Assessing quantitative/qualitative risks and benefits in the era of the Fourth Industrial Revolution

Prof. dr. Takis Damaskopoulos
Industry 4.0 impact on management practices and economics (IN4ACT)
ERA Chair Holder
School of Economics and Management
Kaunas University of Technology

The historical setting

Industry 4.0 in historical perspective: Is there a Fourth Industrial Revolution underway?

Part I: Micro-level – Industry 4.0 at the level of the firm, functions and phases of production

I. 1. The decomposition / re-composition of production and the changing value composition of Global Value Chains

I. 2. AI: the cloud, big data, algorithmic models and the Internet of Everything

I. 3. The “platform economy” and associated business models: the changing form of the corporation

Part II: Meso-level – Industry 4.0 at the level of regional economic and innovation ecosystems

II. 1. Centralization vs. decentralization in Industry 4.0

II. 2. The changing economic geography of Industry 4.0

II. 3. The challenges of commoditization and “smart specialization”

Part III: Macro-level – Industry 4.0 at the level of governance systems and innovation strategy

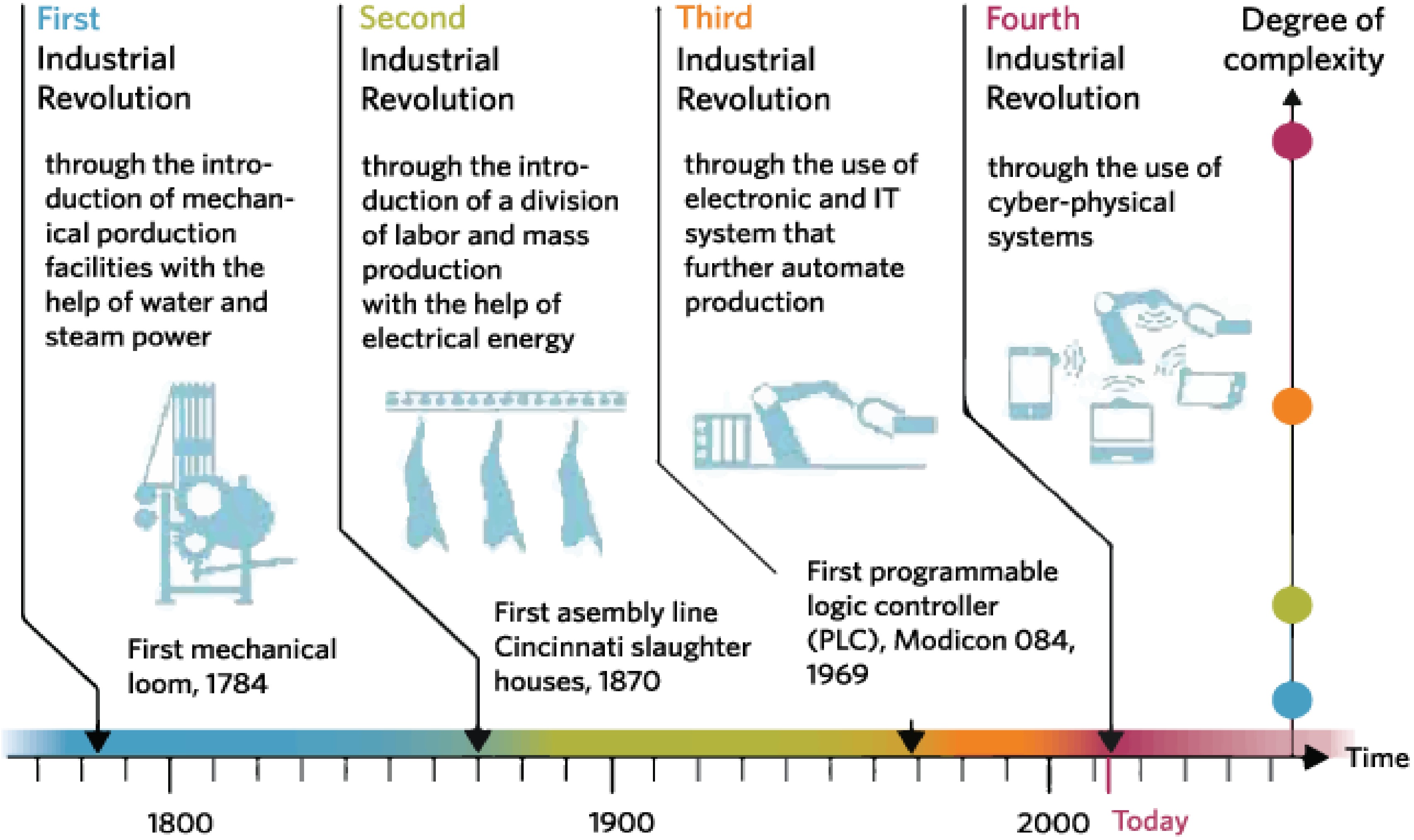
III. 1. Methods and approaches for assessing comparative readiness for Industry 4.0

III. 2. Employment and skillset challenges in Industry 4.0

III. 3. Systems of business and innovation governance: regulation, innovation and sustainability in Industry 4.0

VUCA

Volatility, Uncertainty, Complexity, Ambiguity



Source: Deutsches Forschungszentrum für Künstliche Intelligenz, (DFKI), 2011.

Why a “Fourth Industrial Revolution”?

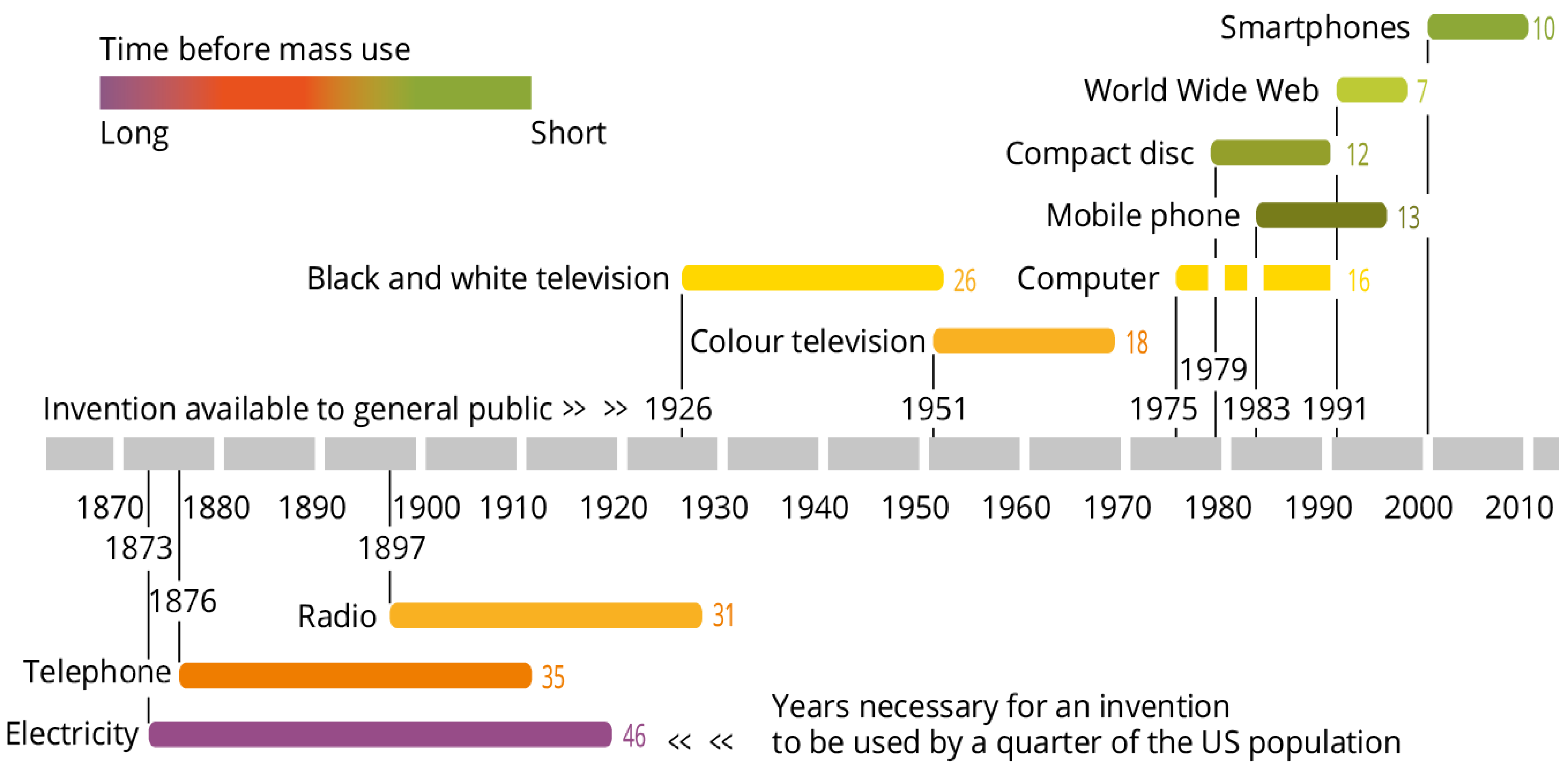
The origins of the Fourth Industrial Revolution can be traced to the beginning of this century and builds on and amplifies the impact of the digital revolution. So why not call it a more intense phase, a phase of maturation, of the computer or digital revolution? There are mainly three reasons why not:

- ***Velocity and scale*:** In contrast to the previous industrial revolutions, the Fourth Industrial Revolution has the potential to evolve at an exponential rather than linear pace;

- ***Breadth and depth*:** the Fourth Industrial Revolution builds on the digital revolution and combines multiple technologies from across various fields that have the potential to lead to unprecedented paradigm shifts in established practices in the domains of business, the economy, and society;

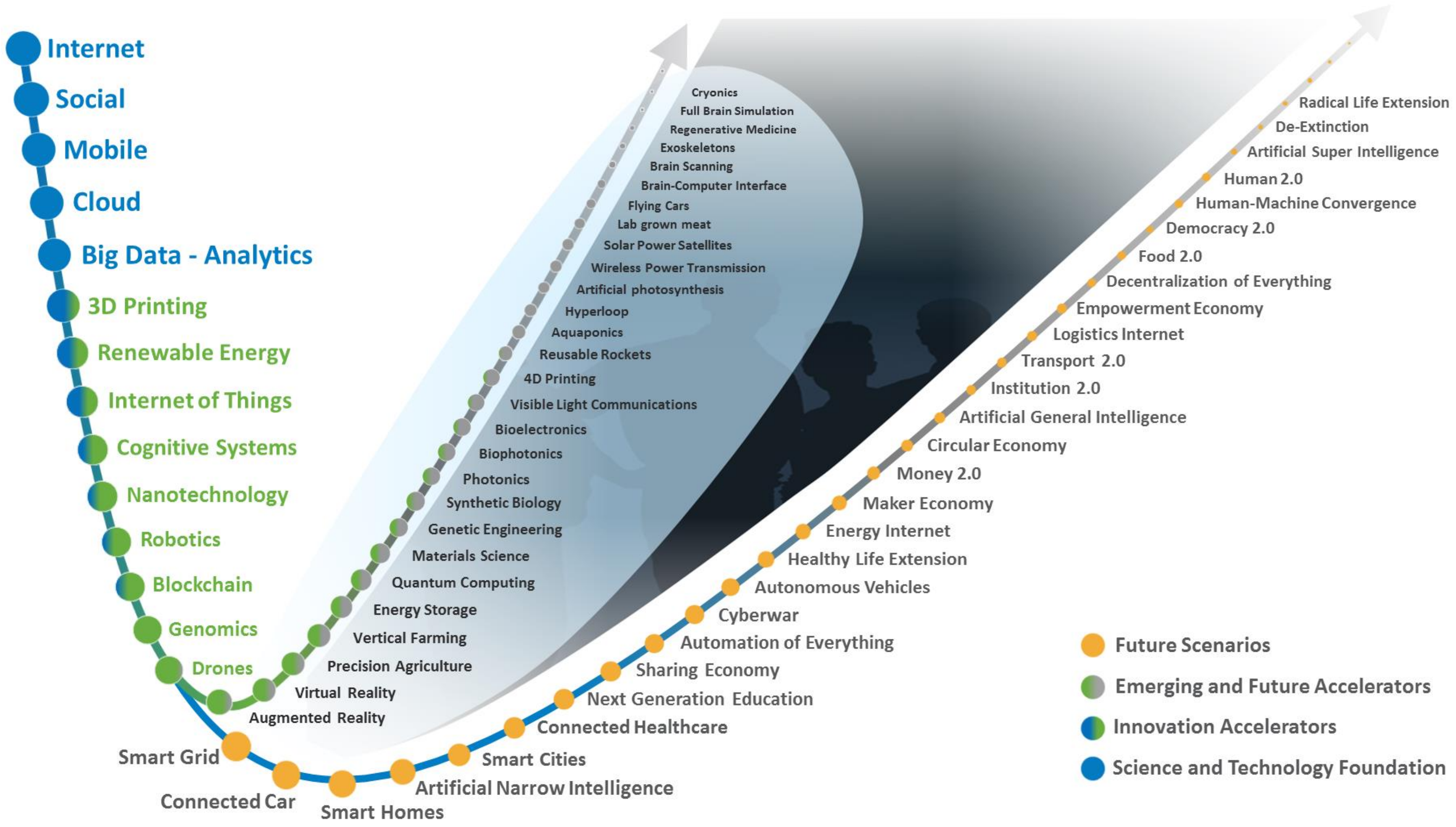
- ***Systemic Impact*:** the Fourth Industrial Revolution presents the real possibility of transforming entire systems, across and within countries, companies, industries and civil society as a whole and the structures of the state.

Velocity: Shortening Time Lapse before Mass Adoption of New Technologies



Source: World Economic Forum, *Mitigating Risks in the Innovation Economy*, 2017.

