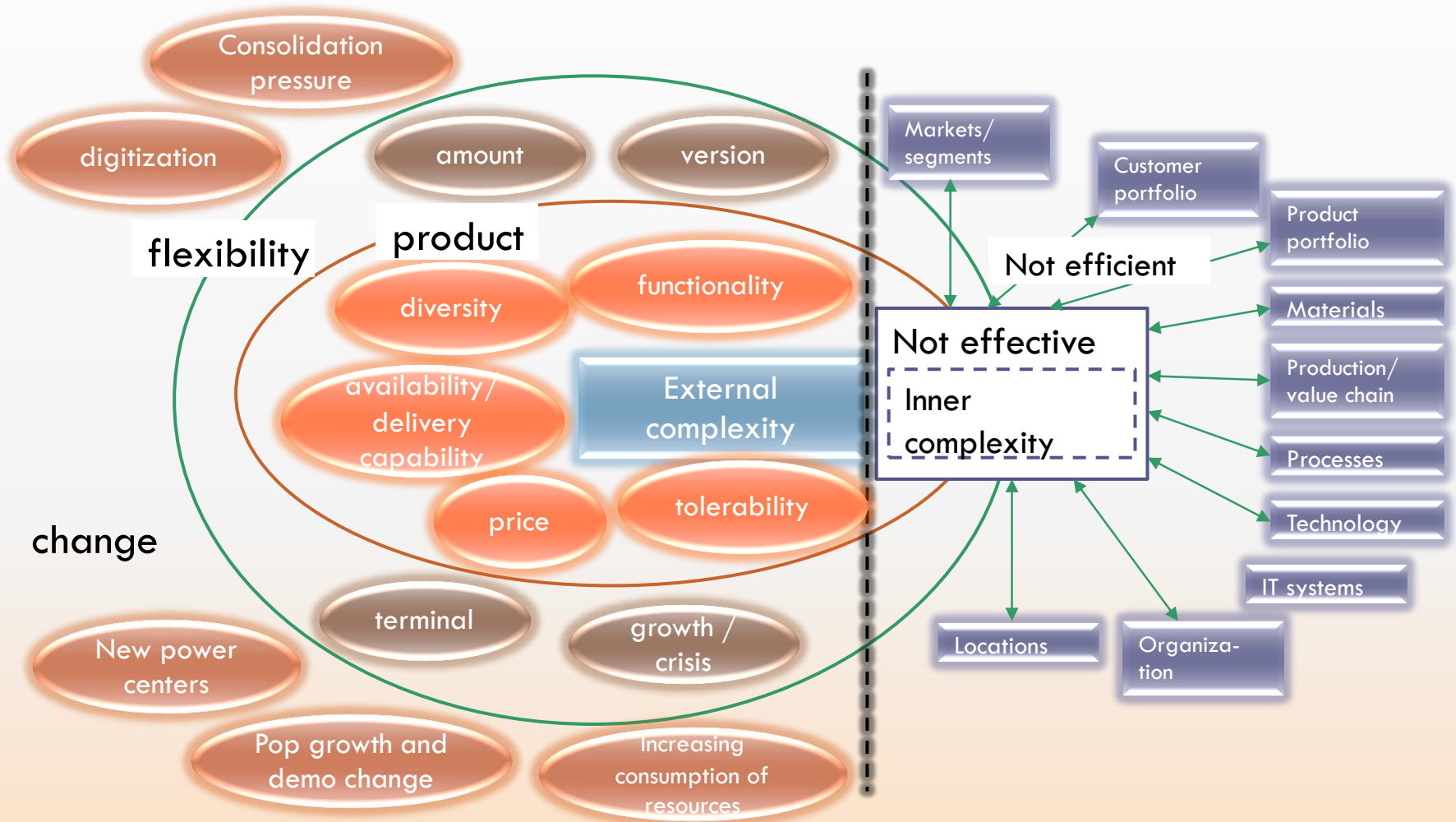


■ Complexity means...

- Increased functionality
- Increased diversity
- Massive requirements
- Price elasticity
- Compatibility
- Reliability

*“Only complexity can deal with complexity.” – Ross Ashby
1956*

Balancing between inner and outer complexity

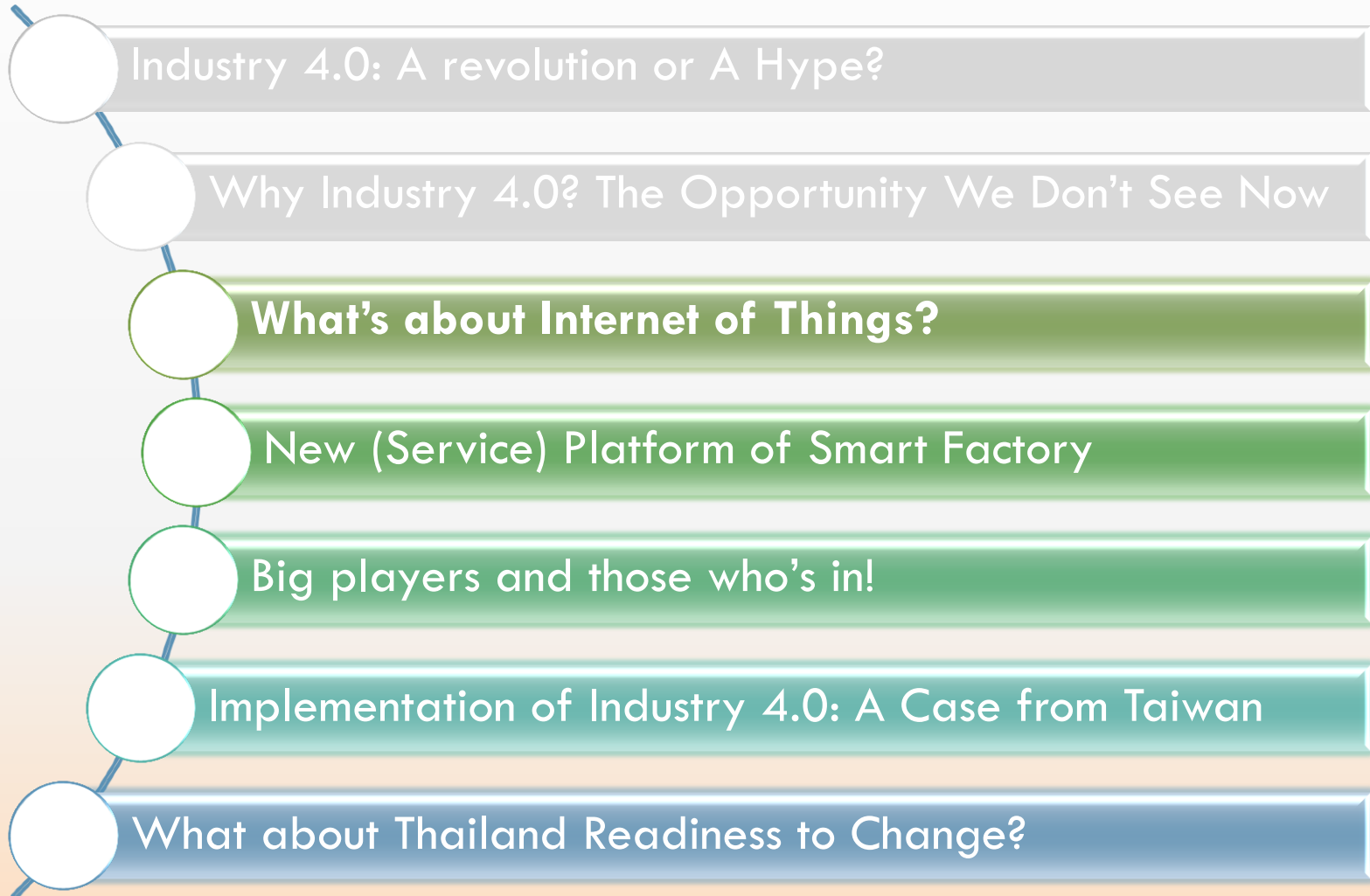


Initial Assessment of Potential Benefits

Cost structure	Reasons	benefits
Inventory cost	<ul style="list-style-type: none">• Reduction of safety stock• Prevention of bullwhip effect	-30% to -40%
Manufacturing cost	<ul style="list-style-type: none">• Improvement of OEE• Process control loops• Improvement of vertical and horizontal staff flexibility	-10% to -20%
Logistics cost	<ul style="list-style-type: none">• Increase level of automation	-10% to -20%
Complexity cost	<ul style="list-style-type: none">• Line tension enhancements• Reduction troubleshooting	-60% to -70%
Quality cost	<ul style="list-style-type: none">• Near real-time quality control loops	-10% to -20%
Maintenance cost	<ul style="list-style-type: none">• Optimization of spare parts inventories• Condition-based maintenance• Dynamic prioritization	-20% to -30%

Source: Fraunhofer IPA, Stuttgart University, 2014

Outline





“The rise of IoT is approaching as the prices of IoT hardware are dropping, putting sensors, processing power, network bandwidth, and cloud storage within reach of more users and making a wider range of IoT applications practical.”

