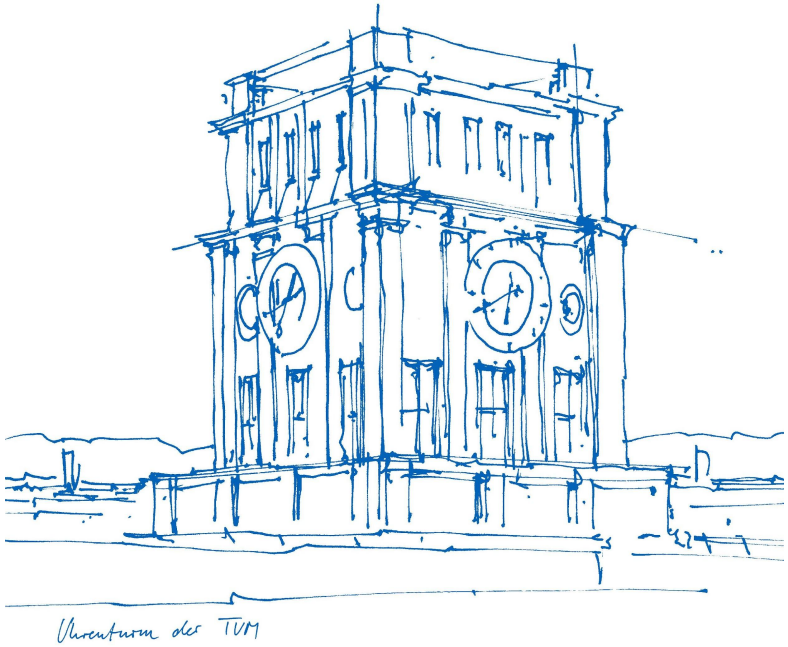
Ethics and Innovation in Industry 4.0

Prof. Dr. Christoph Lütge

Technical University of Munich

Peter Löscher Endowed Chair for Business Ethics

and Global Governance



Overview

1) The Concept of Industry 4.0
2) Innovation 4.0
3) Ethics in Innovation 4.0
4) Governance 4.0
5) Shared Value 4.0 for Companies
6) Education 4.0