Breadth and depth: systemic impact



The iPhone: “Made in the World”

Manufacturing Network

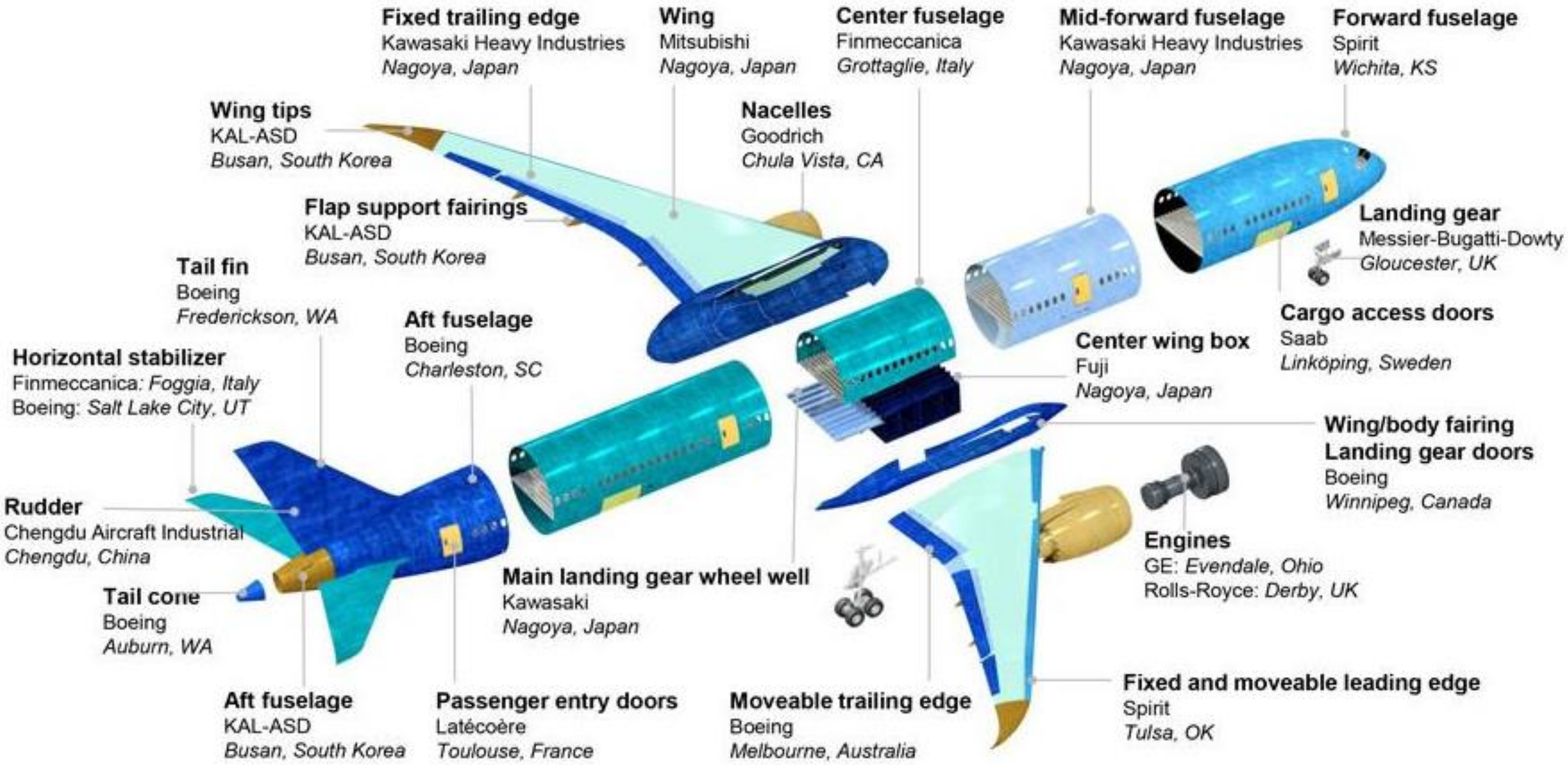
Accelerometer: Bosch Sensortech (Germany)
Audio chipsets: Cirrus Logic (US)
Baseband processor: Qualcomm (US)
Battery: Samsung (Korea)
Battery: Huizhou Desay Battery (China)
Camera: Qualcomm (US)
Camera: Sony (Japan)
Chips for 3G/4G/LTE networking: Qualcomm (US)
Compass: AKM Semiconductor (Japan)
Glass screen: Corning (US)
Gyroscope: STMicroelectronics (France, Switzerland)
eCompass: Alps Electric (Japan)
Flash memory: Toshiba (Japan), Samsung (Korea)
DRAM: TSMC (Taiwan)
LCD screen: Sharp (Japan), LG. (Korea)
A-series Processor: Samsung (Korea), TSMC (Taiwan)
Touch ID: TSMC (Taiwan), Xintec (Taiwan)
Touchscreen controller: Broadcom (US)
Wi-Fi chip: Murata (US)
Fingerprint authentication: Authentec (China, Taiwan)

Assembly Network

Hon Hai Precision Industry Co. Ltd. or Foxconn (its trading name) (Taiwan, with locations in China, Thailand, Malaysia, the Czech Republic, South Korea, Singapore, and the Philippines)

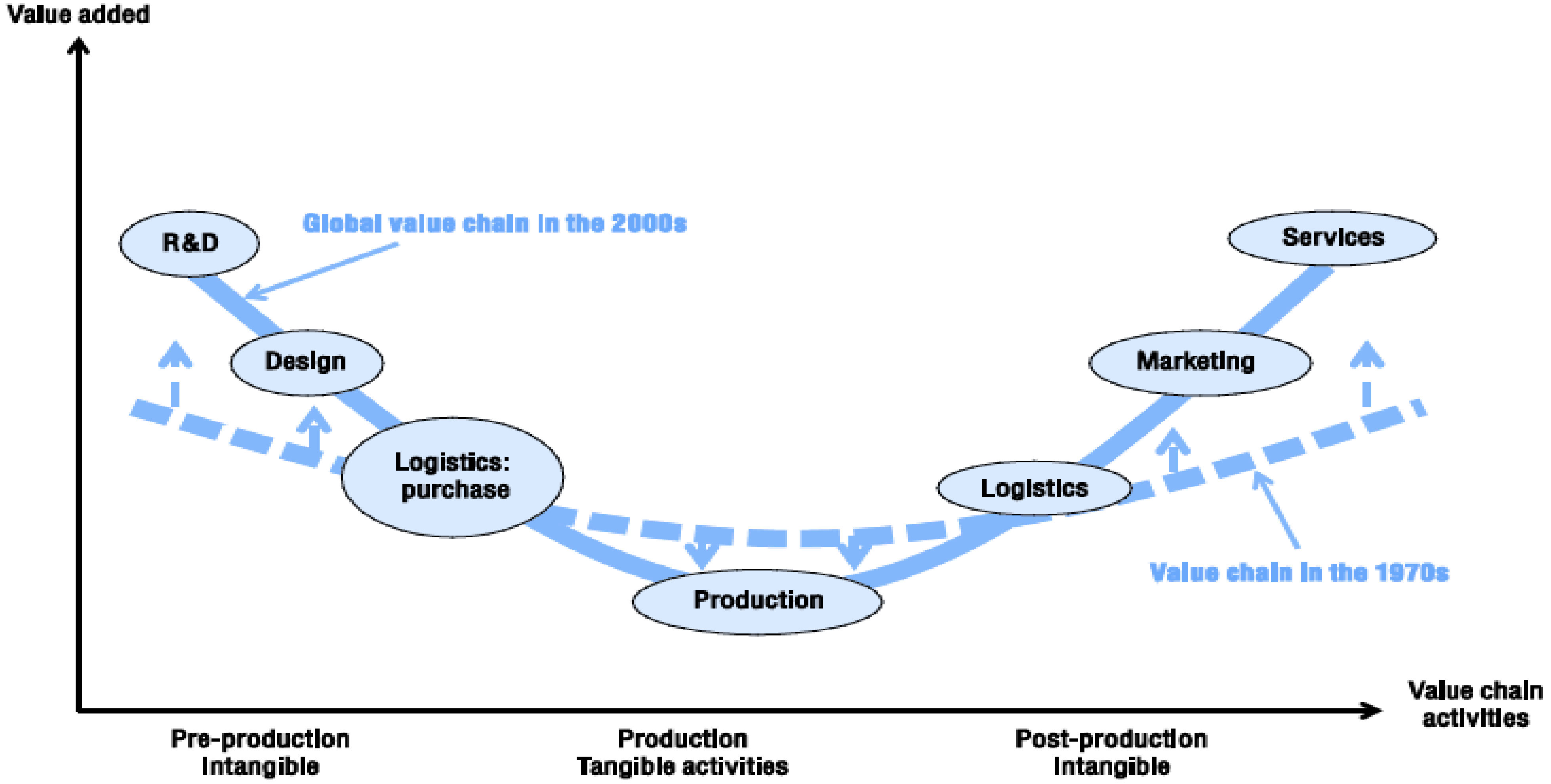
Pegatron (Taiwan)

The Boeing 787 Dreamliner: “Made in the World”



Source: Boeing, 2015.

Global Value Chains: qualifying the “global”



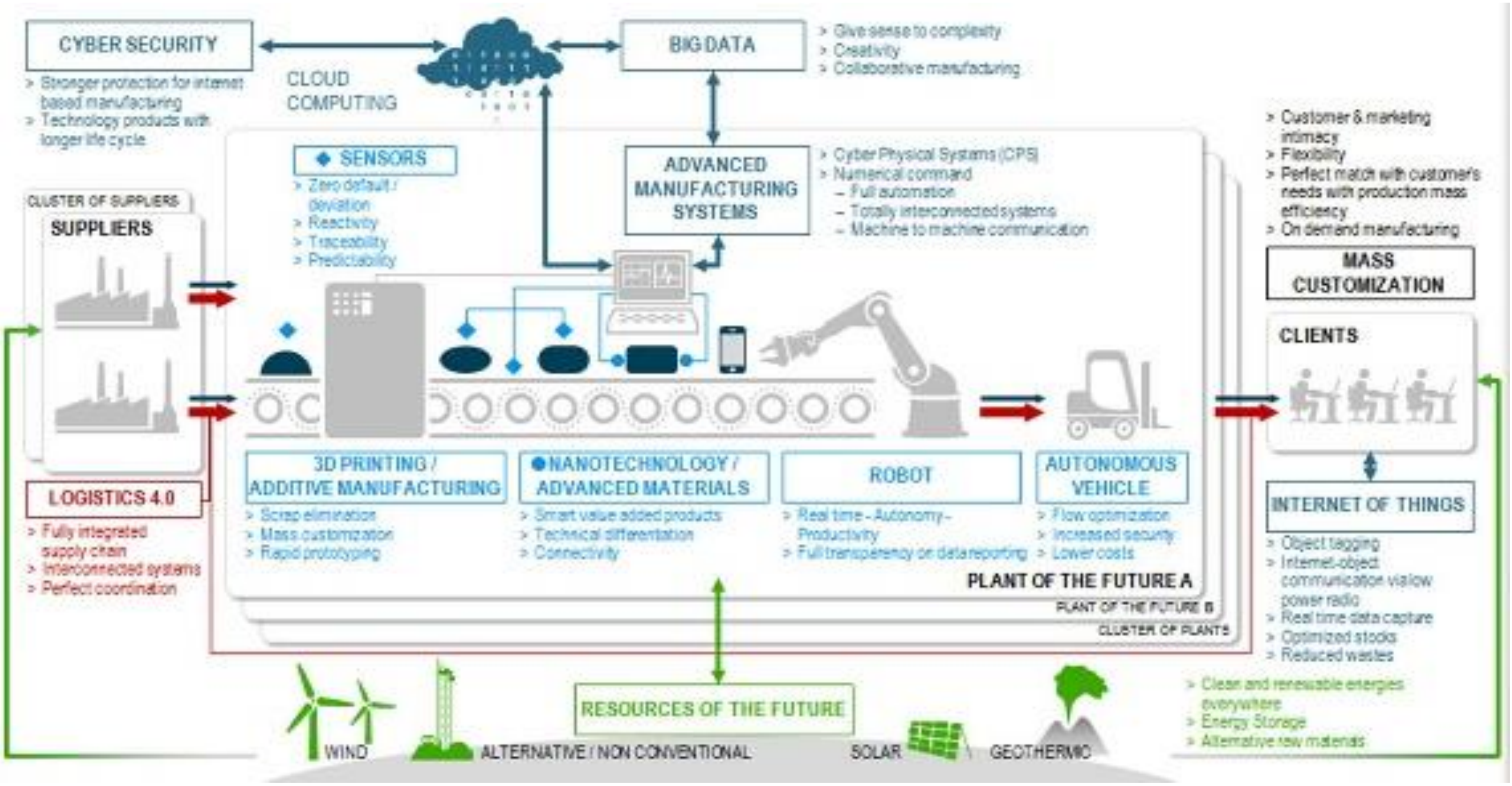
Source: OECD, *Interconnected Economies: Benefiting from Global Value Chains*, Paris 2013.

Key characteristics of Industry 4.0

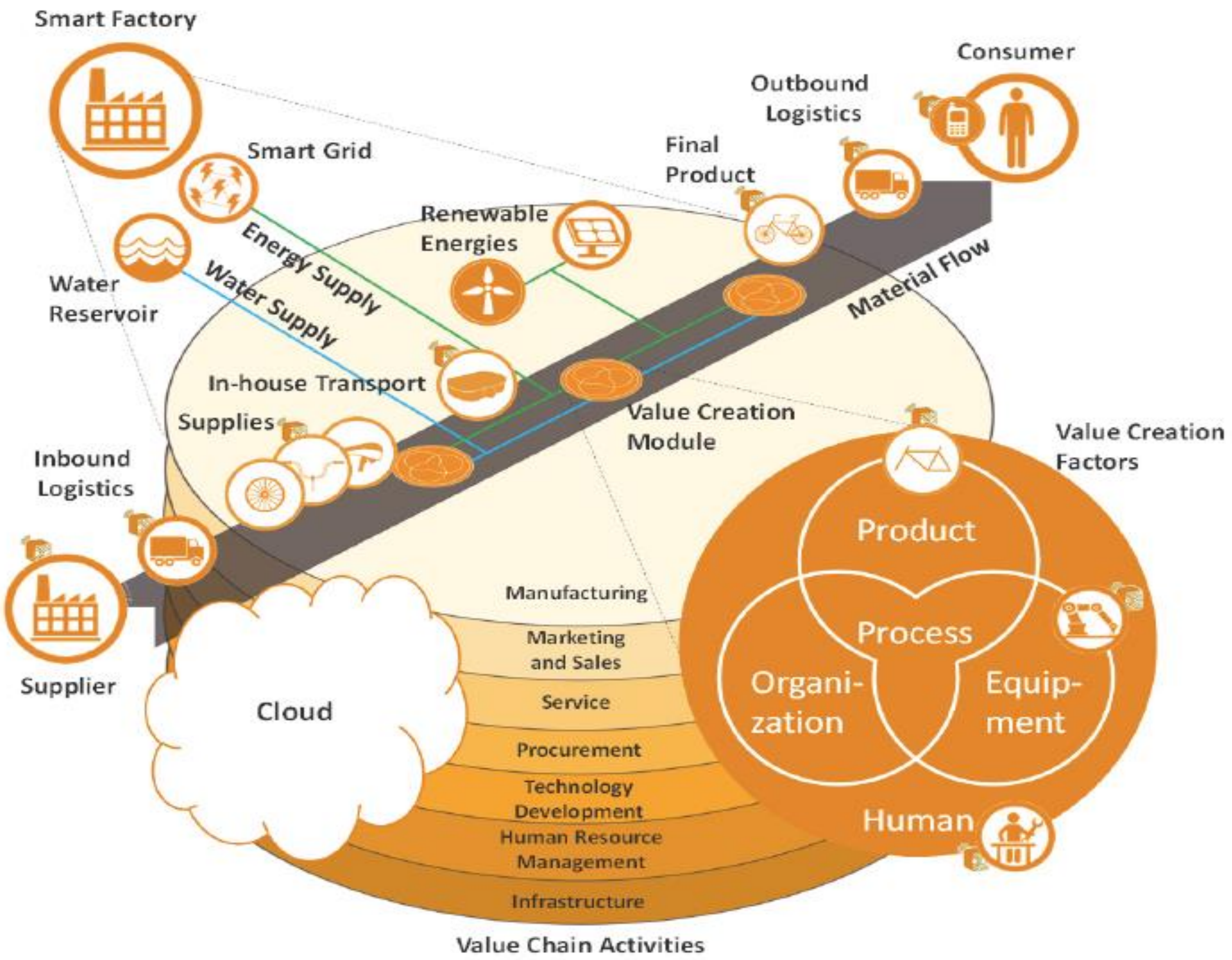
Industry 4.0 refers to:

- The technological evolution from embedded systems to cyber-physical systems (CPS), a *paradigm shift* from “centralized” to “decentralized” production.
- I4.0 involves the organisation of production processes based on technology and devices autonomously communicating with each other along the value chain: a model of the ‘smart’ factory of the future where computer-driven systems monitor physical processes, create a virtual copy of the physical world and make decentralised decisions based on self-organisation mechanisms.
- In I4.0 manufacturing systems are *vertically networked* with business processes within factories and enterprises, and *horizontally connected to spatially dispersed value networks that can be managed in real time* – from the moment an order is placed right through to the outbound logistics.
- The distinction between industry and services becomes blurred. Digital technologies are connected with industrial products and services into hybrid products that cannot be exclusively defined as goods or services. Within the modular structured smart factories, CPS and networks monitor physical processes, creating a virtual copy of the physical world and making decentralized decisions.
- Using the Internet of Things CPS communicate and cooperate among each other and with humans in real time. Through the Internet of Services internal and cross-organizational services are offered and used by the value chain participants. Smart data is collected and processed throughout the whole product life cycle. This generates optimization of smart, flexible supply chains and distribution models, and also efficient and optimized use of machines and equipment. Businesses are able to make quicker, smarter decisions, quickly responding to customer demands, while minimizing costs.