McKinsey MGI, 2015

Nine areas where IoT creates value





MGI Studies Question: *How IoT Create Values?*

- A review over 300 cases of IoT applications around the world
- More than 100 unique applications in 9 settings



IoT Value Creations

1. Interoperability is critical source of value in IoT systems

- ▣ 40 percent of the total values
- ▣ \$7 trillion per year in 2025
- ▣ In factory setting accounted \$1.3 trillion (majority)

2. Most IoT data collected are not used

- ▣ Less than 1 percent of data being gathered were used



IoT Value Creations

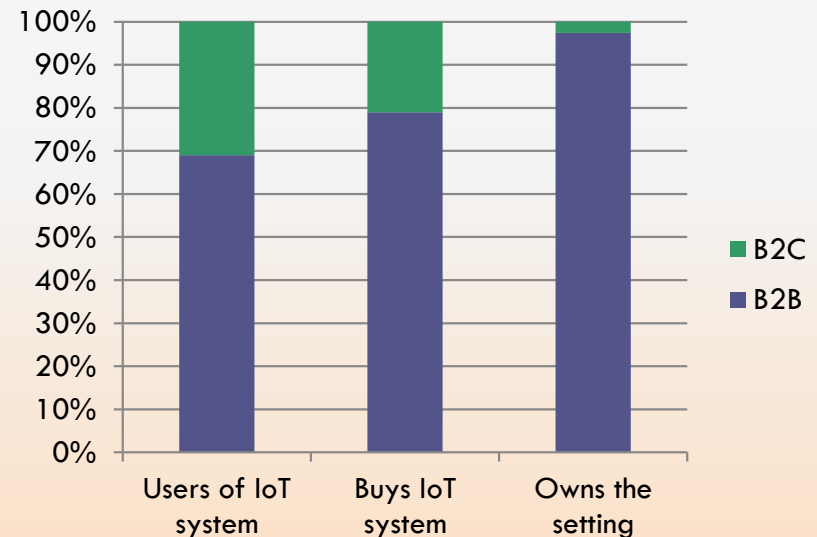
3. More value will be created in advanced economies, but there is substantial opportunity in the developing World

- 62 percent share of increased productivity value from IoT in advanced economies
- 38 percent share in developing economies
- The labor wage is significant factor of IoT adoption in developed economies
- China will be the biggest IoT adopter in manufacturing and industrial settings

IoT Value Creations

4. B2B applications of IoT have greater economic potential than B2C applications

- Using IoT technologies in developing economies may have opportunity to make “leapfrog” gains in productivity and competitiveness





IoT Value Creations

5. Users of IoT technologies will capture most of the potential value overtime
 - ▣ An upward of \$1.75 trillion a year to be shared by the companies that build IoT technologies
 - ▣ 85 percent of software and services is related to IoT in 2025
6. IoT will change the bases of competition and drive new business models for users and supplier companies
 - ▣ Highly flexible manufacturing
 - ▣ More customizable production and made for personal orders

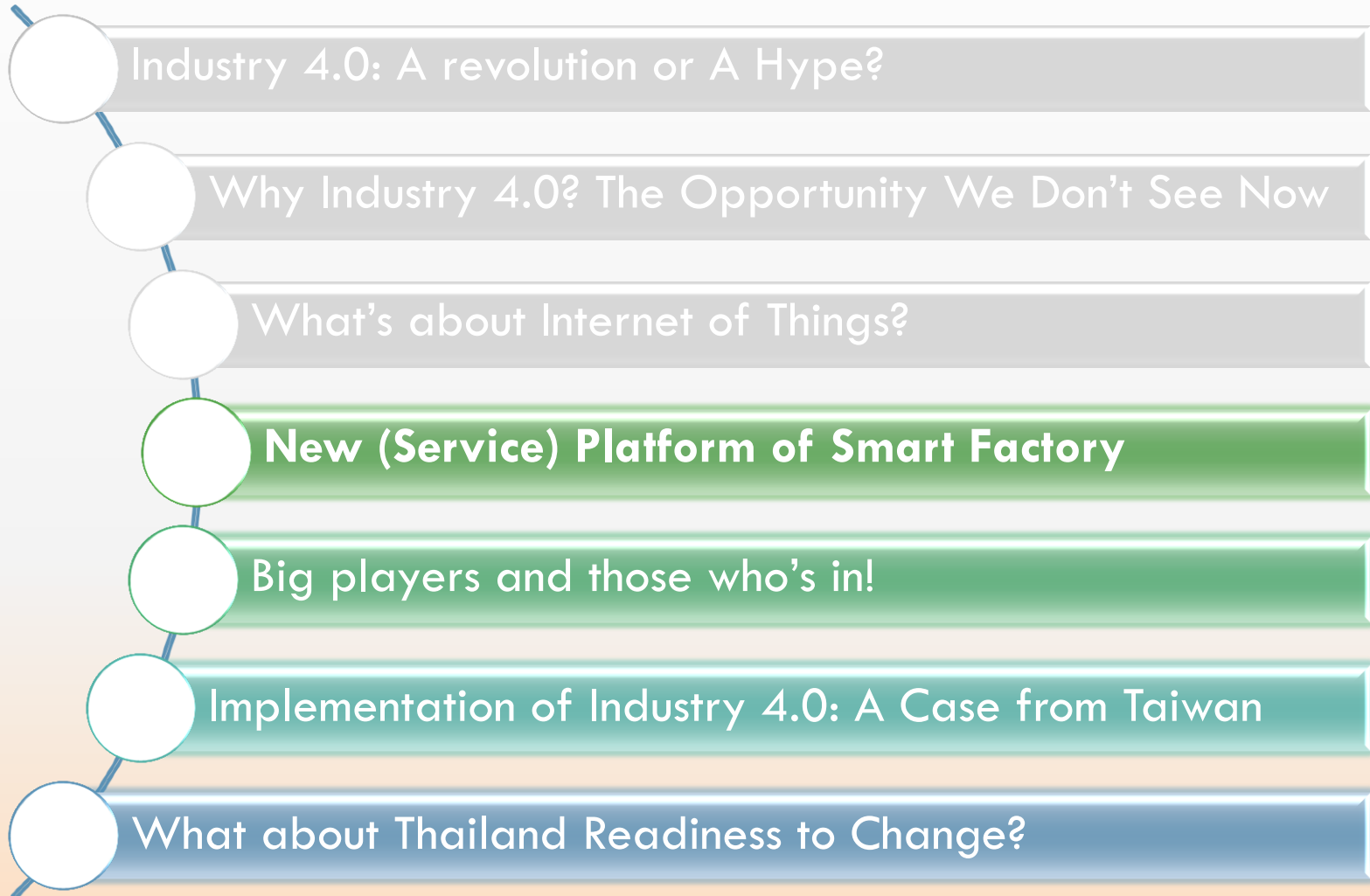
SECRET



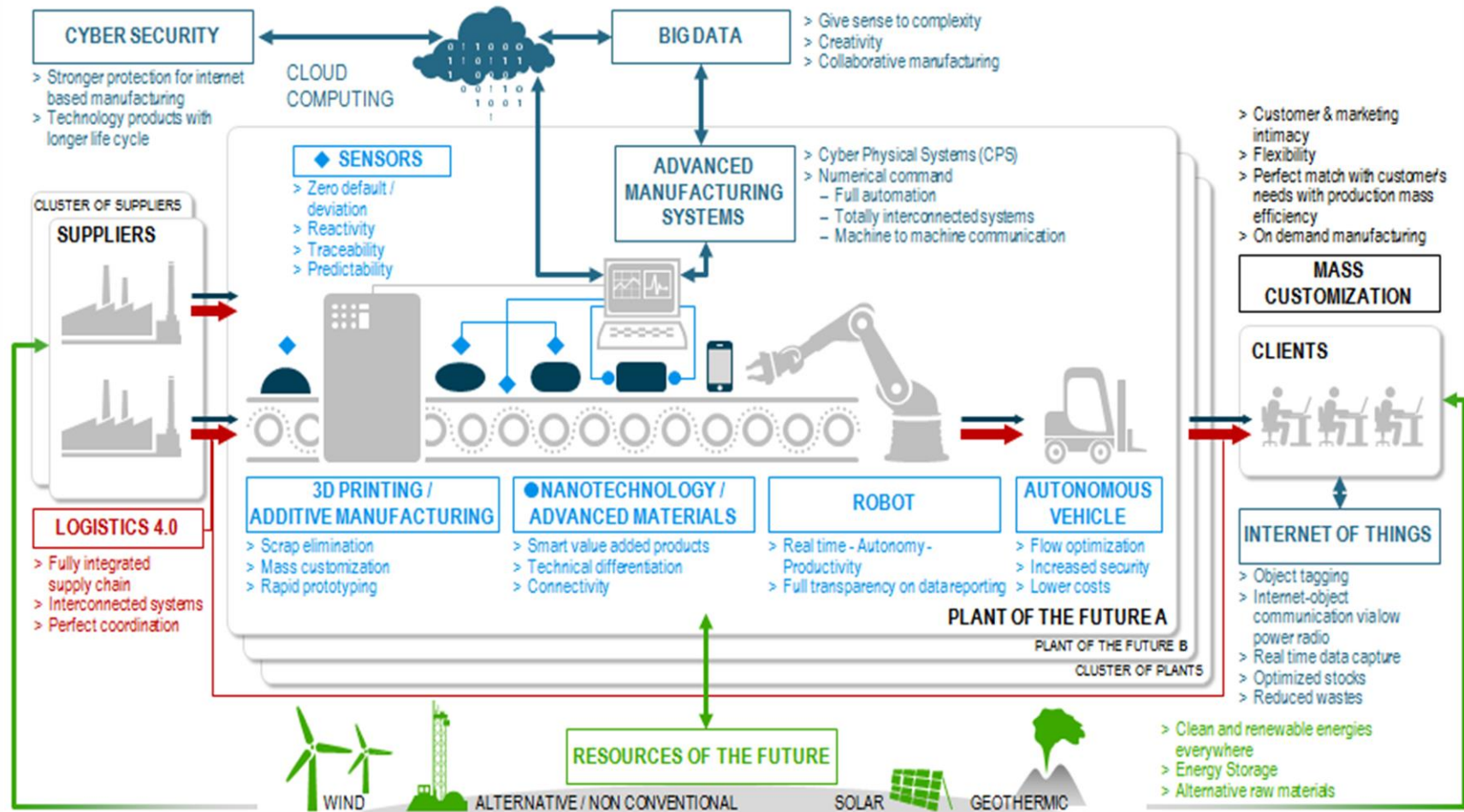
- # Automation and Control



Outline



The Industry 4.0 Ecosystem





Why Smart Factory?