Chapter 1

The Concept of Industry 4.0

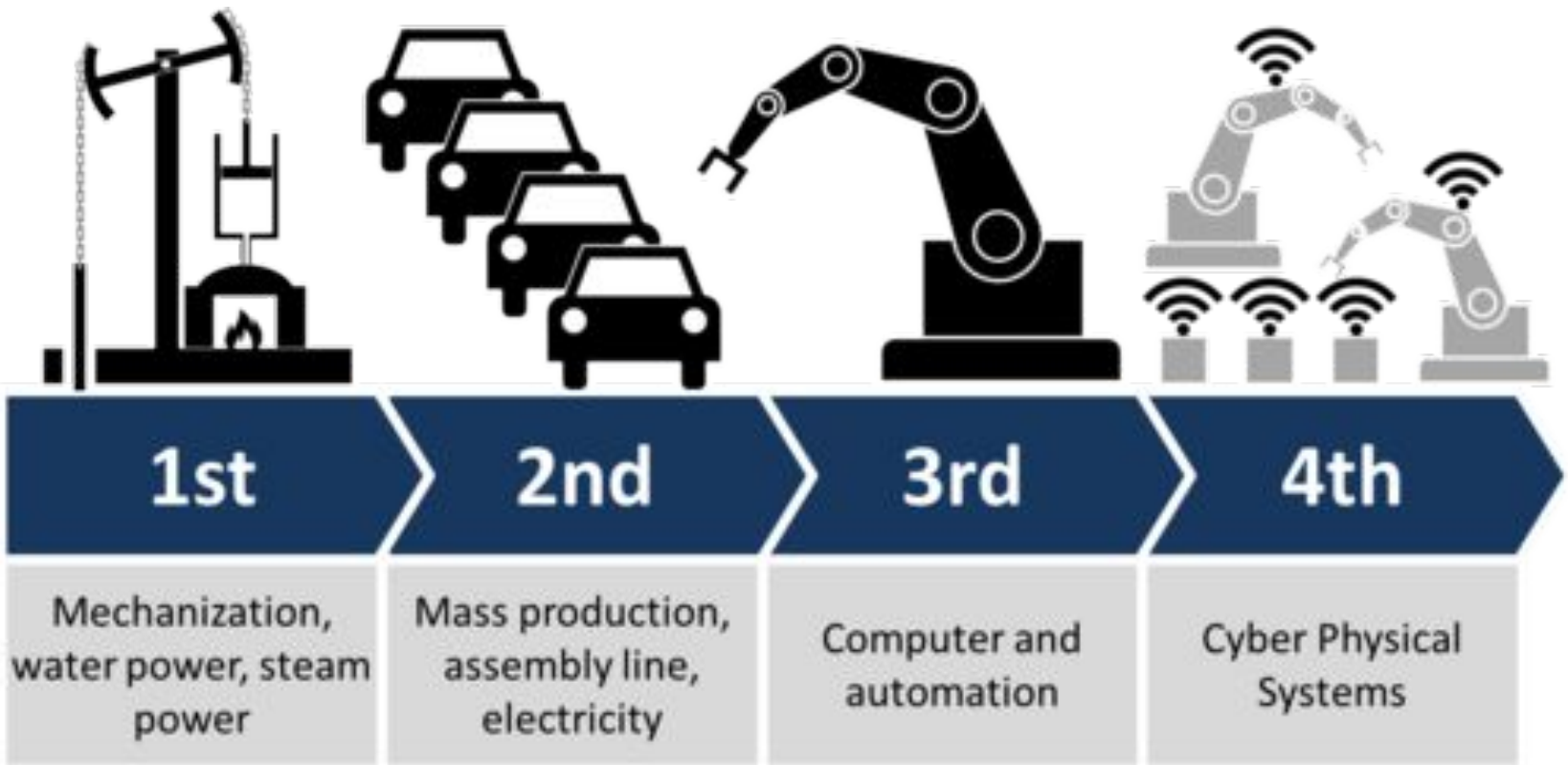
The Concept of Industry 4.0

- German Concept
  - origin: high-tech strategy of the German government
  - related concepts: The Fourth Industrial Revolution, The 4th Revolution

- “Industry 4.0“ is a marketing term that is also used in science communication

- The fourth industrial revolution that the term refers to is characterized by
  - individual customization (even in mass production)
  - hybridization of products (goods and services)
  - integration of customers and business partners in business processes and value creation processes

The Concept of Industry 4.0



The Concept of Industry 4.0

3D printers will be one of the main drivers of individualisation

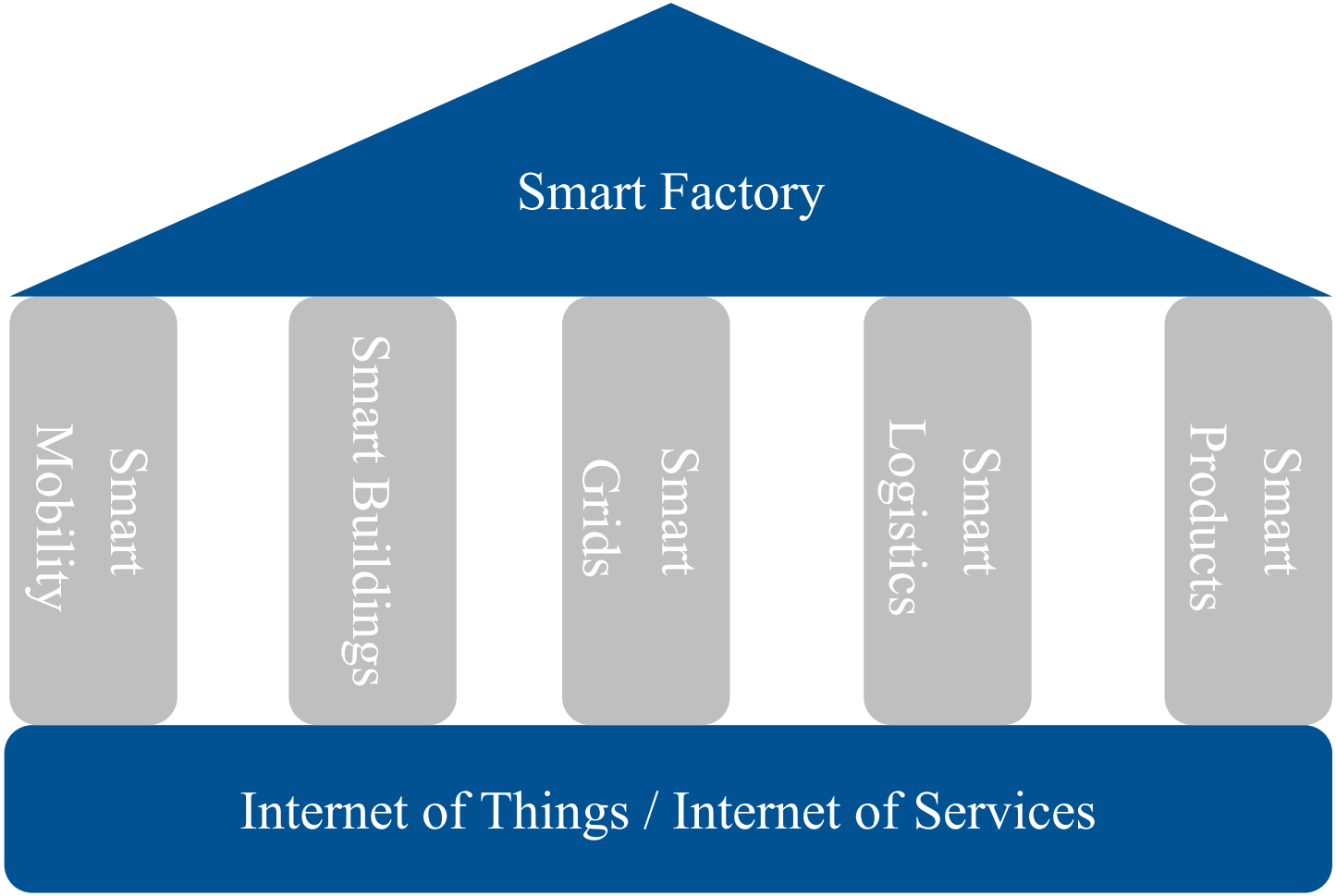
A specific industry will design the mechanical and electronic “inner lives“ of the products which users will then be able to print out in the desired shape and desired combination of modules.