The technological ecosystem of Industry 4.0

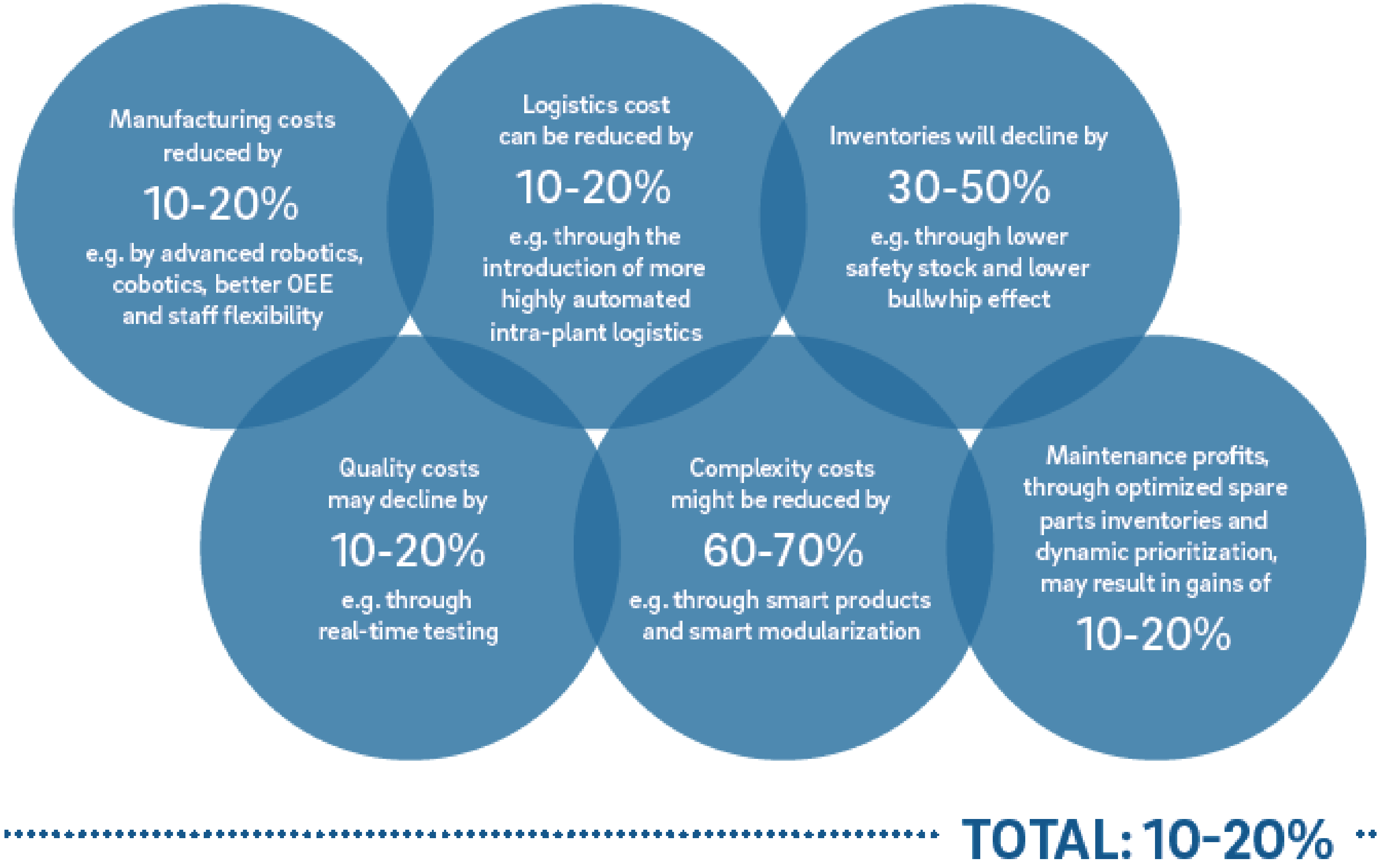


A micro-perspective on Industry 4.0: the “smart factory”



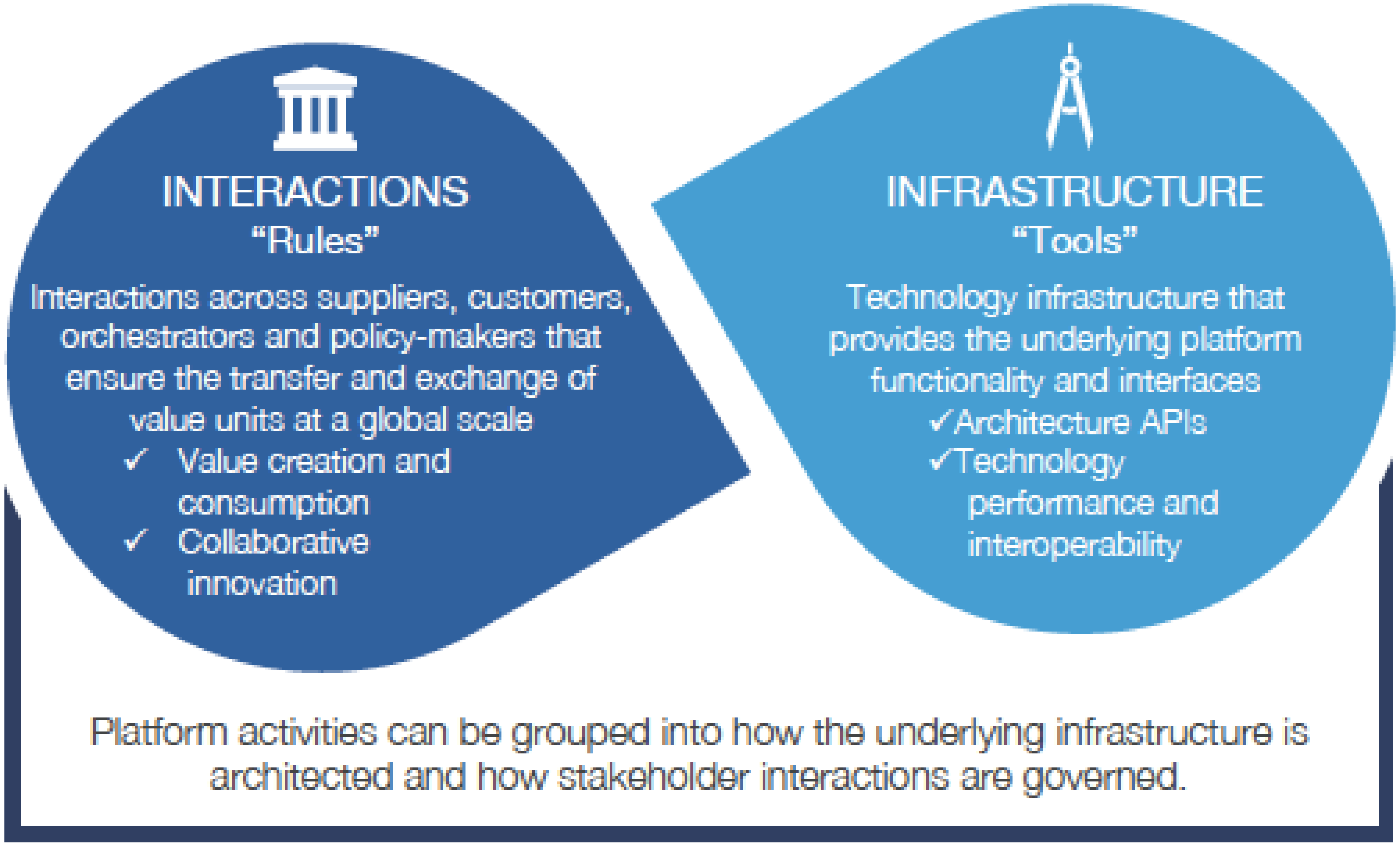
Projected efficiency gains

Digital factories are predicted to reduce cost in almost all operations functions



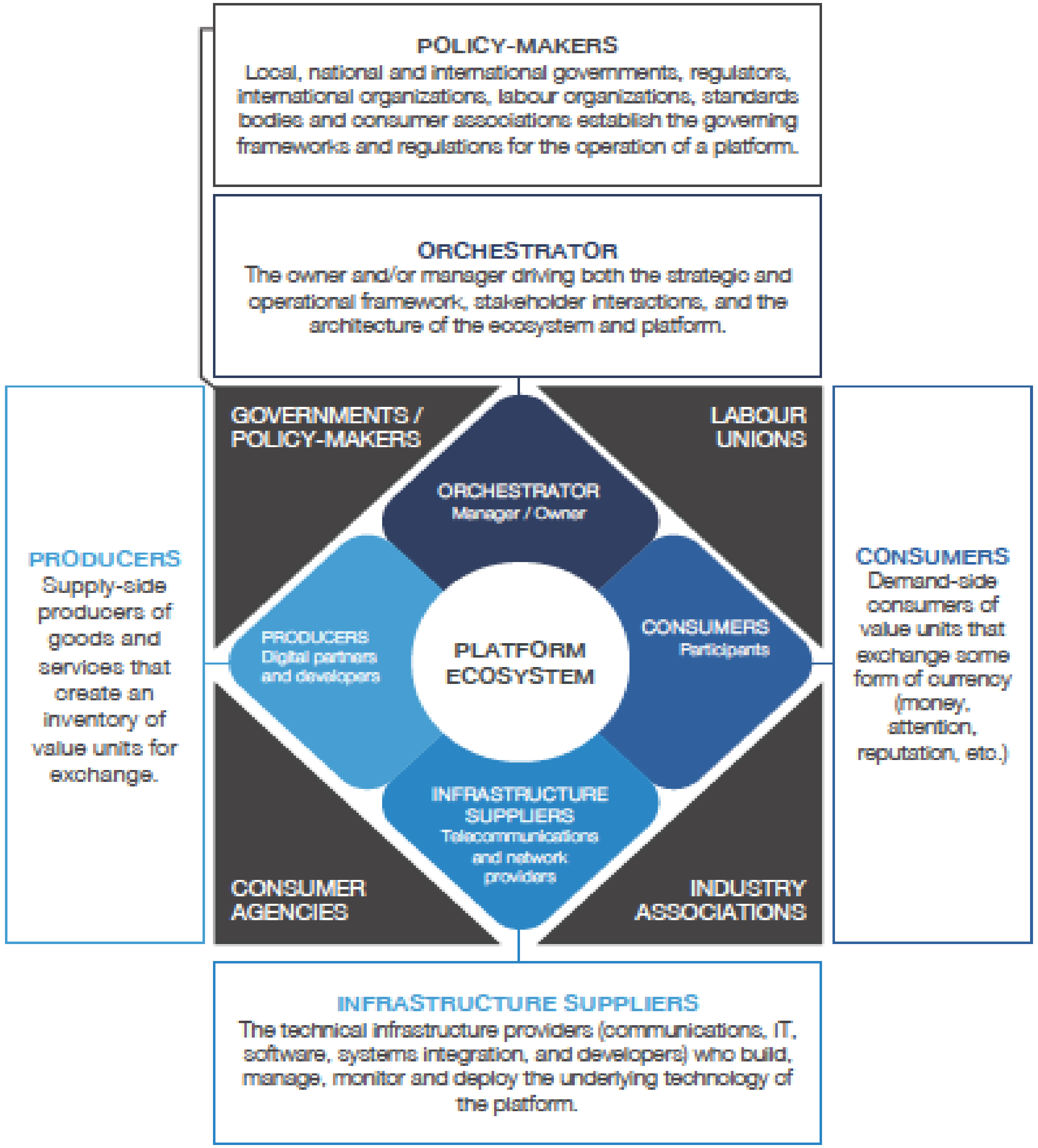
Source: Fraunhofer Institue for Manufacturing Engineering and Automation (IPA), 2016.

The two functional elements of platforms



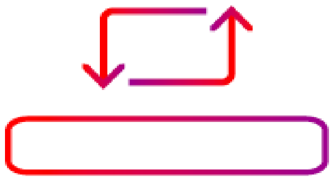
Source: World Economic Forum, *Digital Transformation Initiative: Unlocking B2B Platform Value*, 2017.

Platform ecosystem roles and interactions

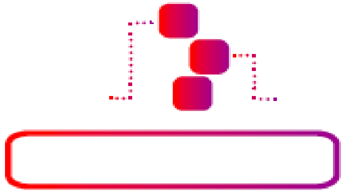


Source: World Economic Forum, *Digital Transformation Initiative: Unlocking B2B Platform Value*, 2017.

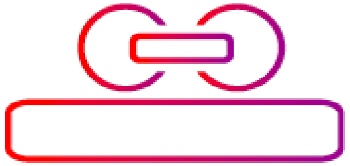
Platform types



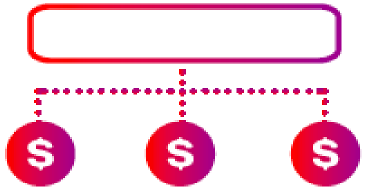
Transaction platforms: A transaction platform is a technology, product or service that acts as a conduit (or intermediary) facilitating exchange or transactions between different users, buyers, or suppliers.



Innovation platforms: An innovation platform is a technology, product or service that serves as a foundation on top of which other firms (loosely organized into an innovative ecosystem) develop complementary technologies, products or services.



Integrated platforms: An integrated platform is a technology, product or service that is both a transaction platform and an innovation platform. This category includes companies such as Apple, which has both matching platforms like the App Store and a large third-party developer ecosystem that supports content creation on the platform.