- Different variants
- Personalized
- Unpredictable of volume

*“Giving customer exactly what they wanted, quickly.” –
Amancio Ortega of Zara*

Smart Factory

- The merging of the virtual and the physical worlds through cyber-physical systems and the resulting fusion of technical processes and business processes are leading the way to a new industrial age best defined by the Industrie 4.0 project's "smart factory" concept.
- Smart factory is a self-similar, self-organizing, self-optimizing fractalized production line that can communicate with each other, and also be formed on the basis of complexity drivers.
- This smart factory is expected to kick into high gear by 2020 with productivity 30% higher than in current factories.





Smart Factory Initiation

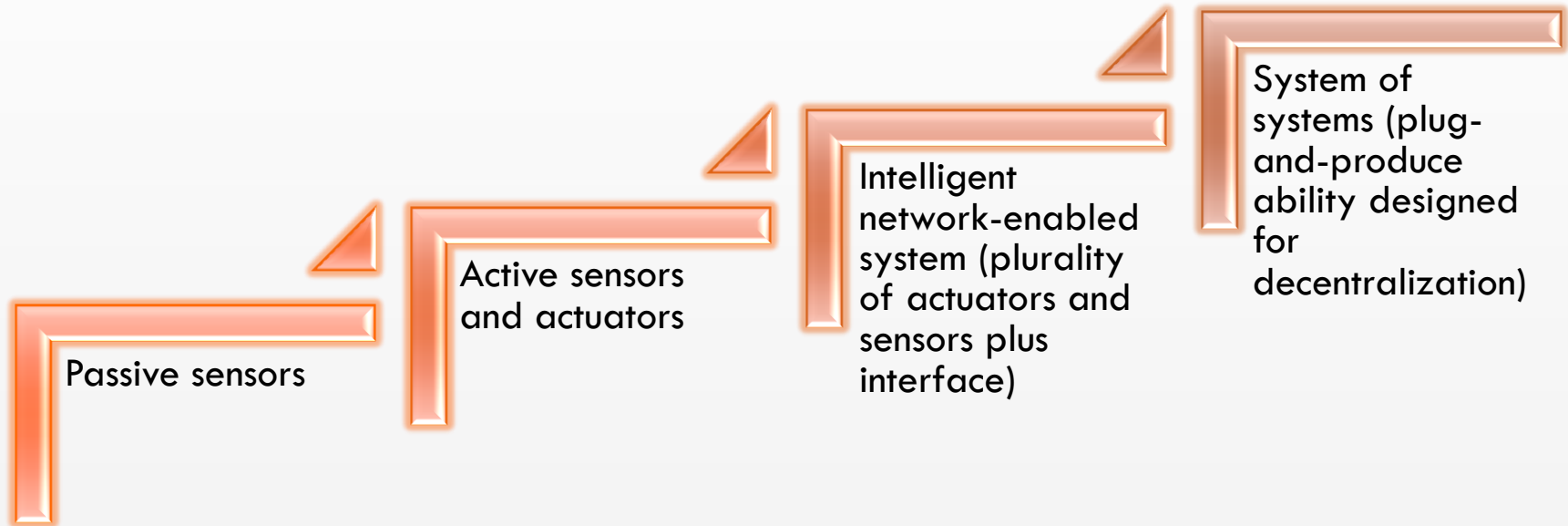
1. Complexity fields in the value network

- Highly distributed decentralized production value chain
- Different process technologies
- Information systems and multi-layer organization
- Synergistic structures
- Decentralized autonomous
- Fractalization in the value network

2. CPS as the basis of smart factory

- CPS = objects, equipment, buildings, transport, production, logistic components that contain embedded systems with communication
- From fractal factory towards cyber physical production systems with communication capabilities over the Internet and use Internet Services
- Sensors and actuators
- Human – machine interface through CPS
- Merge real world with virtual world
- Internet of People, Internet of Things, Internet of Service

Stages of CPS Development



CPS successful?

- Growing power (Moore's law)
- The value of cross links (Metcalfe's law)
- Decentralization and autonomy due to increasing complexity

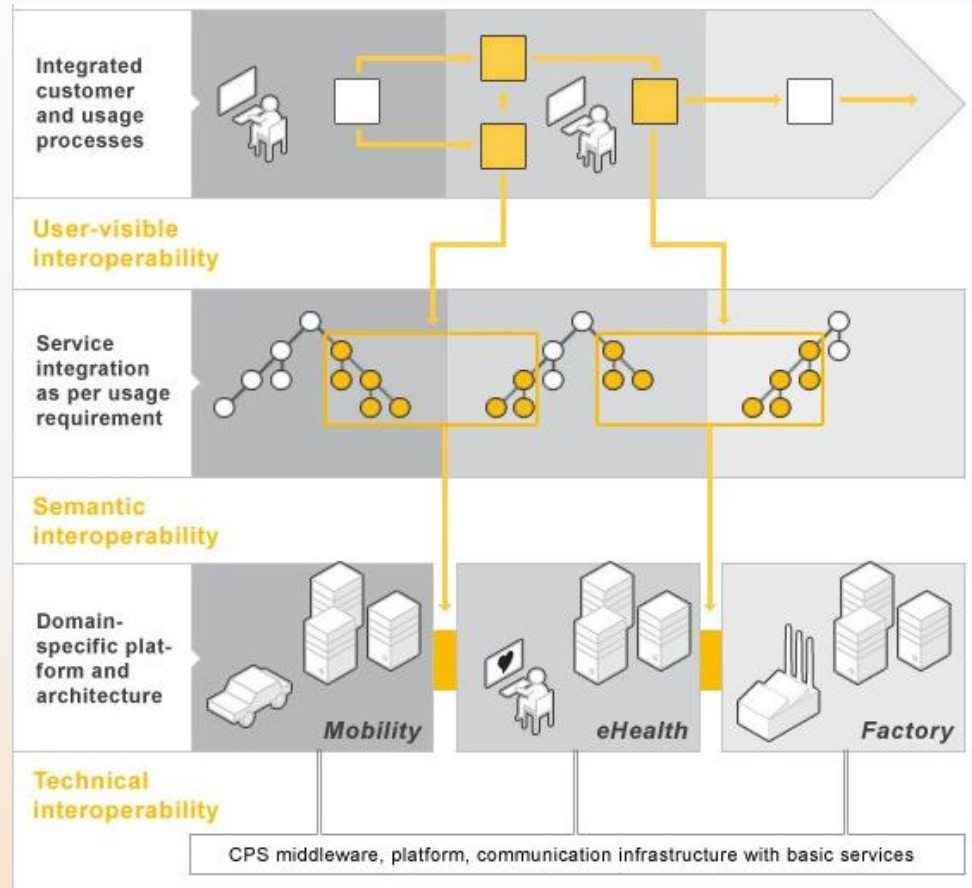


Future Potential of Cyber-Physical Systems 2025

1. **Energy:** Cyber-physical systems for the smart grid
2. **Mobility:** Cyber-physical systems for networked mobility
3. **Health:** Cyber-physical systems for telemedicine and remote diagnosis
4. **Industry ("Smart Factory"):** Cyber-physical systems for industry and automated production.