The Concept of Industry 4.0

- Key components are
  - embedded systems and (partly) autonomous machines that act in their environments without human intervention
  - connected technologies and devices that are equipped with microchips result in highly complex structures and cyber-physical systems (CPS) like the Internet of Things

- Main fields of application are
  - Mobility (smart factory, driverless cars)
  - Health (electronic medical record, health service robots)
  - Climate and energy (smart grid)

The Concept of Industry 4.0



The Concept of Industry 4.0

- Chances are
  - adaptability and versatility
  - Resource efficiency
  - Improvement of ergonomics

- Challenges are
  - decision errors by machines that may follow inappropriate rules or that misinterpret processes or situations (subject to Machine Ethics)
  - manipulation by hackers or use of faulty data; transparent citizens or patients (subject to Information Ethics)
  - substitution of human labor by machine labor (subject to Labor Ethics)

Chapter 2

Innovation 4.0

Innovation 4.0

- In our age, we are witnessing a new era of artificial intelligence driven by communication technology, semantic technologies and embedded systems
- These innovations will address and probably solve some of the challenges we will face in the 21th century such as resource and energy sufficiency, urban production and an ageing society

Source: www.linkedin.com

Source: www.spectrum.ieee.org

Source: www.tesla.com

Big Data

- Big data is a term for data sets that are so large or complex that traditional data processing application software is inadequate to deal with them

Source: www.bigdatablog.de

Source: www.simplilearn.de

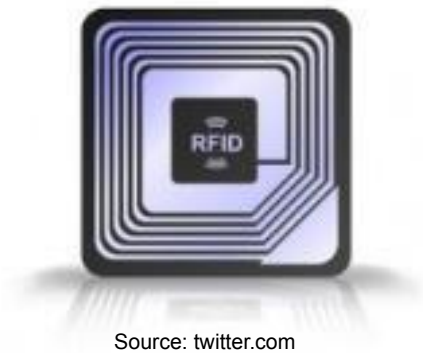
Components of Big Data

- Techniques for analyzing data, such as A/B testing
- Machine learning
- Natural language processing
- Business intelligence
- Cloud computing and databases
- Visualization, such as charts, graphs and other displays of the data

Internet of Things

- The Internet of Things is the inter-networking of physical devices, facilities, and other items embedded with electronics which enable these objects to collect and exchange data
- In the sense of IoT, things can refer to a wide range of devices such as monitoring implants (RFID chips)

Source: blog.cammy.com



Source: twitter.com

Smart Grids

- A smart grid is an electrical grid including smart meters, smart appliances, renewable energy resources, and energy efficient resources.
- It allows two-way communication between the utility and its customers, and the sensing along the transmission lines.

Source: offshorewind.biz

Source: euronomikon.com

Telehealth

- Telehealth is a collection of means or methods for enhancing health care, public health, and health education delivery and support using telecommunications technologies (California Telehealth Resource Center)