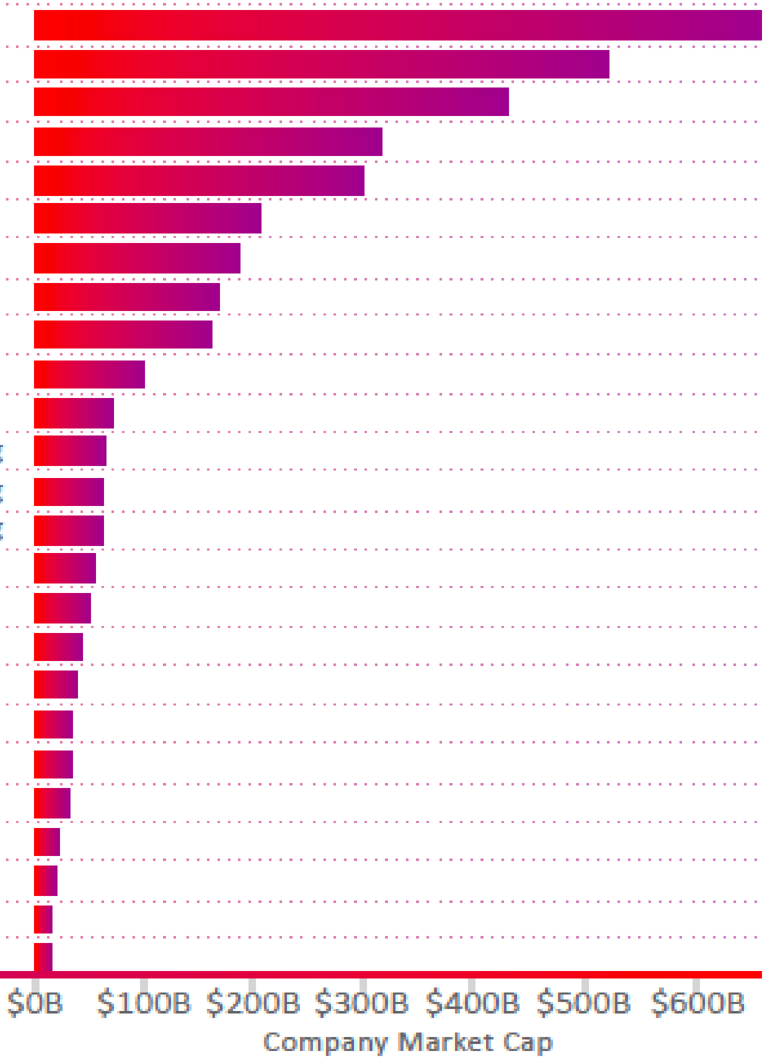


Investment platforms: Investment platforms consist of companies that have developed a platform portfolio strategy and act as a holding company, active platform investor or both.

Source: The Centre for Global Enterprise, *The Rise of the Platform Enterprise: A Global Survey,* 2016.

Top 25 Publicly Traded Platforms

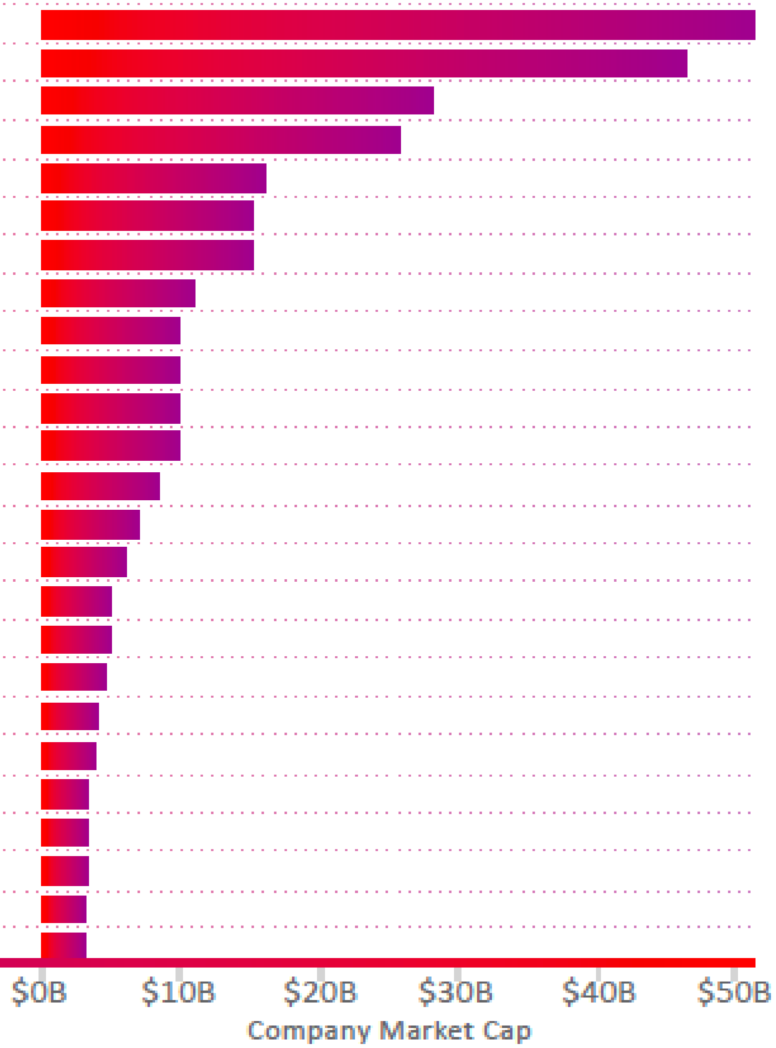
RANK	Company	Country	Type	Platform Type
1	APPLE	US	Public	Integrated
2	GOOGLE	US	Public	Integrated
3	MICROSOFT	US	Public	Innovation
4	AMAZON	US	Public	Integrated
5	FACEBOOK	US	Public	Integrated
6	ALIBABA	China	Public	Integrated
7	TENCENT	China	Public	Transaction
8	ORACLE	US	Public	Innovation
9	INTEL	US	Public	Innovation
10	SAP	Germany	Public	Innovation
11	BAIDU	China	Public	Transaction
12	SOFTBANK	Japan	Public	Investment/Holding
13	NASPERS	S. Africa	Public	Investment/Holding
14	PRICELINE	US	Public	Investment/Holding
15	NETFLIX	US	Public	Transaction
16	SALESFORCE	US	Public	Innovation
17	PAYPAL	US	Public	Transaction
18	JD.COM	China	Public	Transaction
19	EBAY	US	Public	Transaction
20	LINKEDIN	US	Public	Transaction
21	YAHOO!	US	Public	Transaction
22	YAHOO JAPAN	Japan	Public	Transaction
23	RAKUTEN	Japan	Public	Transaction
24	NAVER	South Korea	Public	Transaction
25	TWITTER	US	Public	Transaction



Source: The Centre for Global Enterprise, *The Rise of the Platform Enterprise: A Global Survey*, 2016.

Top 25 Privately Owned Platforms

RANK	Company	Country	Type	Platform Type
1	UBER	US	Private	Transaction
2	XiaMi	China	Private	Transaction
3	AliPay	China	Private	Transaction
4	Airbnb	US	Private	Transaction
5	Snapchat	US	Private	Transaction
6	Didi Kuaidi	China	Private	Transaction
7	Flipkart	India	Private	Transaction
8	Pinterest	US	Private	Transaction
9	Dropbox	US	Private	Transaction
10	Lu.com	China	Private	Transaction
11	Lufax	China	Private	Transaction
12	WeWorK	US	Private	Transaction
13	Spotify	Sweden	Private	Transaction
14	Meituan	China	Private	Transaction
15	Meizu.com	China	Private	Transaction
16	Olacabs	India	Private	Transaction
17	Stripe	US	Private	Transaction
18	Zenefits	US	Private	Transaction
19	Dianping	China	Private	Transaction
20	Shanghai Han Tao	China	Private	Transaction
21	Beijing Feixiangren	China	Private	Transaction
22	Credit Karma	US	Private	Transaction
23	Atlassian	Australia	Private	Transaction
24	Delivery Hero	Germany	Private	Transaction
25	Fanatics	US	Private	Transaction



Source: The Centre for Global Enterprise, *The Rise of the Platform Enterprise: A Global Survey*, 2016.

Macroeconomic Transformation – The Platform Economy

Industrial Era Changed every aspect of life	**Digital Economy Era** Transforming every dimension of life
Products	Platforms
Value chains (linear)	Ecosystems (non-linear)
Power of controlling supply chain	Coordination of supply chain
Supply-side economies of scale	Demand-side economies of scale
Physical assets and capital depreciation	Digital assets and innovation capital
Diminishing returns	Distribution power law and network effects
Market valuations driven by return on assets	Market valuations driven by ecosystems
Growth organic or via mergers & acquisitions	Growth driven by asymmetric network effects
GDP as economic measurement	New measures, digital density & ‘free goods’

Macroeconomic Transformation – The Platform Economy

The Business Model of the Industrial Era	The ‘platform economy’ business model

❑ Centered on the corporate imperative for growth
❑ Scale and asset-heavy
❑ Vertical integration
❑ Asset-heavy
❑ Hierarchy attached to “job ladders”
❑ Performance measured by industrial “territory” and market “footprint”
	❑ Centered on big data and algorithms
	❑ Finance-heavy in the sense that “size” relates predominantly to market capitalization value
	❑ Asset-light (but variations apply)
	❑ Labor-light (minimal employment commitments disappearance of ‘job ladders’)
	❑ Oriented toward market capture through:
	  ❑ Monopoly (Google, Facebook) or
	  ❑ Monopsony (Amazon)

Detroit (February 2018)

GM
Market capitalization; $57,06 bn
Revenue: $166,3 bn
Employees: 209,000

Ford
Market capitalization; $42,16 bn
Revenues: $151,8 bn
Employees: 201,000

FCA FIAT CHRYSLER AUTOMOBILES
Market capitalization; $32,65 bn
Revenue: 111 bn (2016)
Employees: 225,587

Totals:
Market cap: $131,87 bn
Revenues: $429,10 bn
Employees: 635,587

Silicon Valley (February 2018)

Market capitalization; $905,15 bn
Revenue: $ 229,2 bn
Employees: 123,000 (global)

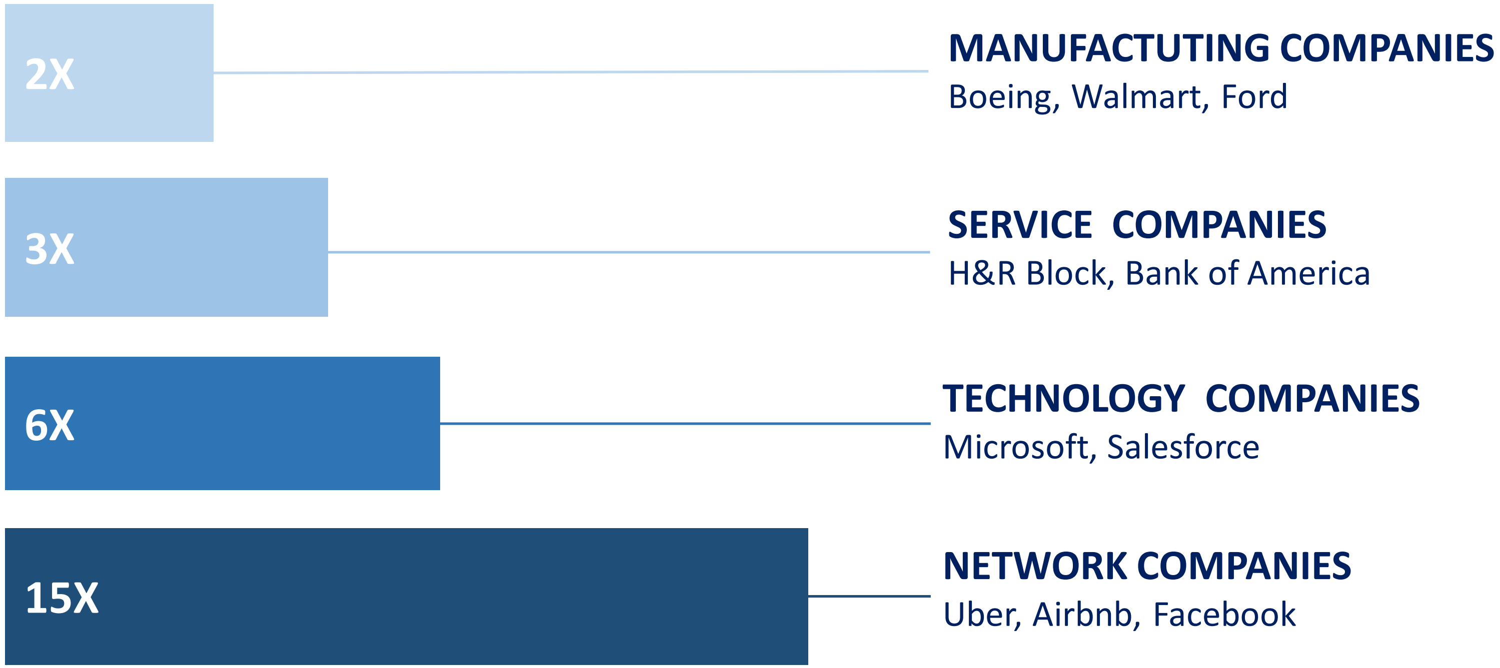
Market capitalization; $776,61 bn
Revenues: $109,65 bn
Employees: 73,992

Market capitalization; $527,14 bn
Revenue: 40,65 bn
Employees: 25,105

Totals:
Market cap: $2,20 trillion
Revenues: $379,40 bn
Employees: 222,209

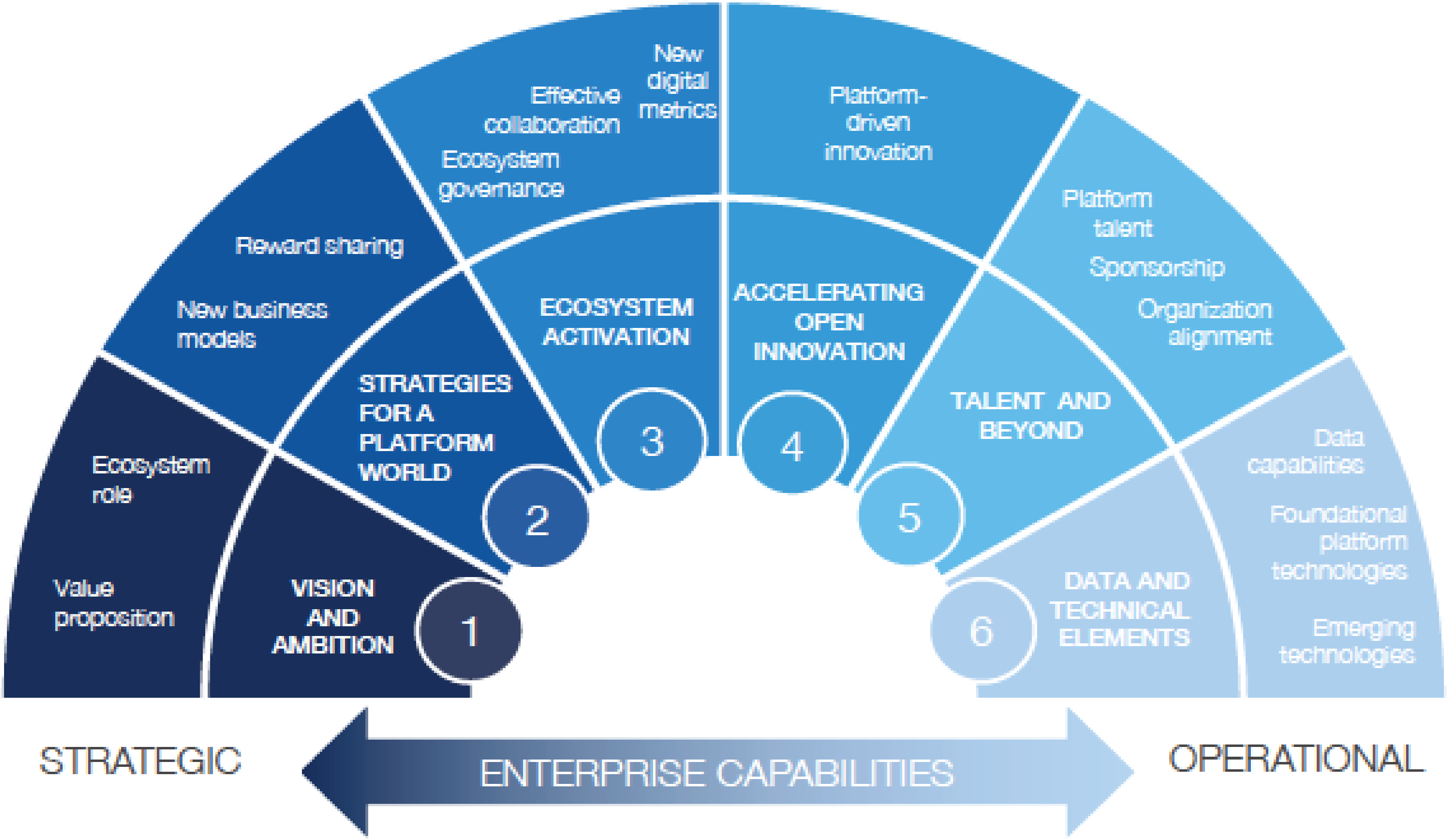
The ROI value genome

In 1975, 83% of all assets were made up of tangible things. Over the next four decades the allocation of capital shifted dramatically. By 2013, only 15% of the world economy was in tangible items.