Important Cyber-Physical Systems Characteristics:

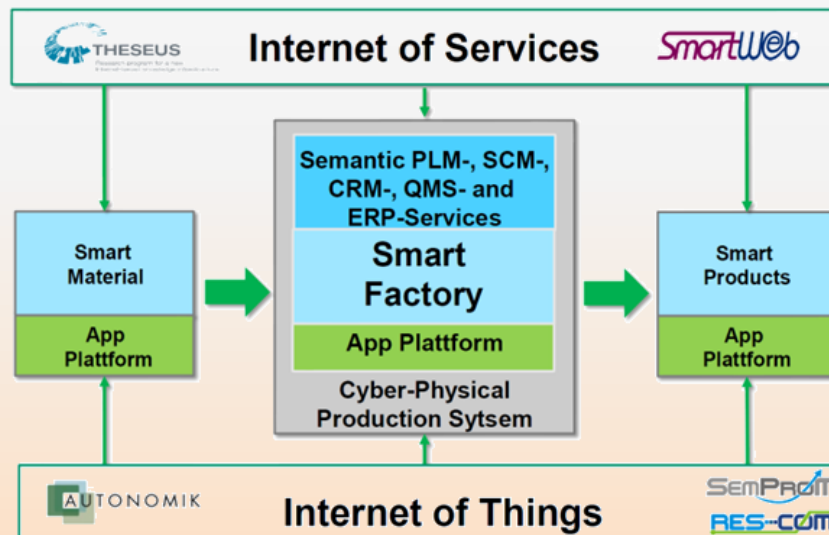
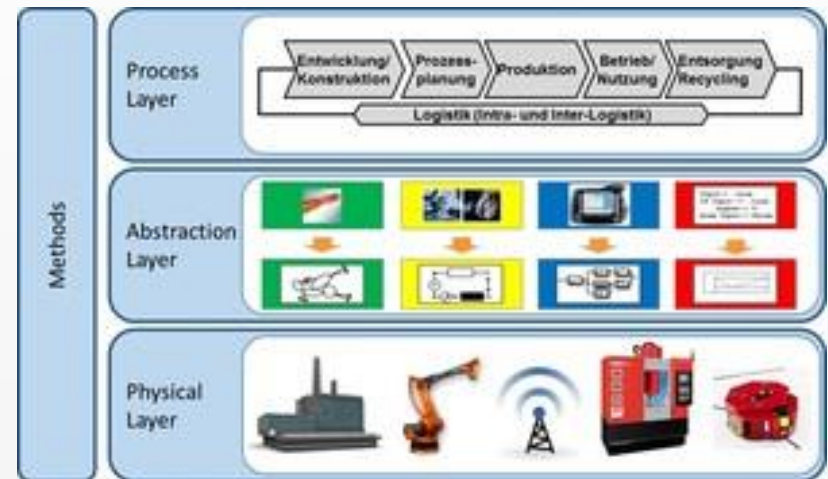
- Direct connection between the physical and digital worlds
- New system functions through information, data and function integration
- Function integration (multifunctionality)
- Access over networks (supraregional and location bound)
- "Soft" and "hard" time requirements
- Sensor and actuator networks
- System internal and external networking
- Dedicated user interfaces (integration in operational processes)
- Deployment under difficult physical boundary conditions
- Long-time operation
- Automation, adaptivity and autonomy
- High requirements of:
 - i. Functional security
 - ii. Access security and data protection
 - iii. Reliability
 - iv. Cost pressure



Source: Acatech 2011

Cyber Physical Production System (CPPS)

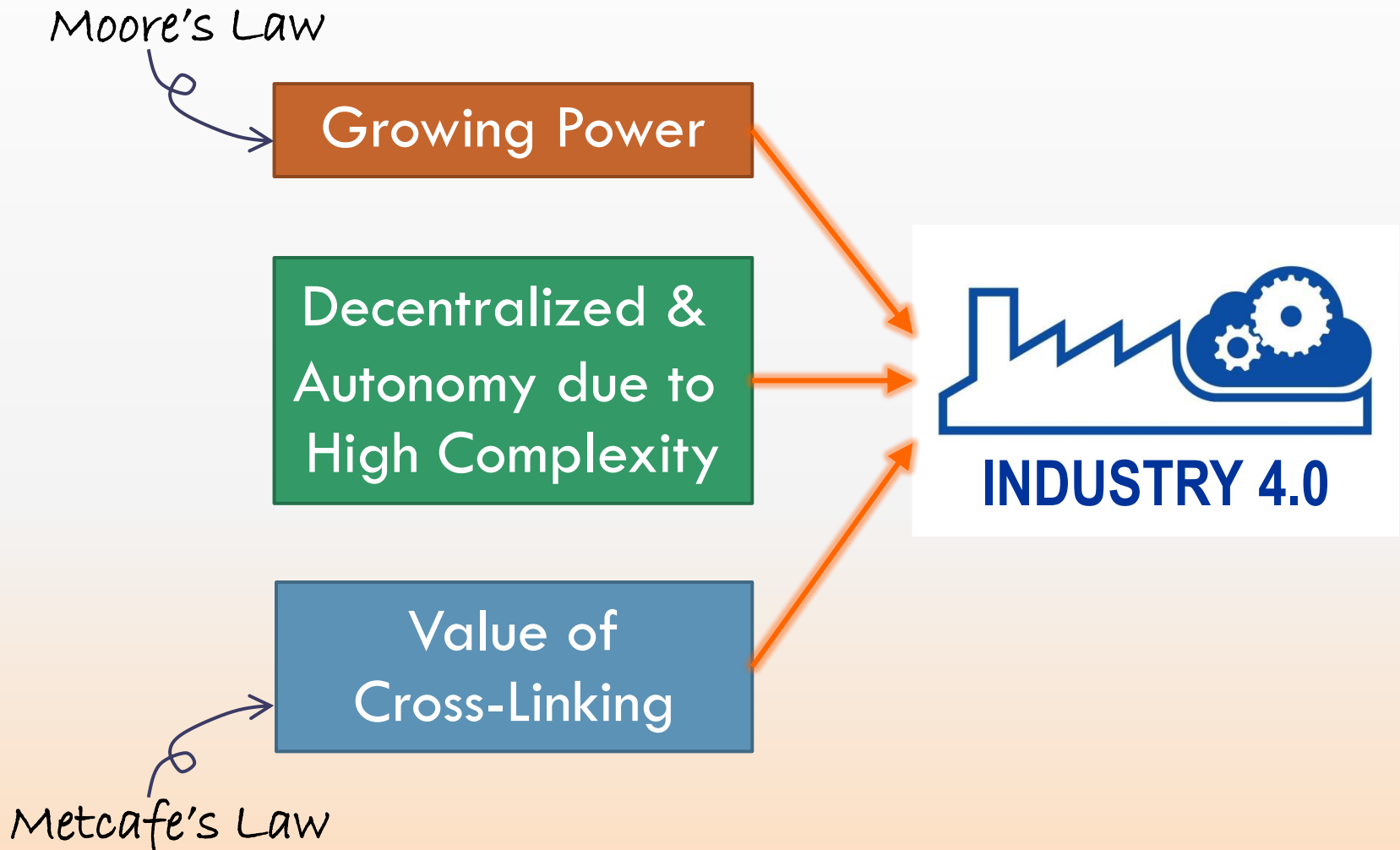
- Decentralized
- Service
- Software
- Objects of the factory



Source: Doctoral College of Cyber-Physical Production System Online. <http://dc-cpps.tuwien.ac.at/>

Smart factory in the age of Industry 4.0
(Source: Material from Prof. Wahlster's presentation, BMR 2012, Luxembourg, 2012)

Enablers of Smart Factory (The Power of IoT)



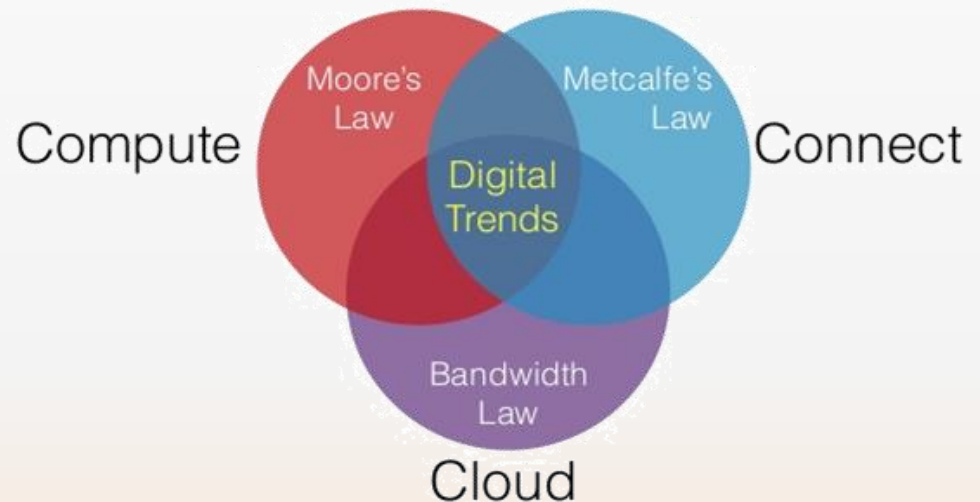
Two Crucial Rules of IT Development

Moore's Law

- Computer performance is doubled every two years and always cheaper more than half.

Metcalfe's Law

- Benefits of communication system is equal to n^2 where n is number of objects connected to each other





Advantage of Smart Factory

- CPS-optimized production processes: smart factory "units" are able to determine and identify their field(s) of activity, configuration options and production conditions as well as communicate independently and wirelessly with other units.
- Optimized individual customer product manufacturing via intelligent compilation of ideal production system which factors account product properties, costs, logistics, security, reliability, time, and sustainability considerations.
- Resource efficient production.
- Tailored adjustments to the human workforce so that the machine adapts to the human work cycle.