- An example might be a health app that alerts the public of a disease outbreak

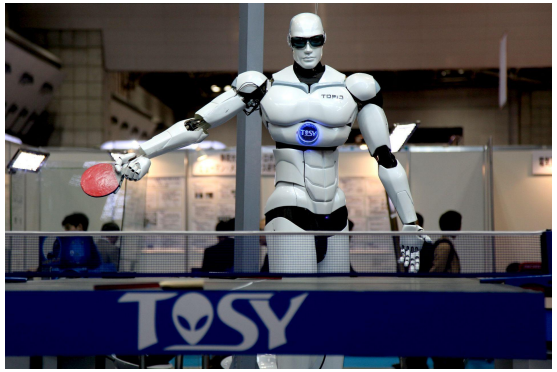
Source: www.mintortynurse.de

Telemedicine

- Telemedicine is a specific kind of telehealth that involves a clinician providing some kind of medical service
- This includes mobile apps that let physicians treat their patients remotely via video-chat or a software solution that lets primary care providers send patient photos of a rash or mole to a dermatologist at another location for quick diagnosis

Robotics

- In the last decade, we have witnessed the emergence of new types of robots:
  Reconfigurable robots, Bionic Robots, Swarm Robots and Humanoid Robots.
- Autonomous robots are able to act on their own.
- At the same time the use of military robots is spreading.



Source: wikimedia.com

Source: thesun.co.uk

Source: wikimedia.com

Autonomous Driving (1/2)

- Mobility is becoming increasingly shaped by the digital revolution
- As the „perception“ of the vehicle‘s surroundings becomes increasingly perfected, there is likely to be an ever better differentiation of road users, obstacles and hazardous situations (BMW Vision Next 100, Google Car)

Source: www.electrek.com

Source: www.wired.com

Autonomous Driving (2/2)

- Already in 2008, driverless and fully automated trains have been introduced in Nuremberg
- Starting October 2016, all Tesla cars are built with the necessary hardware to allow full self-driving capability at a safety level

Source: www.streetsblog.org

Source: www.businessinsider.de

Chapter 3

Ethics in Innovation 4.0

Historical perception in innovation (1/2)

The fear of losing control due to scientific progress is a common theme in literature and arts. A prominent example is the poem "The Sorcerer's Apprentice" (Der Zauberlehrling, Goethe, 1797).

The story begins when an old sorcerer departs his workshop and leaves his apprentice alone. Tired of fetching water, the apprentice enchants a broom to do the work for him. The floor is soon awash with water, and the apprentice realizes that he cannot stop the broom.

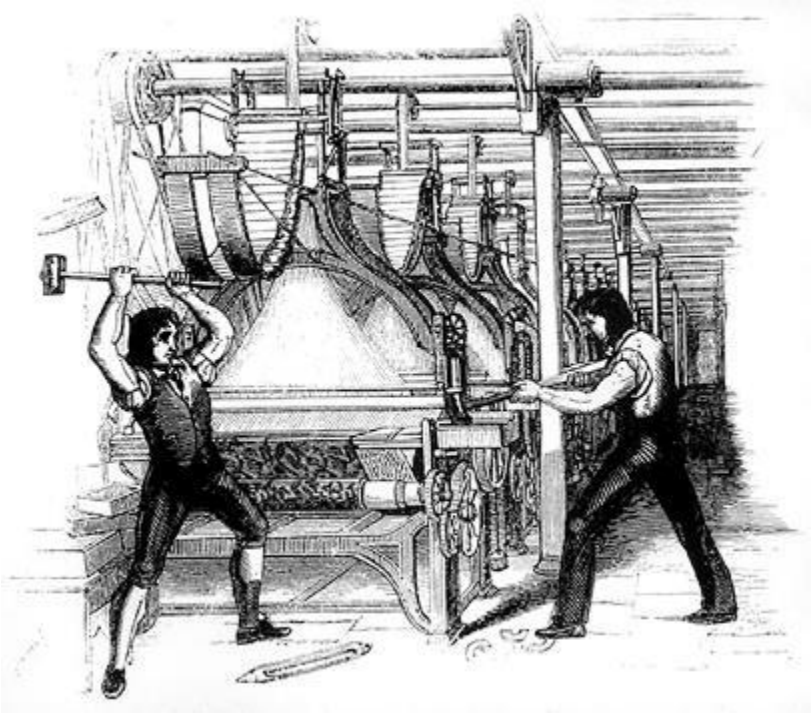
Source: wikimedia.com

Source: https://www.youtube.com/watch?v=Rrm8usaH0sM

Historical perception in innovation (2/2)

Fears about technological advance did also affect socio-political movements.

A well-known example are the Luddites, a group of English textile workers in the 19th century who destroyed weaving machinery as a form of protest, fearing that the time spent learning the skills of their craft would be wasted, as machines would replace their role in the industry.