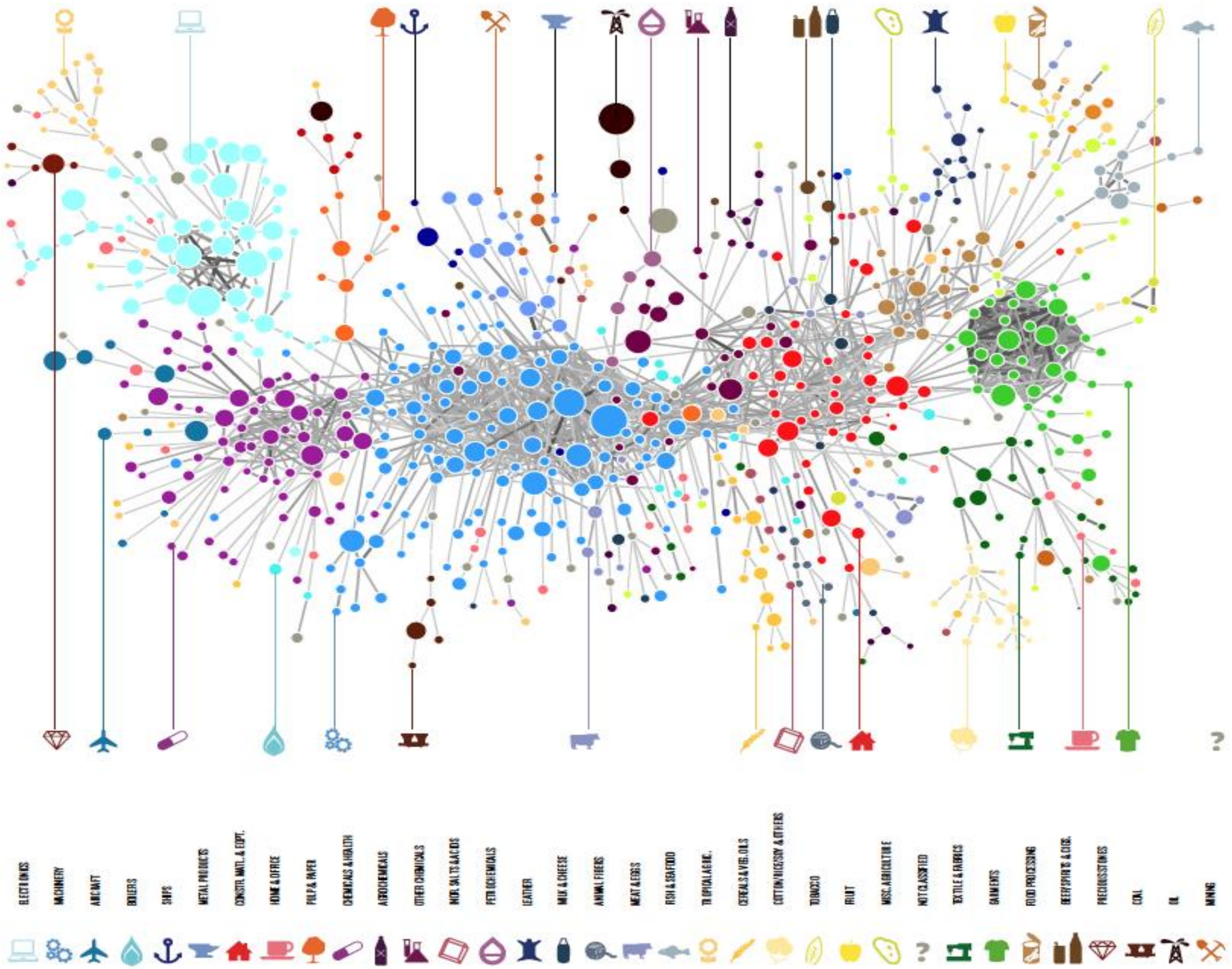


Sources: MIT Platform Strategy Summit, 2017; *Haskel and Westlake, Capitalism without Capital*, 2018.

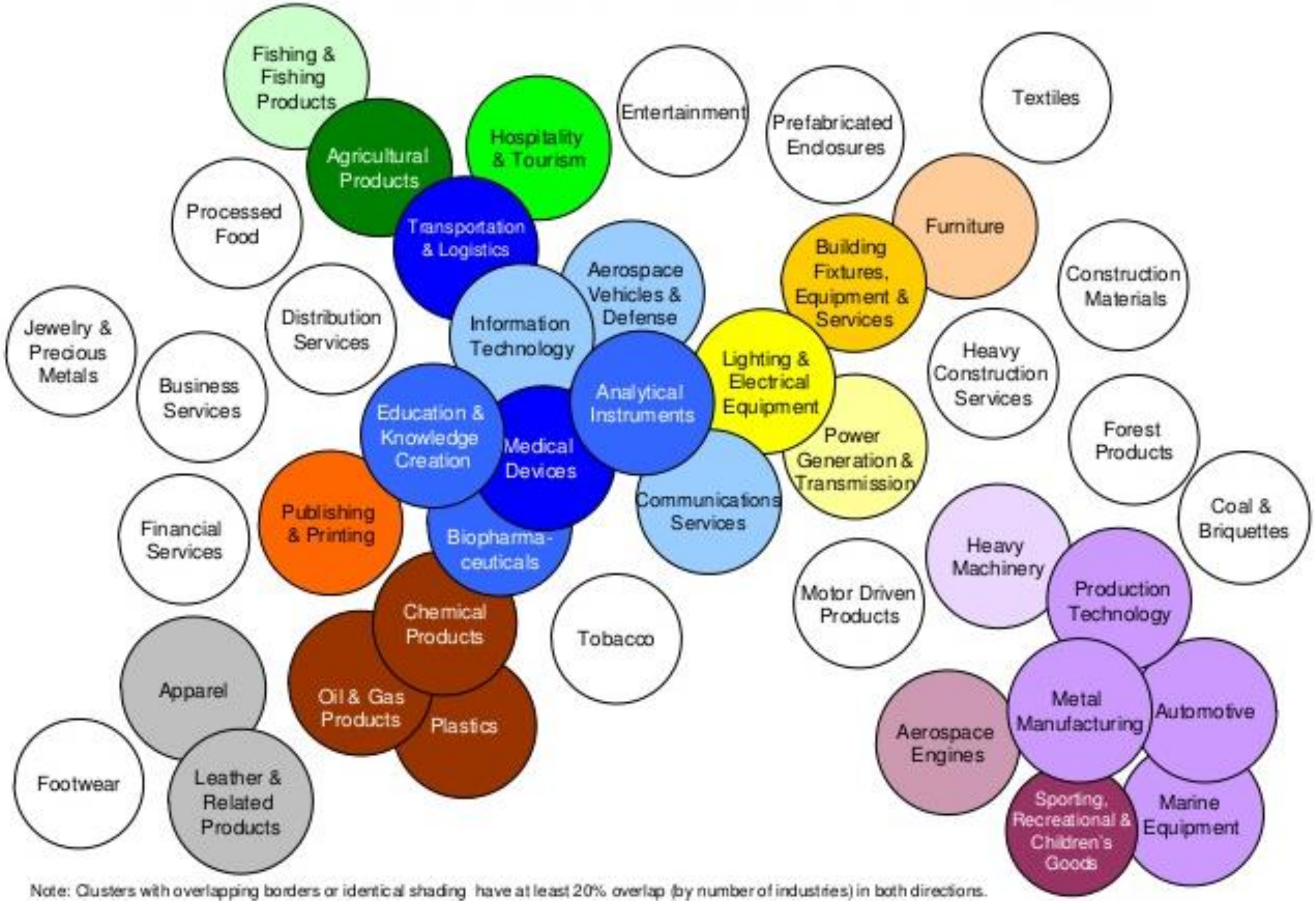
New strategies and operational capabilities are critical for success in the platform economy



Source: World Economic Forum, *Digital Transformation Initiative: Unlocking B2B Platform Value*, 2017.



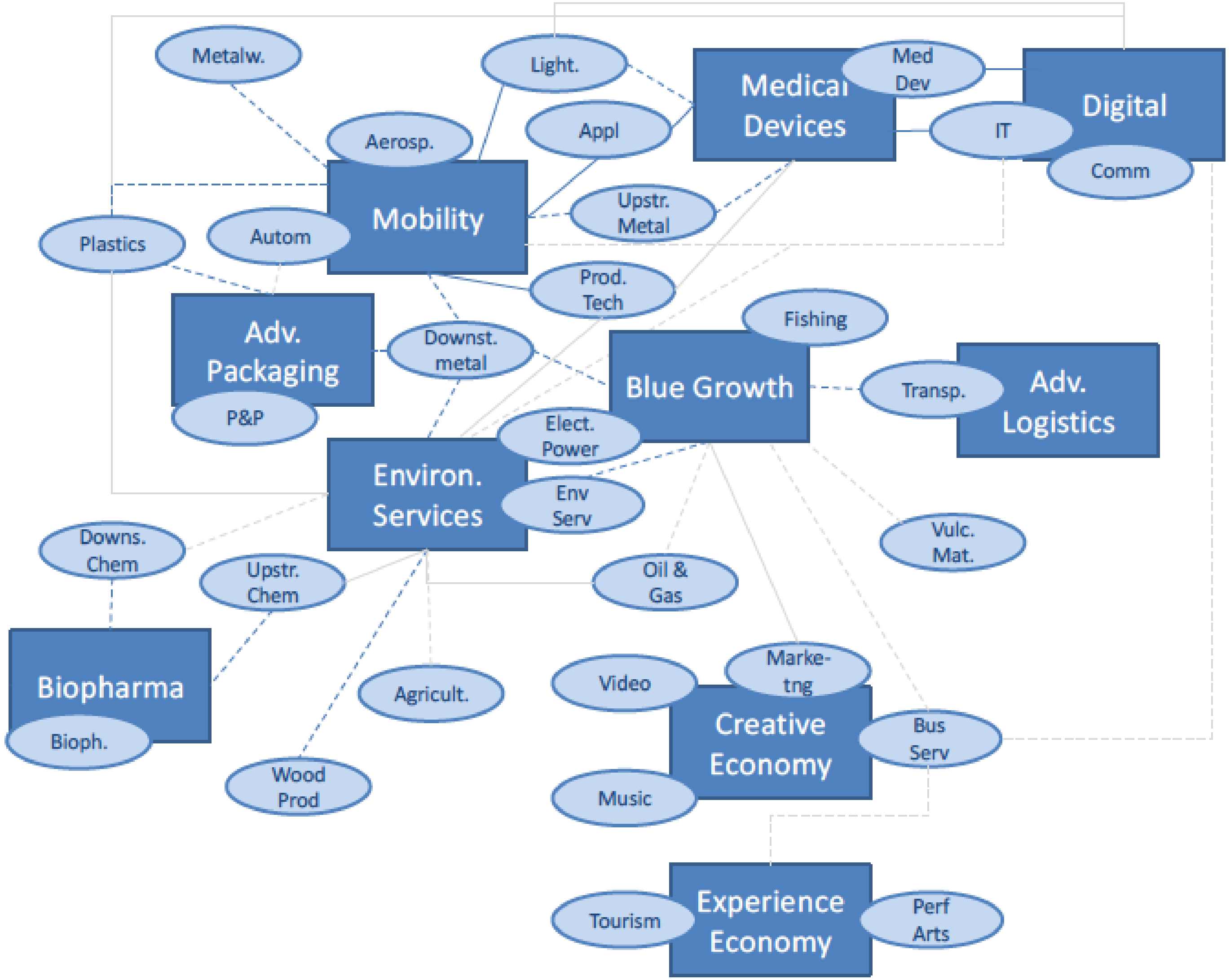
Source: The Atlas of Economic Complexity, MIT, 2019.