Key Challenges for Smart Factory

1. Complex material flow caused by high product variances
2. Short delivery times required by customer in market
3. Various software are required to manage the material flow and delivery time
 - ▣ Product Life Cycle Management (PLM)
 - ▣ Supply chain management (SCM)
 - ▣ Enterprise resource planning (ERP)
 - ▣ Scheduling system
 - ▣ Manufacturing execution systems (MES)
 - ▣ Process Control System (PCS)
4. Big data and availability of information
5. Over-simplification of complex issues due to poor data quality
6. Lack of feedback data produce poor planning and control results
7. Design of appropriate control model
8. Human problem (knowledge workforce are required)

Outline





Germany

High-Tech Strategy 2020

- The Action Plan identifies 10 “Future Projects” – including INDUSTRIE 4.0 - which are considered as being critical to addressing and realizing current innovation policy objectives as the focus of research and innovation activity.
- The INDUSTRIE 4.0 project has been allocated funding of up EUR 200 million within the High-Tech Strategy 2020 Action Plan.
- Germany aims to be the lead provider of cyber-physical systems by 2020.
- Innovative ICT research (including IT systems for INDUSTRIE 4.0) is provided by the Federal Ministry of Education and Research (BMBF) in its “ICT 2020 – Research for Innovations” program
- Software systems and knowledge processing research funding is divided into three specific categories:
 - Embedded systems focusing in particular on software-intensive embedded systems with links to electronics, communication technology and microsystems technology
 - Simulated reality for grid applications and infrastructure, virtual/augmented reality and ambient intelligence, simulation, information logistics and software development for high-performance computing
 - Human-machine interaction with language and media technologies, bioanalogous information processing, service robotics and usability



Japan

Industrial Value Chain Initiative

- Japanese companies launched the "Industrial Value Chain Initiative", the Japanese reply to Germany's Industry 4.0 and similar industrial initiatives in the U.S.
- This initiative aims at creating standards for technology to connect factories and to combine efforts to internationalize industrial standards from Japan.
- IVI members will discuss how to create common communications standards for linking factories and facilities as well as how to standardize security technology, and focusing on small and mid-sized companies.
- The idea is to move from intranet to internet - from having proprietary communications structures within organisations to having communications structures with outside organisations.



South Korea

Manufacturing Innovation 3.0

- South Korean government also announced to improve the “manufacturing innovation 3.0 strategy implementation plan.” This marks the Korean version of “Industry 4.0” formalized strategy. The use of “manufacturing innovative 3.0” was meant not intact copy Germany “Industry 4.0,” the whole idea.
- Clear strategic goals to promote manufacturing and information technology (ICT) integration, thereby creating a new industry, to enhance competitiveness of Korean manufacturing industry.
- Positioning Korea as an information technology power, with basic manufacturing and information technology industry integration.
- South Korean government also plans in 2020 to build 10,000 intelligent production facility, will total more than 20 factories in Korea ,1/3 are transformed into intelligent plant, total investment of about 24 trillion won (US \$ 23 billion) of funds, which directly into the South Korean government is less than 10% (2 trillion won), the rest were to be adopted to attract private capital investment to solve.
- In 2017, 1 trillion won investment research 3D printing, big data, networking and other eight core intelligent manufacturing technology, narrowing the gap with the leading countries as soon as the relevant technology.



China

Made in China 2025

- China is also developing its equivalent to Industry 4.0, which it is calling Made in China 2025. Made in China 2025 will borrow from Industry 4.0 to realize a similar goal.
- Germany and China have agreed to intensify cooperation on digitization of industrial processes, or Industry 4.0, or "intelligent manufacturing and digital networking of production processes."
- "General bases of cooperation" includes effective protection of intellectual property rights, voluntary decision of companies on technology transfer, joint German-Chinese development of norms and standards, data security for the firms involved and efforts to improve the framework conditions for entrepreneurs.
- Made in China 2025 focuses on promoting innovation, smart industrial transition, construction, green industry and the integration of industrialization and information technology to create leading industrial giants that help the country upgrade from its current position as the "world's factory."
- China's manufacturing industry has long been identified with low-end large-scale production and has been haunted with an association with fake goods. For this reason, there is a lot of pressure and urgency behind the push for an upgrade in the industry.