Source: wikimedia.com

Benefits of Innovation 4.0 (1/2)

- Telemedicine:
  - Major problem: Rural depopulation and hence rural services
  - Uneven distribution of physicians
  - Telemedicine as solutions to reach patients in remote areas
- Care-robots:
  - Major problem: Ageing society
  - Shortage on qualified healthcare personnel in the near future
  - Solution: Robots specifically designed for elder care
- Smart grids:
  - Major problem: Globally increasing energy demand
  - Solution: Positive effect of smart grids on the feasibility of renewable power
  - Broad-scale electric vehicle charging

Benefits of Innovation 4.0 (2/2)

- Internet of Things:
  - Optimization of all physical environments for comfort and productivity
  - Reduction of expenses and improvement of efficiency
  - Improved decision making
- Big Data:
  - Major problem: Poor collection and interpretation of data
  - Improved decisions based on more and better information
  - The city of Oslo (Norway) reduced street lighting energy consumption by 62% using big data
- Autonomous cars:
  - Major current problem: High fatality rates in car accidents
  - Car accidents are caused by human error by ca. 90%
  - Autonomous cars as solution to decrease car accidents

Autonomous Driving (1/3)

- Autonomous driving offers an ethical improvement of the actual situation
  - Long-term reduction of the likelihood of an accident
  - More convenience
  - Less physical and mental stress
  - Significant time gain
  - Inclusion and integration into society due to new mobility paths

- The introduction of more highly automated driving systems, especially with the option of automated collision prevention, may be socially and ethically mandated if it can unlock existing potential for damage limitation. (German Ethics Code for Automated and Connected Driving, 2017)

Autonomous Driving (2/3)

Dilemma situations and Moral self-determination

Example:
"The driver of a car is driving along a road on a hillside. The highly automated car detects several children playing on the road. The driver of a manual vehicle would now have the choice of taking his own life by driving over the cliff or risking the death of the children by heading towards the children playing in the road environment. In the case of a highly automated car, the programmer or the self-learning machine would have to decide what should be done in this situation."

Source: extremetech.com

Autonomous Driving (3/3)

Ethics Committee on Automated and Connected Driving of the German Federal Ministry of Transport and Digital Infrastructure:

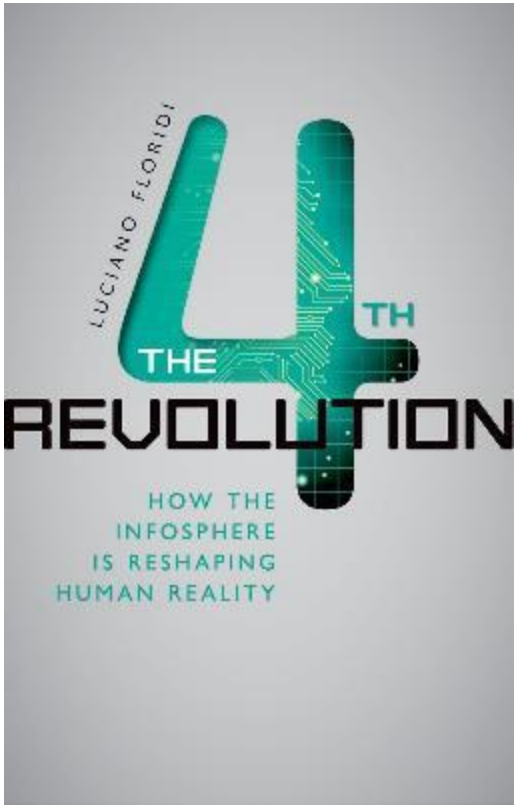
- Worldwide First Ethics Code for Self-Driving Cars, presented in Berlin in 2017

- 20 Ethical Guidelines, e.g.:
  - Protection of individuals takes precedence over all other considerations.
  - Accountability shifts from individual user to manufacturers and operators of systems
  - General programming justifiable to reduce the overall number of personal injuries

Source: bmvi.de

Big Data and the Infosphere

- According to Luciano Floridi (University of Oxford), the whole informational environment is constituted by informational entities, their properties, interactions, processes and mutual relations.
- Online and Offline merge into Onlife
- Problems such as breaches of privacy, violence, harassment, hate speech remain unresolved
- Therefore, it is necessary to focus on proactive regulations.