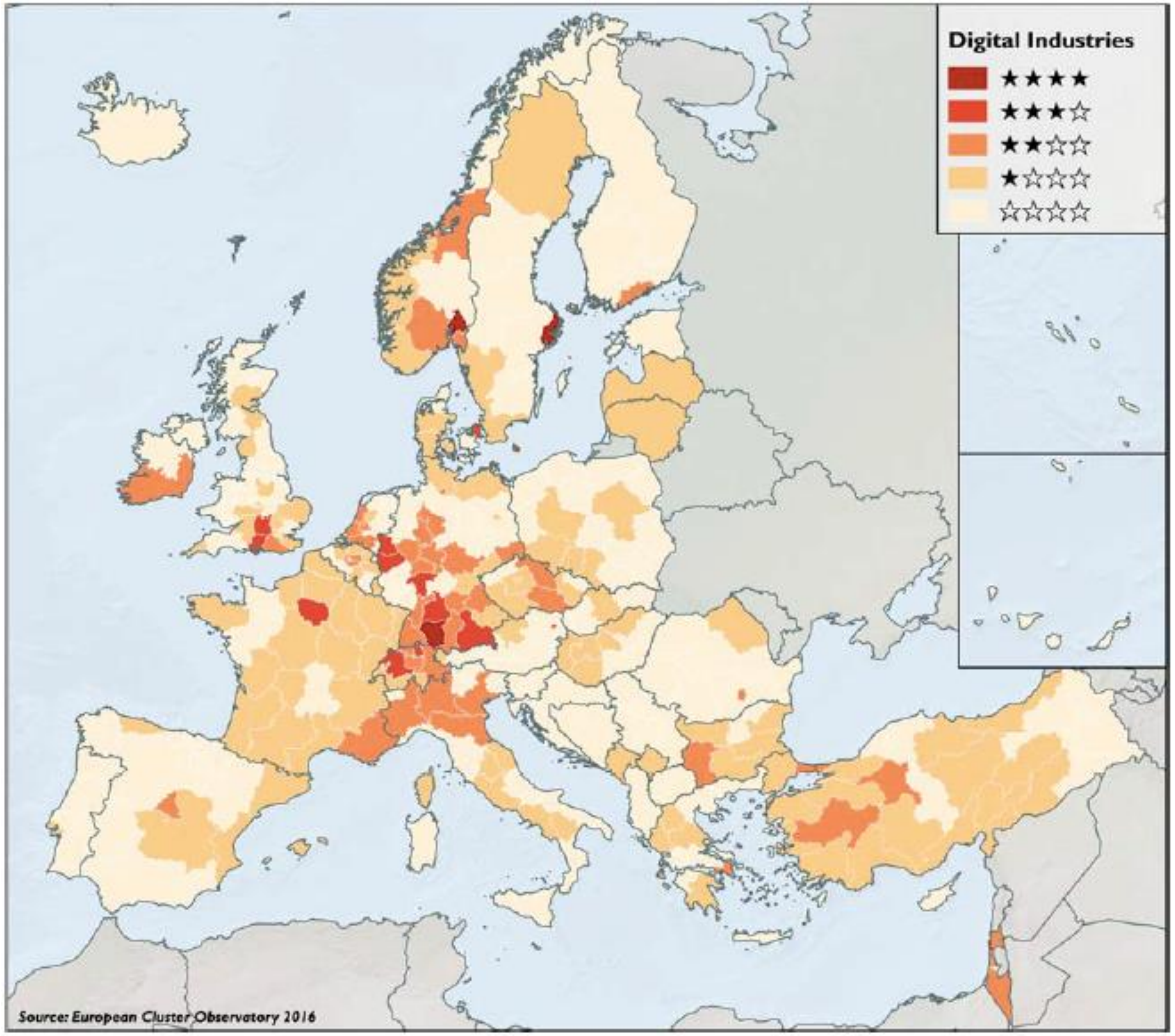
Note: Clusters with overlapping borders or identical shading have at least 20% overlap (by number of industries) in both directions.

Source: Michael Porter, 2014.

EU: emerging industries and clusters



Leading regions in Digital Industries



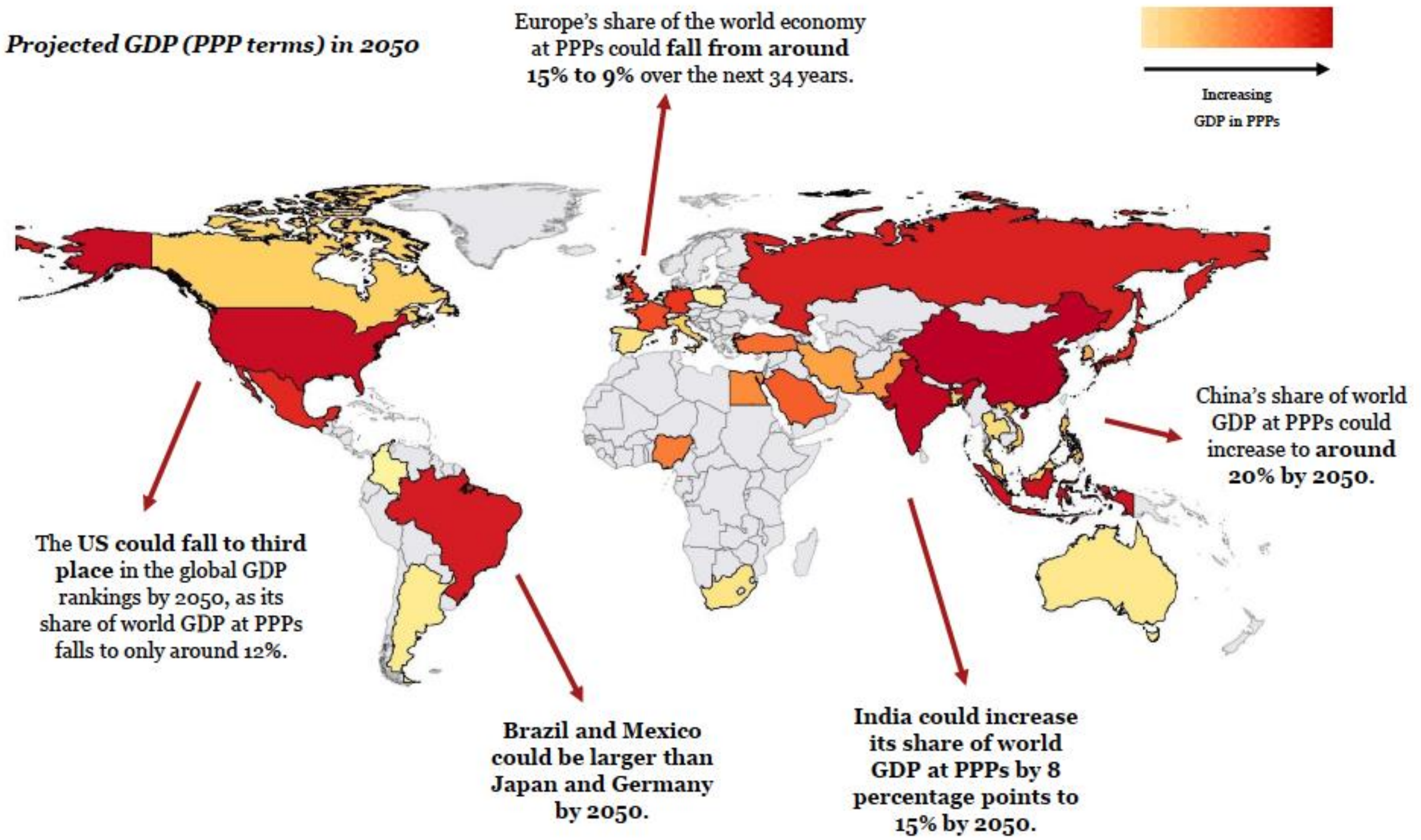
The changing economic geography: reshuffling

- Recent research indicates that the technologies and economic activities the Fourth Industrial Revolution brings in its path are reshuffling the ranks of cities and regions across the globe. The dominant trend is concentration. Indeed, the extent to which economic activity has become concentrated in the world's cities and metropolitan areas is astonishing. The fifty largest metropolitan areas across the globe house just 7% of the world's total population but generate 40% of global economic activity.

- Just forty mega-regions – constellations of cities and metros like the Boston-New York-Washington corridor – account for roughly two-thirds of the world's economic output and more than 85% of its innovation, while housing just 18% of its population.

- Even though it is probably too early to confidently predict specific patters of change, research shows that as capitalism's spatial division of labor – the distribution of economic activities across geographical locations – becomes more finely honed, fewer and fewer cities are able to hold on to the most economically valuable activities and niches.

US and Europe will steadily lose ground to the Asian giants

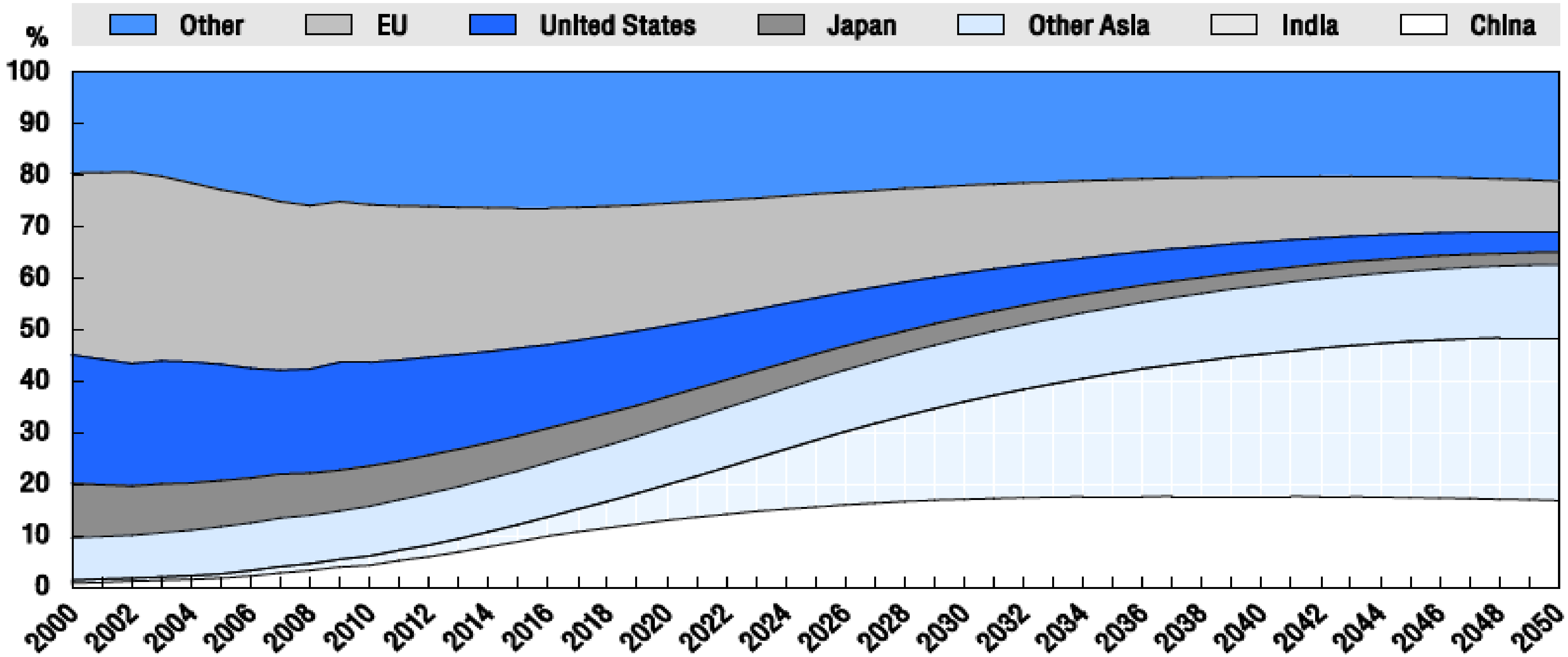


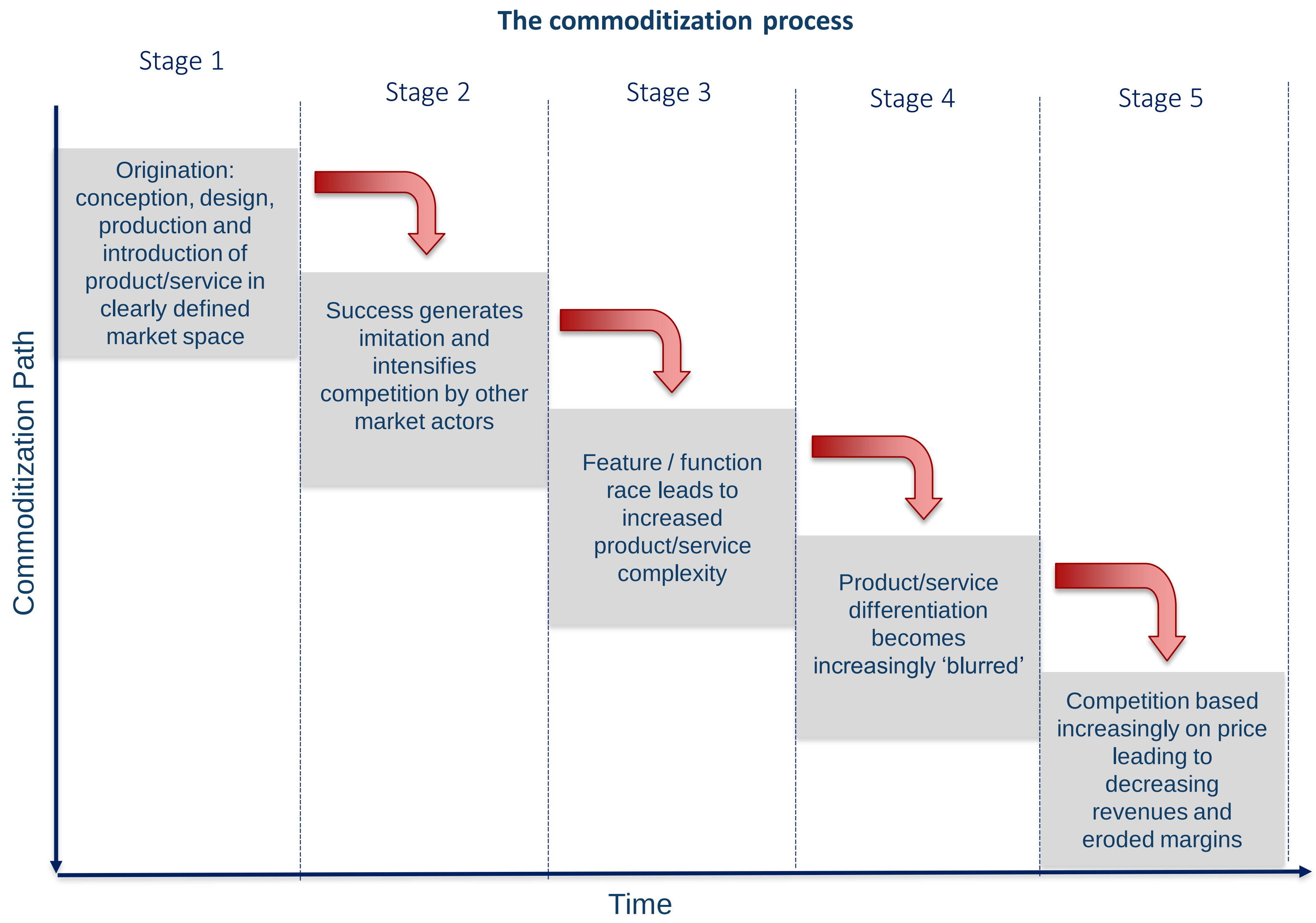
Source: PWC, *The World in 2050*, 2015; OECD, *Perspectives on Global Development,* 2019.