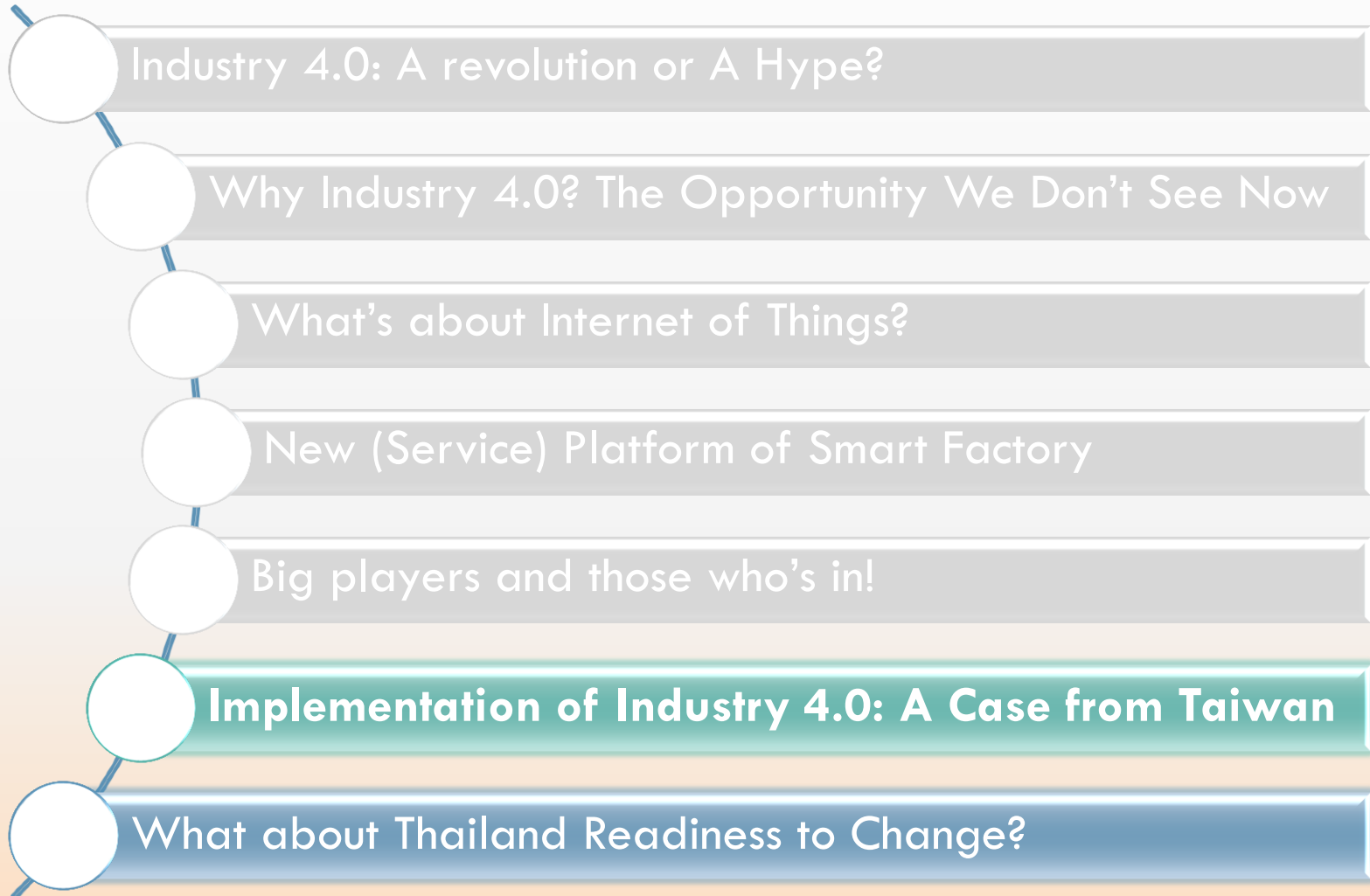
Taiwan

Productivity 4.0

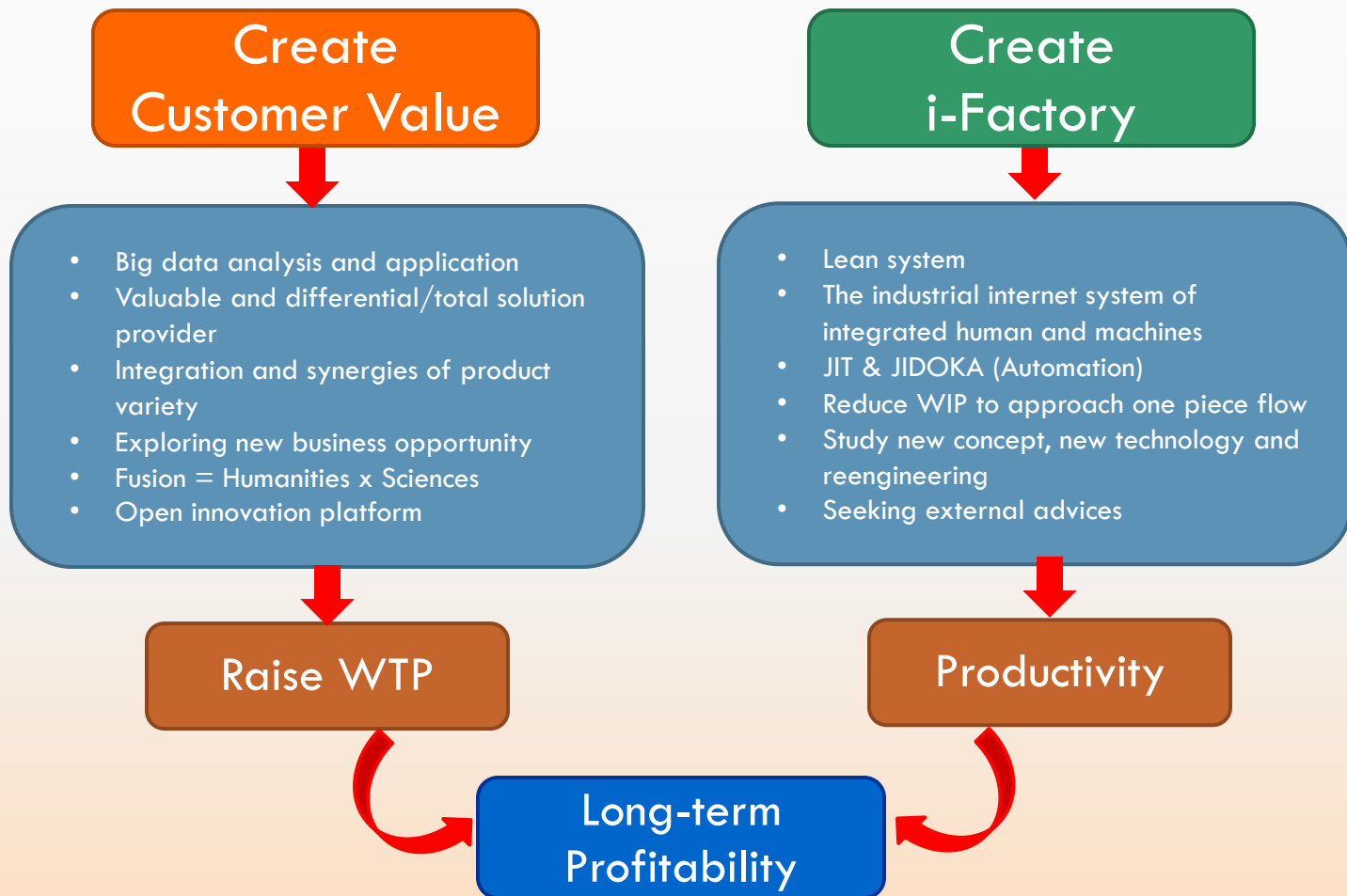
- Productivity 4.0 aims at industrial transformation and the creation of greater value added across the entire value chain in key industries in Taiwan. Productivity 4.0 incorporates the objectives and technologies of Industry 4.0, the European connected industrial automation strategy particularly associated with Germany.
- The government is planning to spend NT\$36 billion (US\$1.12 billion) over the next nine years as part of its Productivity 4.0 project to elevate Taiwan's status in the global supply chain especially on electronics/information technology, metals, transportation, machinery, foodstuffs, textiles, distribution and agriculture, helping to build smart factories to realize massive but diversified production.
- Part of the Productivity 4.0 model is the rival of a former model for industry wide, connected entrepreneurship, known as the A-Team model. This model played a key part in the establishment of Taiwanese industry in the 1950s and 1960s. Revise and utilize the A-Team model, and promoting Productivity 4.0 would help the nation's numerous small and medium-sized enterprises effectively develop their competitiveness.
- The Ministry of Education has been tasked with reviewing the comprehensiveness of teaching materials of relevant courses in the formal education system, including technical and vocational schools, universities and post graduate studies. The Ministry must determine whether graduates are equipped with sufficient fundamental knowledge.




Outline



Industry 4.0 Implementation in Taiwan: High Value Manufacturing Service Model






Industry 4.0 Implementation in Taiwan: Transformation

Plan (P)

- Set up a goal towards innovative revolution
- Establish a smart team to help building a smart enterprise

Do (D)

- Invest in intelligent facility and people to labor a man-machine integrated smart factory
- The factory combines automation and intelligence in production process (intelligent sensors are installed in production systems and integrated with ICT)



Industry 4.0 Implementation in Taiwan: Transformation

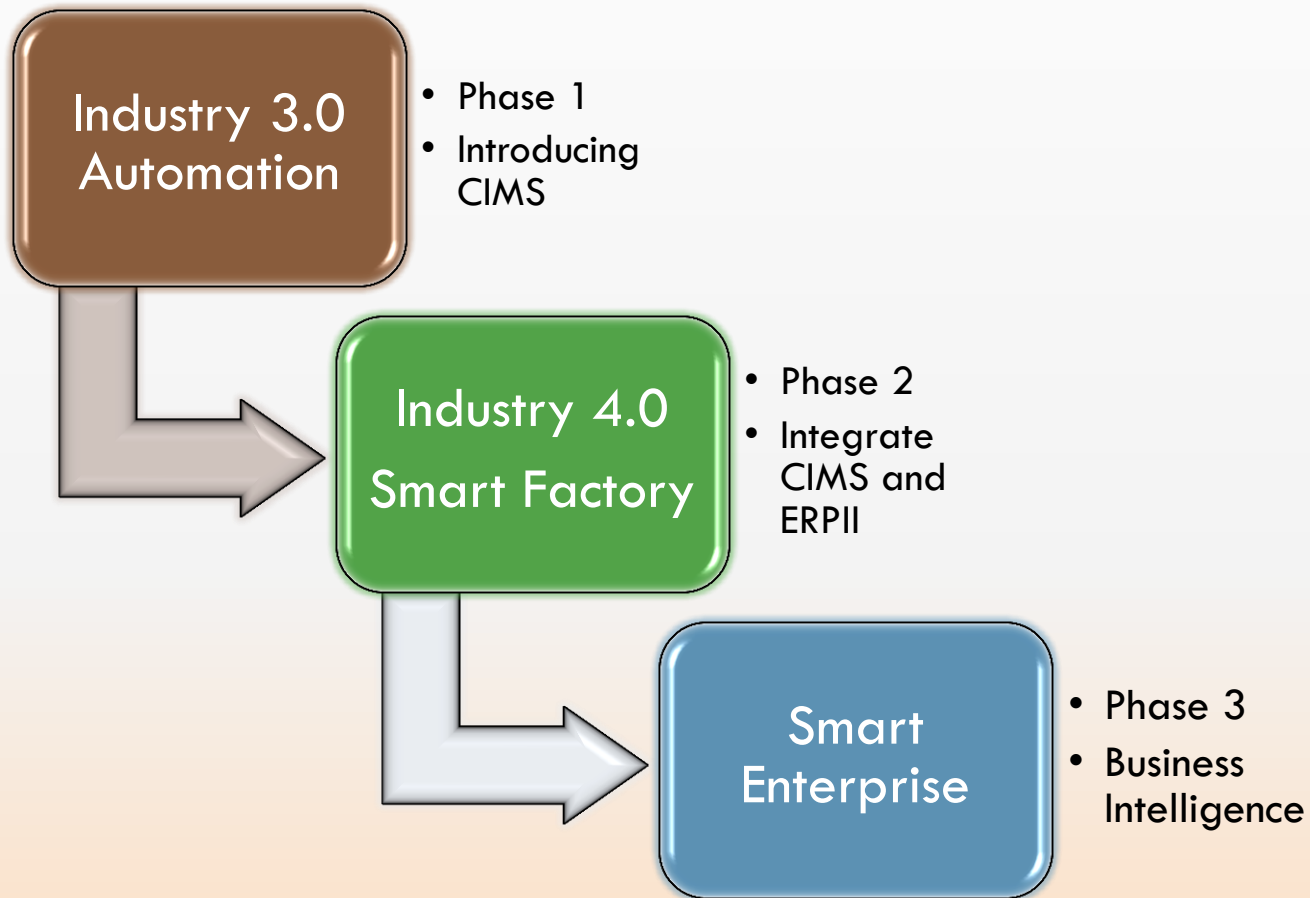
Check (C)

- Organization leaders are supported by a group of experts specialized in ERP, human resources, electronic engineering, etc...also called “smart technology team”

Act (A)

- Start reengineering the manufacturing process
 - computer integrated manufacturing system (CIMS)
 - Manufacturing execution system (MES)
- System design and technology selection

Industry 4.0 Implementation in Taiwan: Transformation



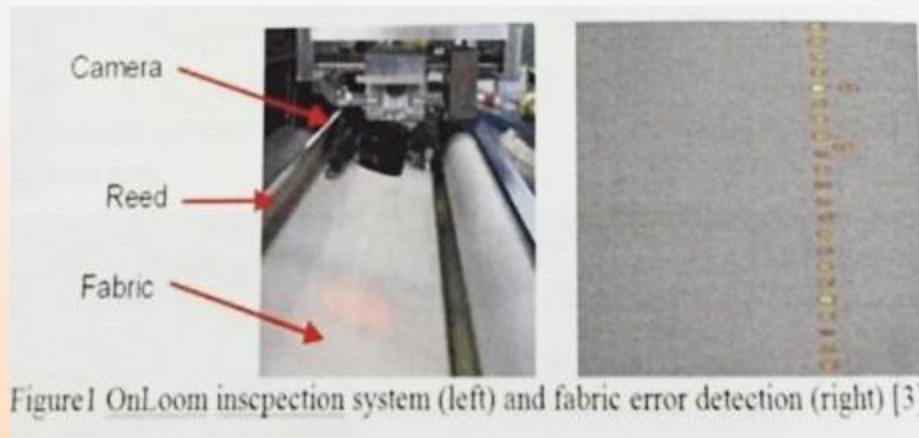
Example 1: Human-machine interactions

- Human-machine interactions help to increase transparency in production by using smart personal devices.
- Faster reaction in machine break downs. Repair of resources can be easier supported by the machine producers (Asset Information Network)
- Emerging issues & prediction: alerting of machine producers & machine operators