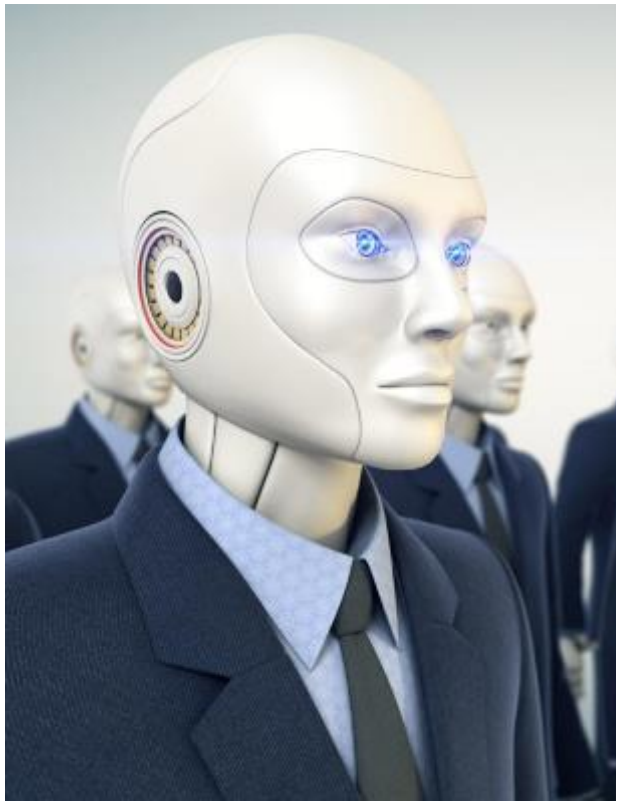
Source: fivebooks.com

Risks of Innovation 4.0 (1/2)

- Tendency of insufficient scrutiny and dependence on the accuracy of technical systems
  - Telemedicine
  - Autonomous driving
- Loss of once autonomous decisions
- Danger of technical mistakes
- Increased vulnerability of cyber attacks and cyber wars
- Inequality and concentration of information and digital literacy
  - Age gap
  - Development gap
  - State vs. Citizens
  - State vs. Multinationals

Risks of Innovation 4.0 (2/2)

- Privacy and danger of data misuse
  - Labor rights
  - Customer rights
  - Challenge of different privacy cultures
- Changing requirements on the quality of the human workforce will be affected by the growing autonomy of machines and robots
  - Education in digital literacy
  - Higher demand for digital qualified workforce
  - Less demand for repetitive work



Source: mckinsey.com

Order ethics (1/2)

Technical progress is not a zero-sum game

- We cannot simply condemn technological progress, as it offers several improvements and solutions
  - Cost savings
  - Energy efficiency
  - Aging society
  - Rural depopulation
  - Reduction of fatalities and accidents
  - Improvement of education
- We need a focus on rules including sector-specific regulations
- Rules and laws have to be based on incentives in order to be effective and to solve dilemma structures

Order ethics (2/2) - Robots

In his 1942 short story “Runaround”, Isaac Asimov developed the first kind of legal framework for robots:

- A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
- A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

Robots can also be used as means for enhancing ethical principles. "Androids must construct themselves as social beings, just as human beings have constructed themselves into people."
(MacDorman and Ishiguro 2006)

Human dignity and technical progress

"Act in such a way that you treat humanity, whether in your own person or in the person of any other, never merely as a means to an end, but always at the same time as an end."
(Immanuel Kant, Groundwork for the Metaphysics of Morals, 1785)

Source: wikimedia.com

Technical progress should serve mankind, not the other way around.

Chapter 4

Governance 4.0

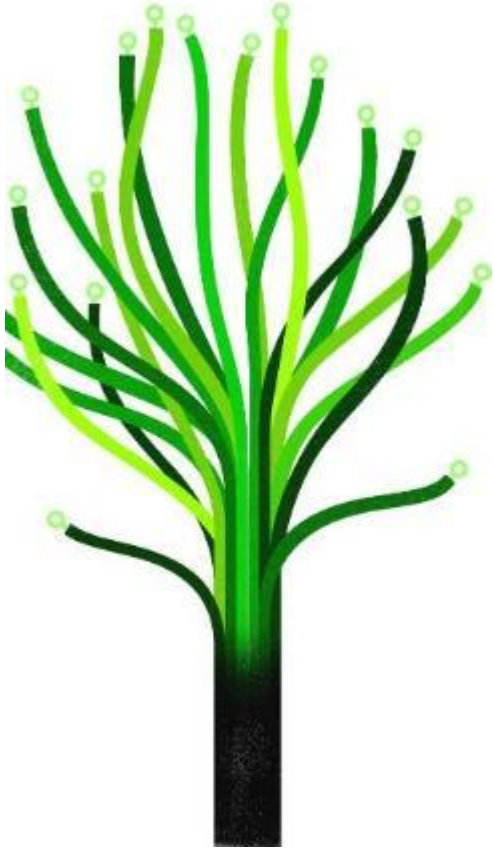
Governance 4.0

- Public administration and regulation are experiencing new chances and challenges as a result of the ongoing technical innovation and the increasing complexity of societies and economies.
- The adaption to technical progress by public and private institutions is slow due to limited financial means and the longsome systematic procedure of political decisions.
  (cf. Kälin 2017, Governance 4.0)