The changing economic geography: reshuffling

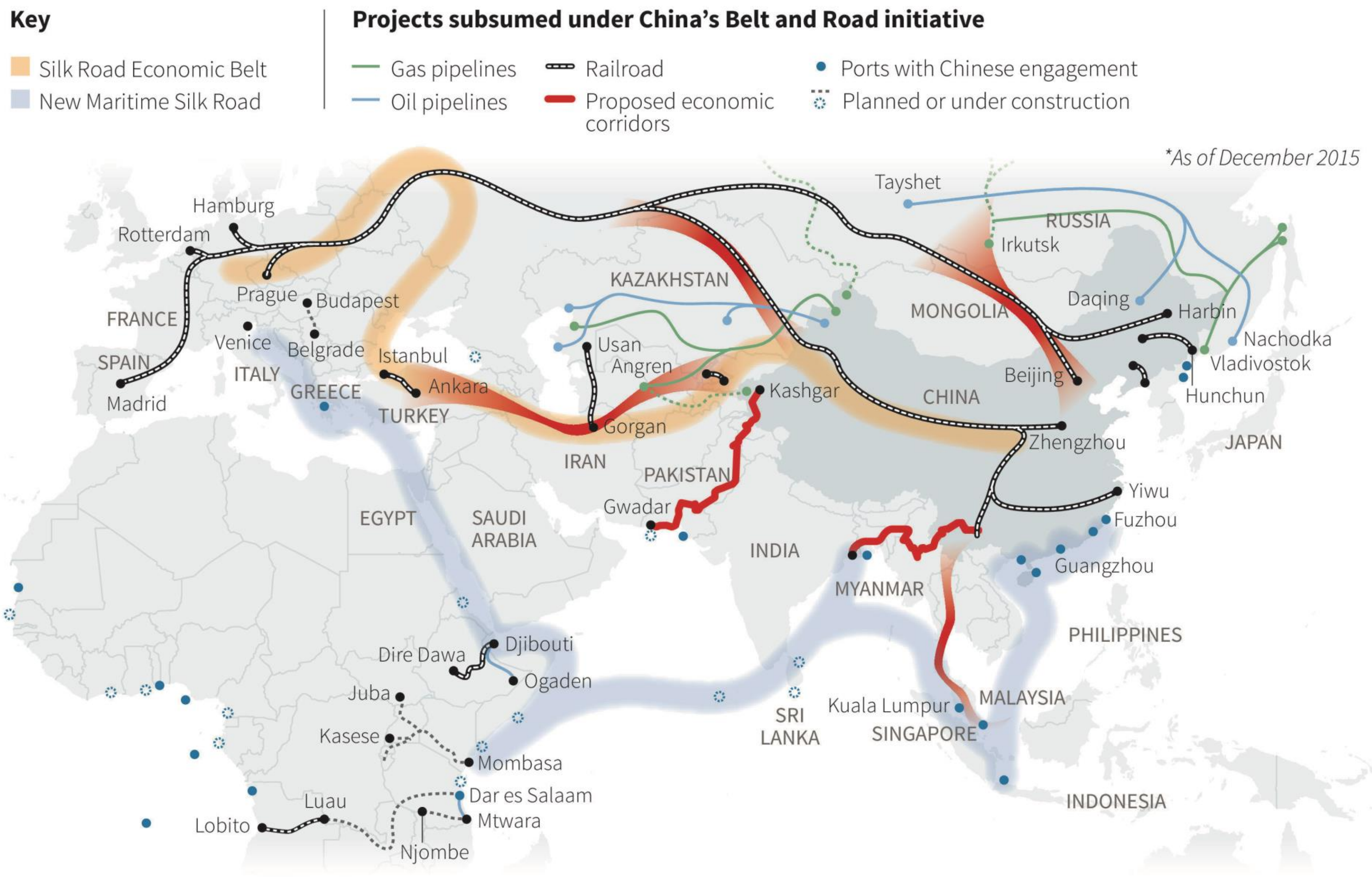
Production activities go where the markets are… While global consumer demand had previously been concentrated in (rich) OECD economies, a new middle class is emerging in China and India. While the middle class worldwide could rise from 1.8 billion to 3.2 billion people by 2020 and to 4.9 billion by 2030, almost 85% of this growth is expected to come from Asia. In 2000, Asia (excluding Japan) only accounted for 10% of the global middle-class spending; this could reach 40% by 2040 and almost 60% in the long term.

The Global Middle Class, by country, 2000-50



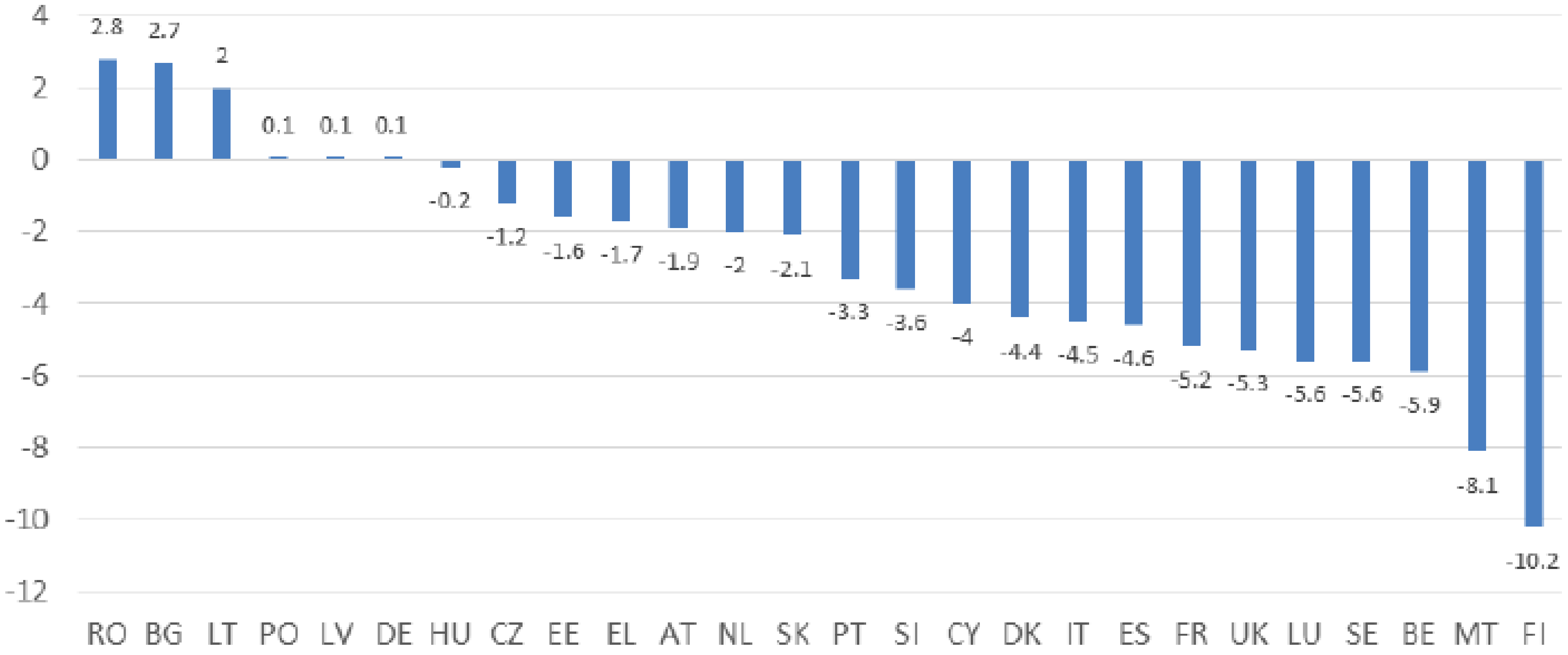

The commoditization process
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Origination: conception, design, production and introduction of product/service in clearly defined market space
Success generates imitation and intensifies competition by other market actors
Feature / function race leads to increased product/service complexity
Product/service differentiation becomes increasingly 'blurred'
Competition based increasingly on price leading to decreasing revenues and eroded margins
Commoditization Path
Time

China: Reviving the Silk Road



Source: Mercator Institute for China Studies, 2017.

Change in share of manufacturing as a percentage of gross added value at basic process 2000-2016 (%)



Source: European Parliament – Directorate General for Internal Policies, *Industry 4.0*, 2016.

WHAT IS SMART?

1. Place **evidence based**
2. Not top-down decision, but **bottom-up partnership approach**
3. A **Global perspective** on potential advantage and potential cooperation
4. Source in **knowledge, technologies, services, talent and investors**

WHAT IS SPECIALIZATION?

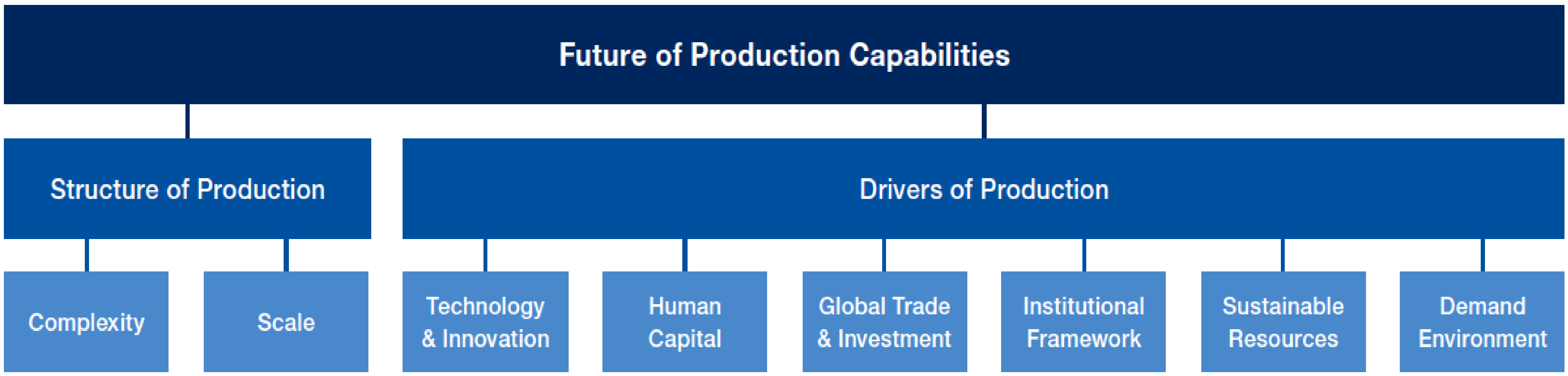
1. **Priority setting** in times of scarce resources
2. **Excellence** in a specific economic activity
3. Accumulation of **critical mass**
4. Not necessarily focus on a single sector but **cross-sectoral approach**

a. Best way to leverage territorial potential through innovation
b. Foster international comparative advantage

Source: European Parliament – Directorate General for Internal Policies, *Industry 4.0*, 2016.

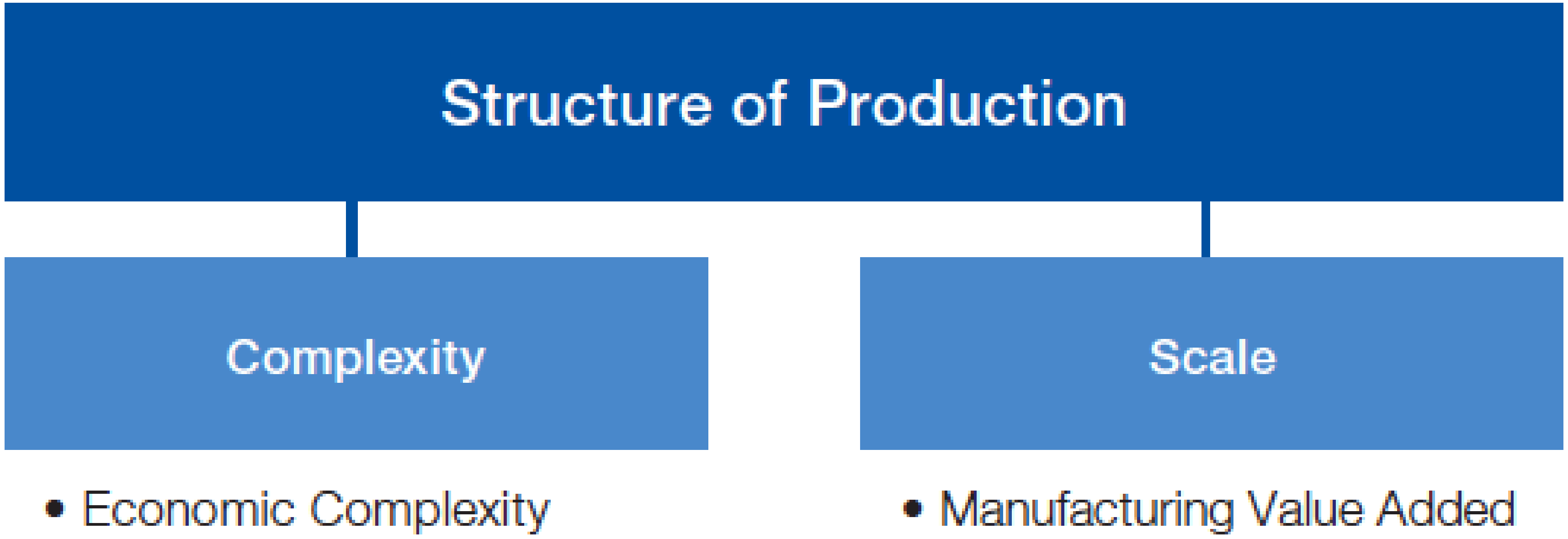
Industry 4.0: Differentiated impact and potential across countries

Industry 4.0: Readiness Diagnostic Model Framework



Source:. World Economic Forum, *Readiness for the Future of Production Report 2018.*

Structure of Production: Concepts measured



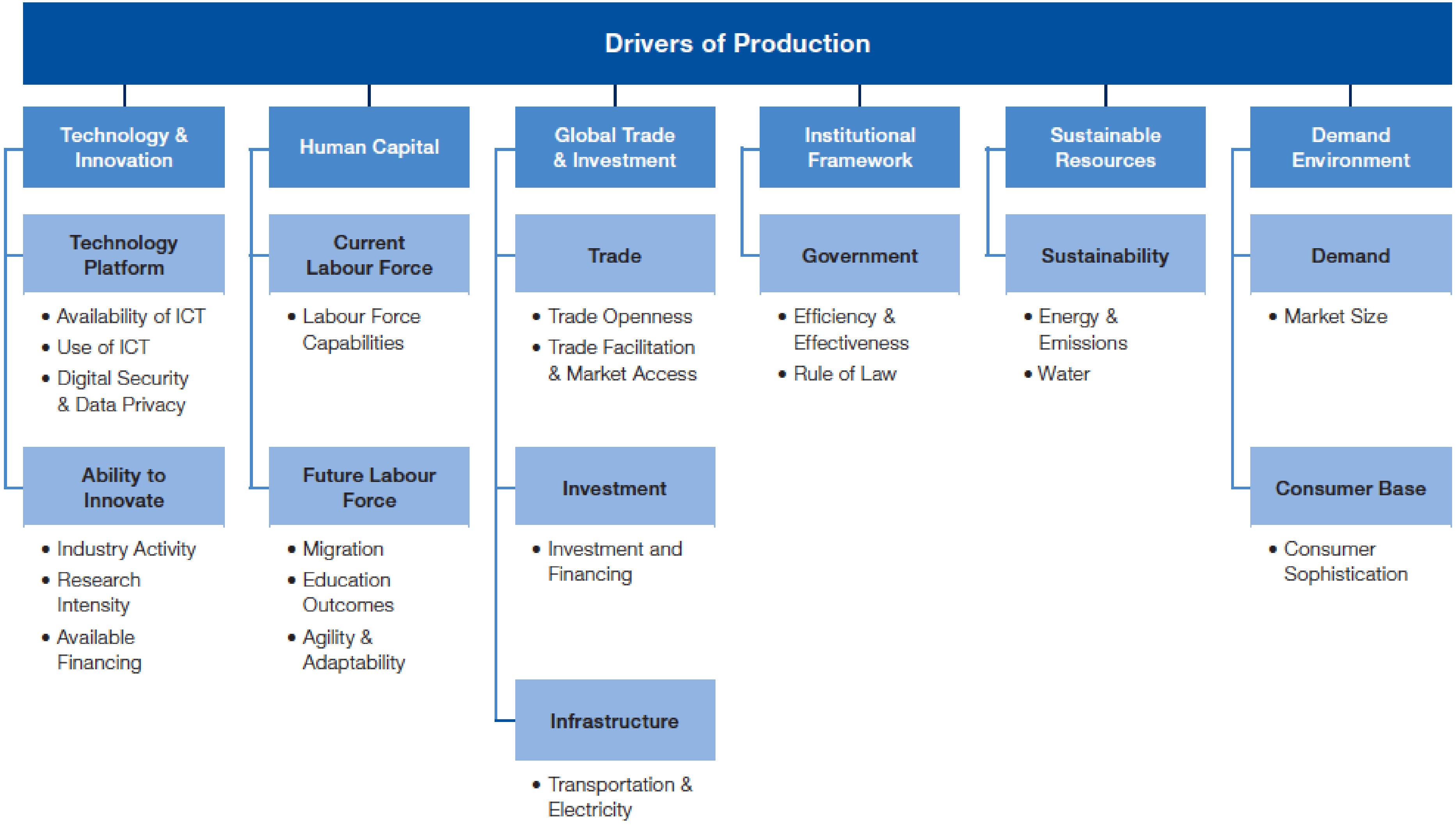
Complexity: Assesses the mix and uniqueness of products a country can make as a result of the amount of useful knowledge embedded in the economy and the ways in which this knowledge is combined.