Example 2: Predictive and in-process quality assurance

- Predictive actions or real-time prompt reaction instead of quality controls
- Decreasing waste rates and stabilized downstream processes by real-time detection of quality issues
- Smart sensors and real-time processing enable automatic in-line flaw detection through high speed imagery processing
- Similar industry 4.0 use case implemented by SAP at German automotive manufacturer

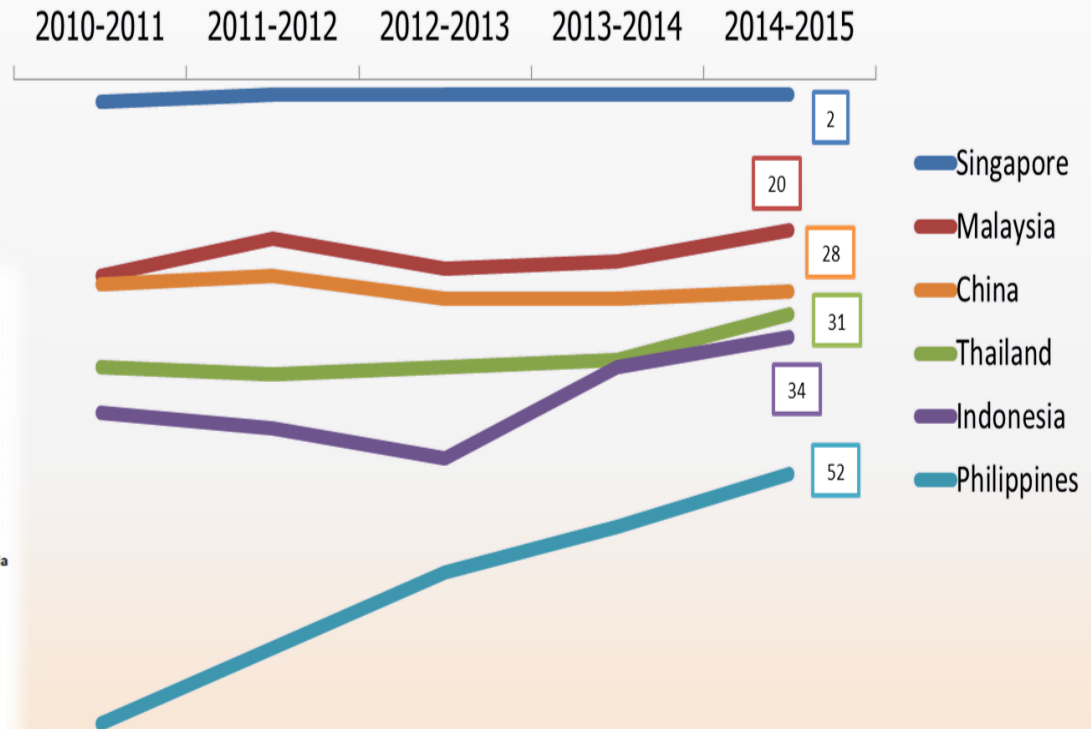
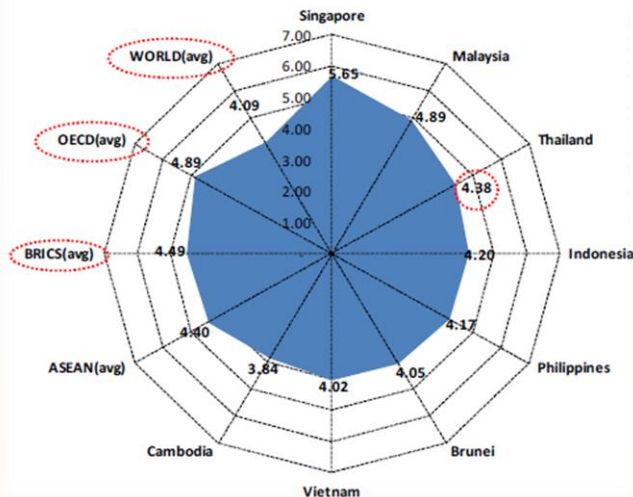


Source: Everest textile

Outline

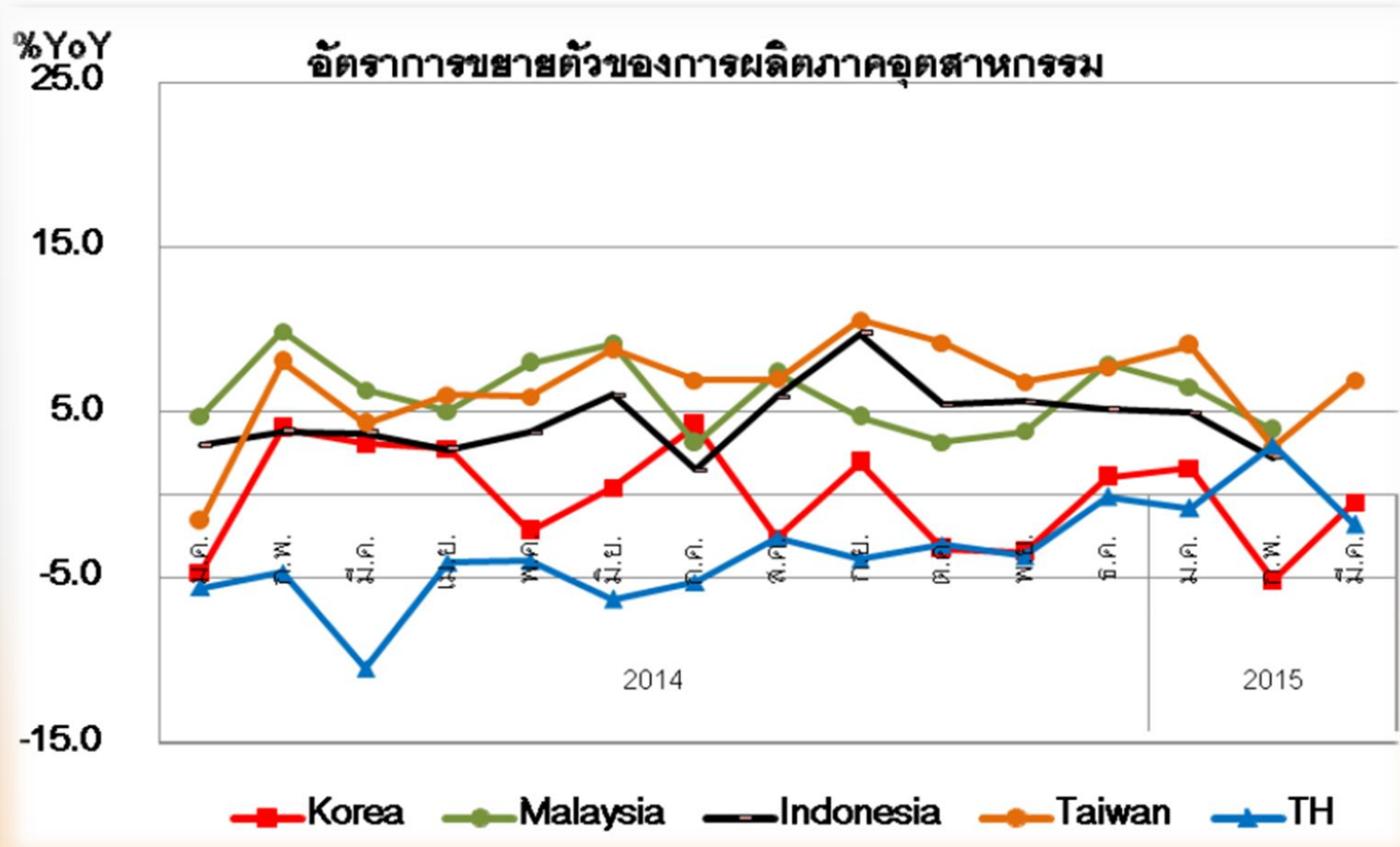


WEF Global Competitiveness Index 2010-2015 (Overall Index)