Governance 4.0 – Characterization

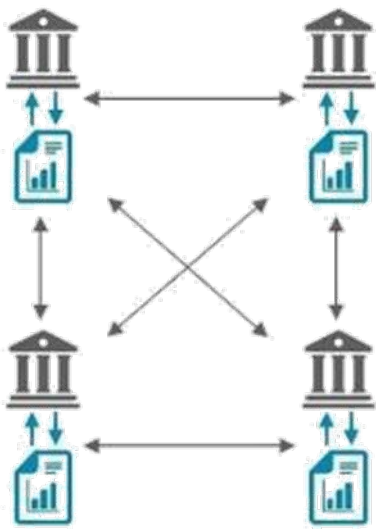
Governance 4.0 is characterized by:

- Internationalization
- Supranationalization
- Decentralization
- Pseudonymity and anonymity
- Neutrality and privacy
- Transparency
- Auditability
- Decreasing transaction costs



Governance 4.0 – Blockchain (1)

- A blockchain is a data structure that makes it possible to create a digital ledger of transactions and share it among a distributed network of participating computers
- It uses cryptography to allow each participant on the network to manipulate the ledger in a secure way without the need for a central authority
- Instead, a protocol defines the rules of how the ledger can be altered



Governance 4.0 – Blockchain (2)

- Once a block of data is recorded on the block-chain ledger, it is extremely difficult to change or remove
- When someone wants to add to it, participants in the network – all of which have copies of the existing blockchain – run algorithms to evaluate and verify the proposed transaction
- If a majority of nodes agree that the transaction looks valid – that is, identifying information matches the blockchain's history – then the new transaction will be approved and a new block added to the chain

Governance 4.0 – Blockchain (3)

- There are different blockchain configurations that use different consensus mechanisms, depending on the purpose of the network
- The bitcoin blockchain, e.g., is public and “permissionless”: anyone can participate and contribute to the ledger
- Many firms also are exploring private or “permissioned” blockchains: networks made up only of known participants
- Key element of any blockchain setup, however, is that the entire network is responsible for validating each transaction

Governance 4.0 – Blockchain (4)

Blockchains can be applied in different ways:

- **Digital signatures:** Verify the origin and authenticity of messages (or generally pos-session of a private keys) and allow version controls of documents and contracts
- **Signed blocks of transactions:** Preserve the sequences of transactions, allow access control and create continually updated audit trails
- **Distributed, shared ledgers:** Establish a single version of transaction truth without third parties and make ledgers accessible for autonomous agents and processes (□ smart contracts)

Governance 4.0 - Smartcontract

- US-American start-up **SmartContract** offers self-verifying and self-executing smart contracts using the Bitcoin and Ethereum blockchains
- Standardized smart contracts can easily be created online
- When doing so, SmartContract accesses external data feeds, uses financial networks and connects to existing IT infrastructure to trigger smart contract events

Governance 4.0 – Bitnation (1)

- Founded in 2014 in an attempt to provide governance services with no geographical bounds, Bitcoin calls itself a Decentralized Borderless Voluntary Nation (DBVN)
- Any individual from around the world can become a “citizen” of Bitnation by signing on to its constitution
- Once registered and issued a digital ID, citizens of Bitnation are provided with services like dispute resolutions, security and insurance

Governance 4.0 – Bitnation (2)

- In Bitnation's blockchain powered jurisdiction, contracts are linked to "cryptoequity" and automatically enforced

- In 2015, Estonia started a cooperation with Bitnation on allowing anyone from the world to digitally notarize documents on the blockchain

BITNATION
GOVERNANCE 2.0

Governance 4.0 – Challenges (1)

- Democratic legitimation and hence trust and acceptance of new systems
- Security problems
  - Up-to-date equipment and know-how is required to protect users' private bitcoin addresses from theft
  - Unless encrypted, bitcoins can be stolen through malware
  - Even prominent bitcoin exchanges have struggled with security, and in the case of Mt. Gox, it is still not clear whether its loss of bitcoin was due to internal problems or hacker attacks
- Privacy issues

Governance 4.0 – Challenges (2)