Scale: Assesses both the total volume of manufacturing output within a country (Manufacturing Value Added) as well as the significance of manufacturing to the economy (Manufacturing Value Added, % of GDP).

.

Source:. World Economic Forum, *Readiness for the Future of Production Report 2018.*

Drivers of Production: Concepts Measured



Source:. World Economic Forum, *Readiness for the Future of Production Report 2018.*

Framework requirements of Industry 4.0 within and across national industrial structures

- Standardisation of systems, platforms, protocols, connections, interfaces seem is crucial and a reference architecture to provide a technical description of these standards and facilitate their implementation to help business implement Industry 4.0 processes.
- *Security / protection of know-how* in a global competitive situation is critical. Will companies/ governments be prepared to invest if their innovations can be readily duplicated by others that have not had to bear the investment in R&D (including those based in Third countries? Will the costs of investing in safety of equipment to protect workers be proportionate to the potential gains?
- *New business models* have to be developed and implemented – what are the costs involved, and who will bear the risks and costs for initiatives that fail?
- *Work organization* will have to change reflecting changes in business models. Complex systems will have to be managed with the help of planning and explanatory models. Real-time oriented control will transform work content and processes & environment, resulting in increased responsibility and continued development required for individuals. This will require a concerted effort amongst stakeholders in order to be successful
- The *availability of skilled workers* that can design and operate Industry 4.0 establishments. Who will invest in their skills and training? What are the implications in terms of employment for those without such skills?
- Who will carry out the *research* required to further develop Industry 4.0 (public/ private)**?**
- How can *a common EU legal framework* to enable the digitalisation of industry be developed and implemented? This is a precondition for companies to implement Industry 4.0 in the Single Market as it would allow them to pool resources to undertake the investments needed to integrate their production systems.

Industry 4.0: the current state of the art in the EU

Technological change

- Digitization has been a major driver of changes throughout the value chain.
- While many businesses recognize the challenges, far fewer, especially among SMEs, are prepared for it.
- There are significant challenges (costs and risks) for firms as regards digital security in: intellectual property protection, personal data and privacy; operability of systems; environmental protection and health and safety.
- Public institutions have been created in many countries to improve cybersecurity.
- There is wide-ranging support for research at both EU and Member State level, but a good deal remains to be done.

Social change

- There is little awareness of Industry 4.0 outside the group of key stakeholders; much about Industry 4.0 remains to be defined.
- Larger firms tend to be more positively disposed towards Industry 4.0.
- Labor unions remain cautious and have reservations.
- While a skills gap as well as a gap in willingness to adjust to the Digital Single Market exists the skill requirements to adjust to Industry 4.0 are much greater.
- New ways of work are needed, as regards which there are positive and negative aspects; and the gap in domestic (and EU) supplies of skills is currently being addressed through sophisticated immigration strategies.
- The supply of Industry 4.0 skills and capabilities throughout the EU is uneven, which is likely to lead to increased concentration in existing centres.

Business paradigm change

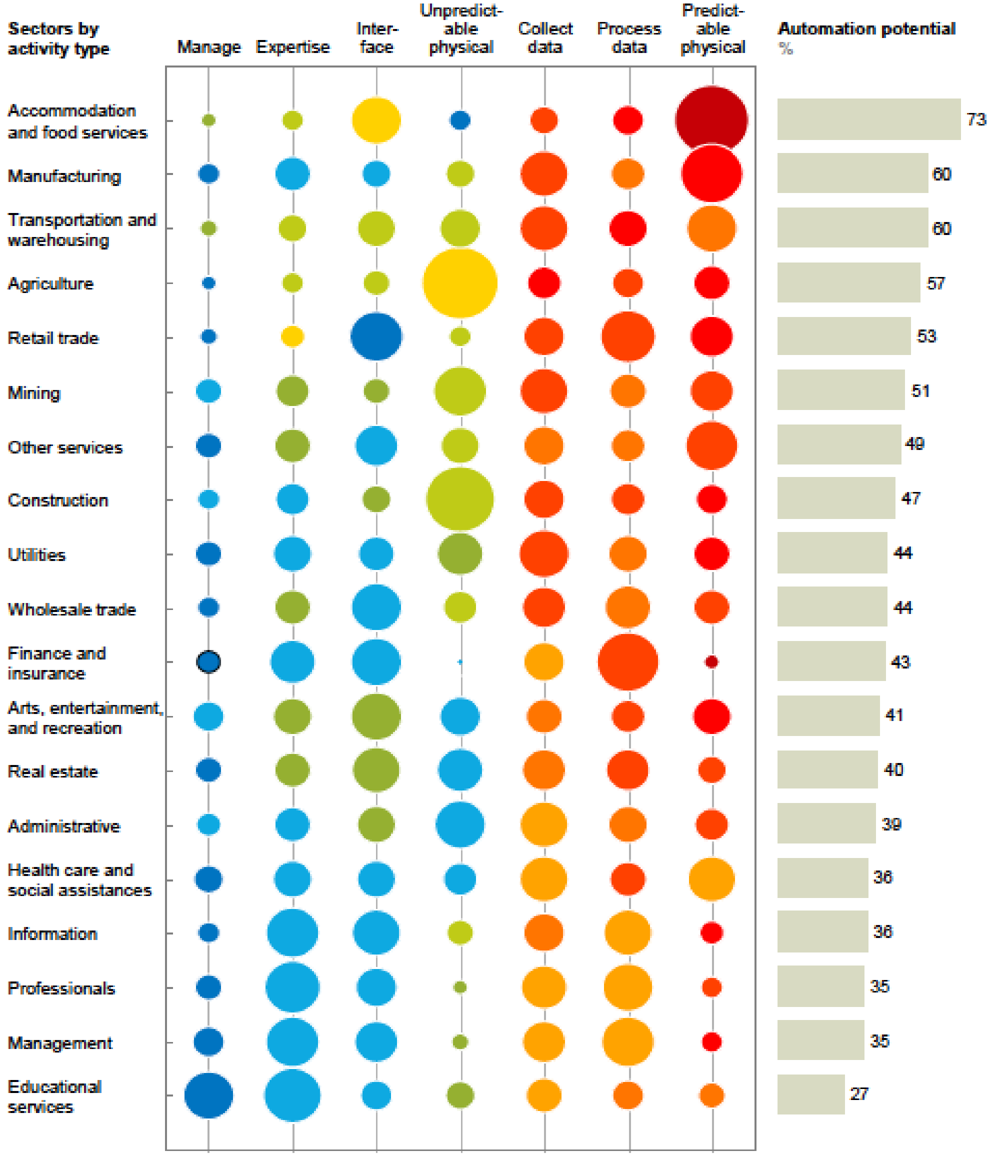
- There are challenges for SMEs in participating in Industry 4.0 supply chains (costs, risks, reduced flexibility and reduced strategic independence).
- Recent surveys in Germany indicate that for SMEs with a turnover of € 500,000 to € 125m, 35% digital technologies play no major role for them. For the smaller companies the respective share is 52%.
- The public sector can play a role in creating an ecosystem that will help SMEs transition to Industry 4.0, but little research has been carried out in this area.
- Standardization remains a major challenge as regards large scale implementation of Industry 4.0. Here the public sector can also contribute.

Current technologies have achieved different levels of human performance across 18 capabilities

	Automation capability	Capability level[1]	Description (ability to …)
Sensory perception	Sensory perception		Autonomously infer and integrate complex external perception using sensors
Cognitive capabilities	Recognizing known patterns/categories (supervised learning)		Recognize simple/complex known patterns and categories other than sensory perception
	Generating novel patterns/ categories		Create and recognize new patterns/categories (e.g., hypothesized categories)
	Logical reasoning/ problem solving		Solve problems in an organized way using contextual information and increasingly complex input variables other than optimization and planning
	Optimization and planning		Optimize and plan for objective outcomes across various constraints
	Creativity		Create diverse and novel ideas, or novel combinations of ideas
	Information retrieval		Search and retrieve information from a large scale of sources (breadth, depth, and degree of integration)
	Coordination with multiple agents		Interact with others, including humans, to coordinate group activity
	Output articulation/ presentation		Deliver outputs/visualizations across a variety of mediums other than natural language
Natural language processing	Natural language generation		Deliver messages in natural language, including nuanced human interaction and some quasi language (e.g., gestures)
	Natural language understanding		Comprehend language, including nuanced human interaction
Social and emotional capabilities	Social and emotional sensing		Identify social and emotional state
	Social and emotional reasoning		Accurately draw conclusions about social and emotional state, and determine appropriate response/action
	Social and emotional output		Produce emotionally appropriate output (e.g., speech, body language)
Physical capabilities	Fine motor skills/dexterity		Manipulate objects with dexterity and sensitivity
	Gross motor skills		Move objects with multidimensional motor skills
	Navigation		Autonomously navigate in various environments
	Mobility		Move within and across various environments and terrain

Source: US Bureau of Labor Statistics; McKinsey Global Institute analysis, 2017.

Technical potential for automation across sectors varies depending on mix of activity types



Source: US Bureau of Labor Statistics; McKinsey Global Institute analysis, 2017.

Employment and skills .

- The global labor share of national income has been in decline since the early 1980s, and this is occurring within the large majority of countries and industries. It has to do with the decline in the relative price of investment goods. Efficiency gains in capital producing sectors, often related to advances in ICT induced firms to shift away from labor and toward capital to such a large extent that the labor share of income declined. The dominant trend has been stagnant rates of unemployment and growing underemployment.

- Decline in medium-skilled routine jobs in recent years reflected in the polarization of skills in demand and labor market dynamics, the parallel but uneven growth of **mcjobs** (>) and **macjobs** (<) across the OECD countries, effectively leading to the hollowing out of middle-class jobs. At the same time the emergence of the platform economy and corporate disintegration through *Nikefication* undermine occupational mobility because by contracting out “non-core” jobs, these jobs become separated from the ladders that once offered a means to move up within an organization. Outsourcing traditional entry-level positions, as a result, tends to leave the holders of these positions stranded without an obvious path for promotion.

- This is one aspect of a deeper fragmentation of the labor process itself. It involves a shift from the **death of the career** and its replacement by **jobs** with employees often moving from firm to firm, or working as independent – a pattern that originated in the 1990s – to a shift from jobs to **tasks** to be performed under task-oriented contracts – a key feature of the platform economy and a pattern observable in several industries today.

- The most important thing is what Uber and other platforms mean for labor markets and how employment is organized. Platforms like Uber make it easy to create a spot market for all kinds of labor. Someone needing a work crew for the day could post a virtual sign-up sheet, and potential contractors with the relevant skills could bid against each other to be in the first, say, five slots. Those who “won” would find their own way to the worksite. This is what is meant by the *Uberization* of labor and the broader transition to a “labor-light” economy.

Governance, regulation and sustainability

- ***Monopoly / Monopsony:*** Regarding anti-trust policy will the break-up of the likes of Google and Amazon by extending and adapting anti-trust regulation? Traditional anti-trust policy will most likely need a more comprehensive reach. For breakup of the dominant platform players would not stop network effects from reasserting themselves: in time, one of the new smaller ones would become dominant again. Nevertheless, regulatory authorities at a minimum will have to sharpen their tools for the digital age.

- ***Technological concentration of power:*** There is accumulating evidence that “super-platforms” wield too much power and their superior technological capabilities, access to data and advanced algorithms facilitate price manipulation and discrimination through tacit collusion. The reality is that we have entered an era where the invisible hand is being replaced by a highly programmable and longer “digital hand”.

- ***Algorithmocracy, “black boxes” and biases:*** Secret and proprietary algorithmic models govern behavior in increasingly larger areas of economic, social and, indeed, political life. Algorithmic models, despite their reputation for impartiality, reflect goals and ideology. The fundamental question for each domain of their operation is not only who designs these models but what the designer’s – be that an individual, a company or a state agency – objectives are.

- ***Challenges of traditional forms of regulation:*** “code is law”: it embodies binding restrictions on behavior. Algorithms and platforms structure and shape behavior according to the objectives built into them. Traditional forms of regulation and the law in the books are often difficult to apply or enforce in the digital world where action is possible only if it conforms to frameworks expressed in the code that shapes and directs behavior. But code and algorithmic models are proprietary.

- ***Cross-industry boundary regulations:*** Disruptive forms of technological change often cross traditional industry boundaries. As products and services evolve, they can shift from one regulatory category to another. If a ride-hailing company begins delivering food, it can fall under the jurisdiction of health regulators. If it expands into helicopter service, it will fall under the purview of aviation regulators. If it uses autonomous vehicles for passengers, it may come under the jurisdiction of telecommunications regulators.

- ***Shifting liabilities:*** The evolving, interconnected nature of disruptive business models also can make it difficult to assign liability for consumer harm. If a self-driving car crashes, who is liable—the software developer, automobile owner, or the occupant?

- ***Concentration of data reservoirs and refineries and the growing possibility of conflict:*** Currently, most big data refineries are based in the United States or are controlled by American firms. As the data economy progresses, this does not seem sustainable. Past skirmishes between the US and the EU over privacy give a taste of things to come.

- ***Weaponizing the internet? Toward "digital Westphalianism"?*** Conflicts over control of oil, the fuel of the industrial era, have scarred the world for decades. Even though it is difficult to delineate the battlefield, the data economy has the same potential for international and cross-regional confrontation.

Thank You

Prof. dr. Takis Damaskopoulos
Gedimino g. 50 – 316
Email: takis.damaskopoulos@ktu.lt
Mob phone: +370 603 98047
in4act.ktu.edu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 810318. The opinions expressed in the document are of the authors only and in no way reflect the European Commission's opinions. The European Union is not liable for any use that may be made of the information.