Source: The Global Competitiveness Report 2015

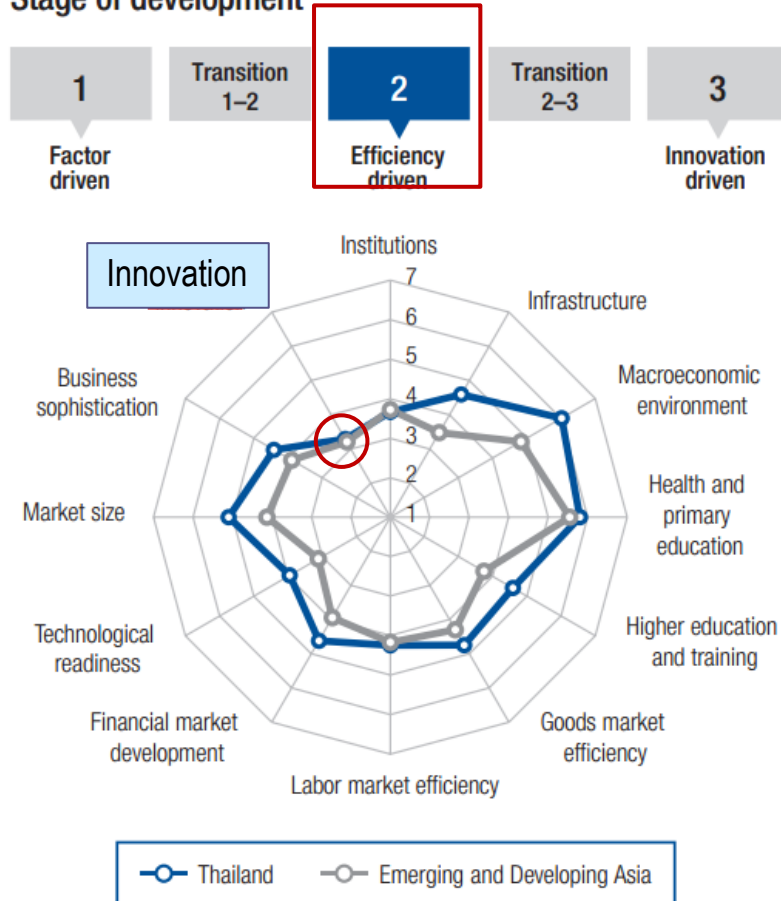
Industrial Sector Growth (Percent)



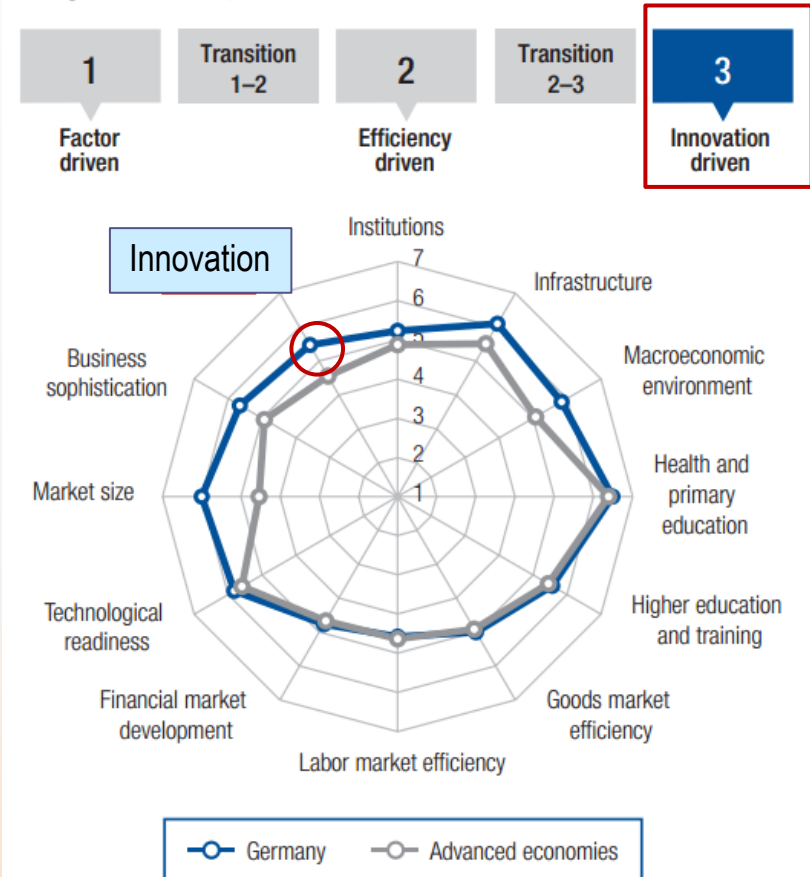
Source: Office of Industrial Economics, Thailand, 2015

National Science and Innovation Score

Stage of development

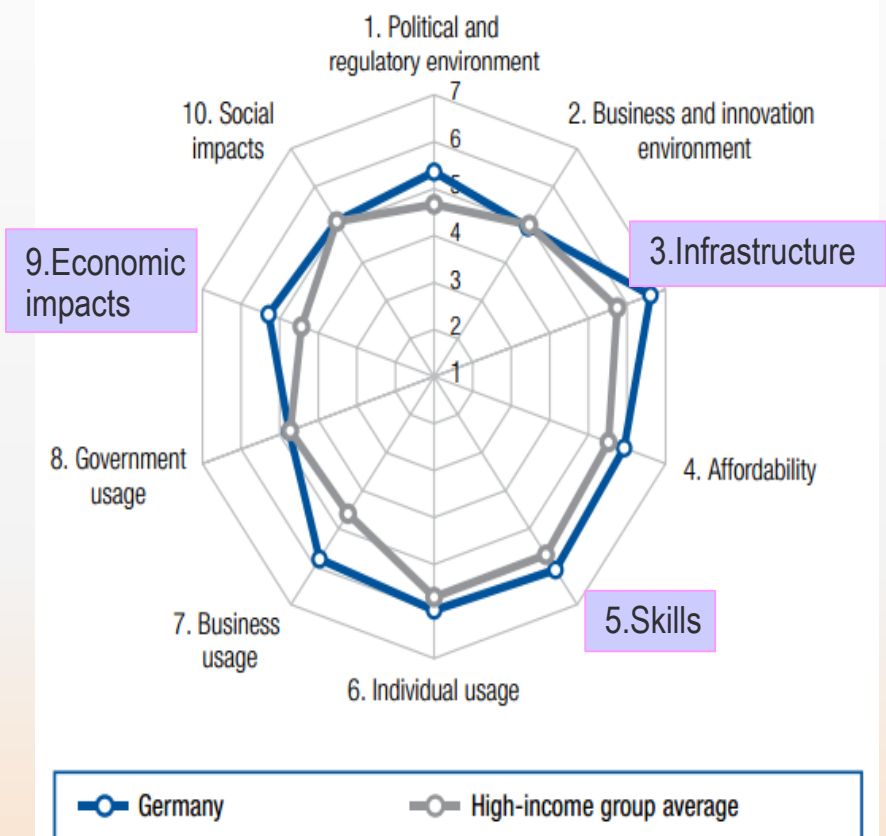
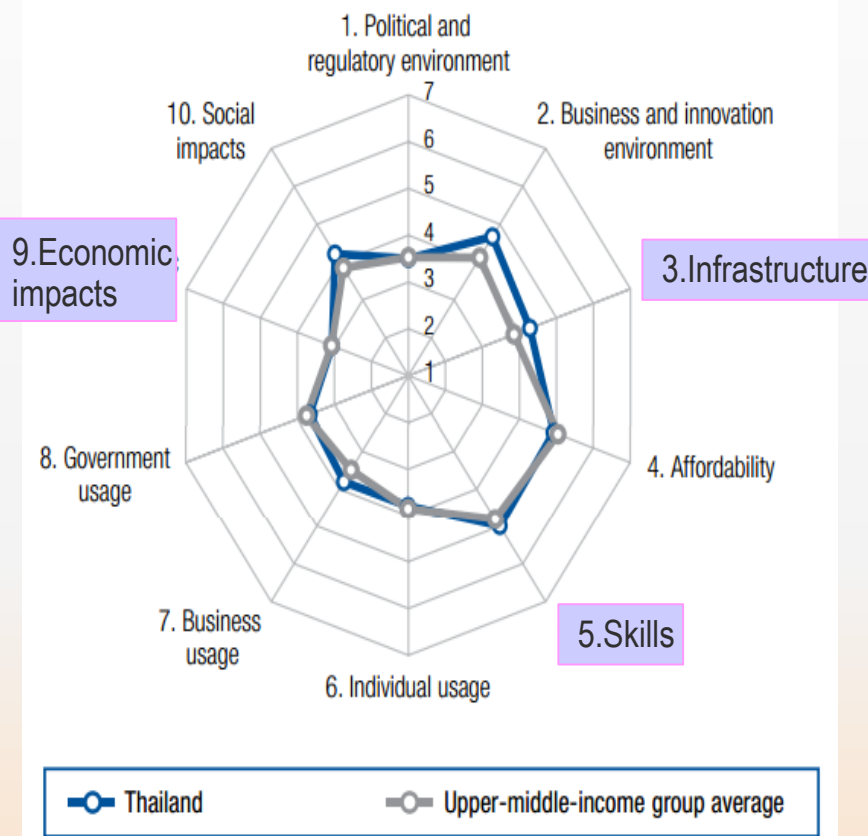


Stage of development



Source: The Global Competitiveness Report 2015

National ICT Readiness Score



Source: The Global Competitiveness Report 2015

Which industry sectors have potential for i-4.0?

Industry Sector	Level of Development (out of 4.0)
Automotive industry	3.0
Electrical and electronic industry	3.0
Food industry	2.5
Garment and textile industry	2.5
Hard and metal industry	3.0
Service industry	2.5

Source: An unofficial study report by KETM, 2015

Kasetsart Business School
Kasetsart Energy and Technology Management Center

THANK YOU