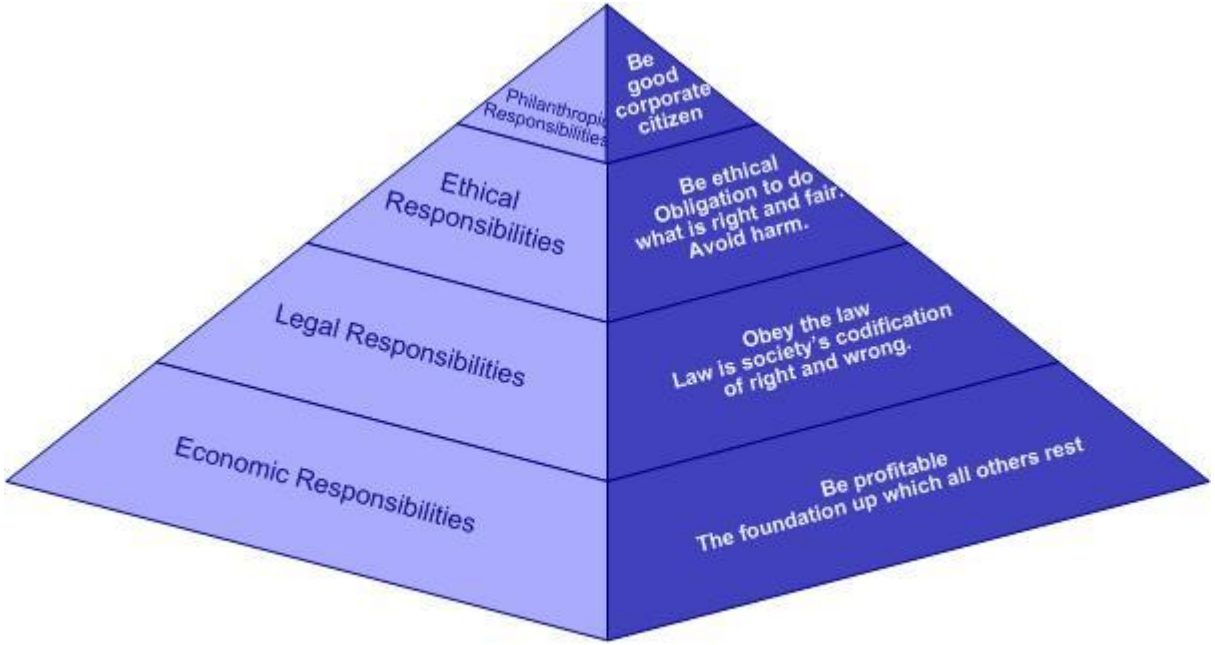
- Inequality
  - Access to and benefits from spearhead internet technology as of today remains very unequally distributed
  - Elderly people might be left behind as they tend to adapt slower to technical innovation
- Criminality

  e.g. money laundering, bypassing of rules

Chapter 5

Shared Value 4.0 for Companies

Corporate Social Responsibility (CSR) as a Traditional Concept



Carroll's CSR Pyramid

CSR – Ethical or Instrumental

Ethical CSR	Instrumental CSR
• CSR as an obligation beyond making profit • Responsibilities if necessary against economic interests	• „The responsibility of business is making profit“ (M. Friedman 1979) • CSR as a Business Case

A New Approach: Doing Good by Doing Well

Creating Shared Value (CSV)

The concept of shared value can be defined as policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the community in which it operates.

– Porter & Kramer 2011 –

Implementing CSV

The Three Levels of CSV

Enable Local Cluster Development

Active supply chain to enable growth and productivity

Redefine Productivity in the Value Chain

Improve resource efficiency and reduce cost of operations and its impacts

Recreate Products and markets

Grow revenue through new or improved products and services to address social issues

CSV – An Example

"WaterHealth International offers an immediately deployable strategy for processing healthy drinking water in underserved communities. WaterHealth Centers deliver a scalable and sustainable solution to purify any source of water to WHO - quality drinking water standards."

- Profit oriented enterprise operating within market conditions
- Goal: Providing 5 Million people in developing countries with drinking water
- Jobs at the „Water Centers" are created on-site
- Sources of financing: customers, private contributions, institutional investors, venture capital

What Does This Mean for Digital Markets?

CSV and Digital Technologies

- Digitization is a prerequisite to participate at the global market
- Especially in countries with weak traditional infrastructure digitization can enable market transactions
- Digital infrastructure can open-up new markets

CSV and the Digital Market – An Example

- Mobile phone-based money transfer service
- Launched in 2007 by Vodafone in Kenia
- Users can deposit, withdraw, transfer money and pay for goods and services
- 7 million M-Pesa accounts in Tanzania (June 2016)
- Also available in Afghanistan, South Africa, Fiji, Congo, India and others
- Add-on M-Shwari: saving deposit, term deposit and credit function

CSV and the Digital Market – Further Fields

- Providing digital infrastructure for rural population (mobile communication, internet)

- Digital technologies as a substitute for deficient institutions in developing countries
  - Payment services via mobile device
  - Online health education
  - Digital e-Learning
  - Bringing together entrepreneurs and investors decentrally
  - Mobile applications to improve farming (weather, soil quality)

- With the help of 3D Printers missing items for production can be quickly provided in remote regions

Chapter 6

Education 4.0

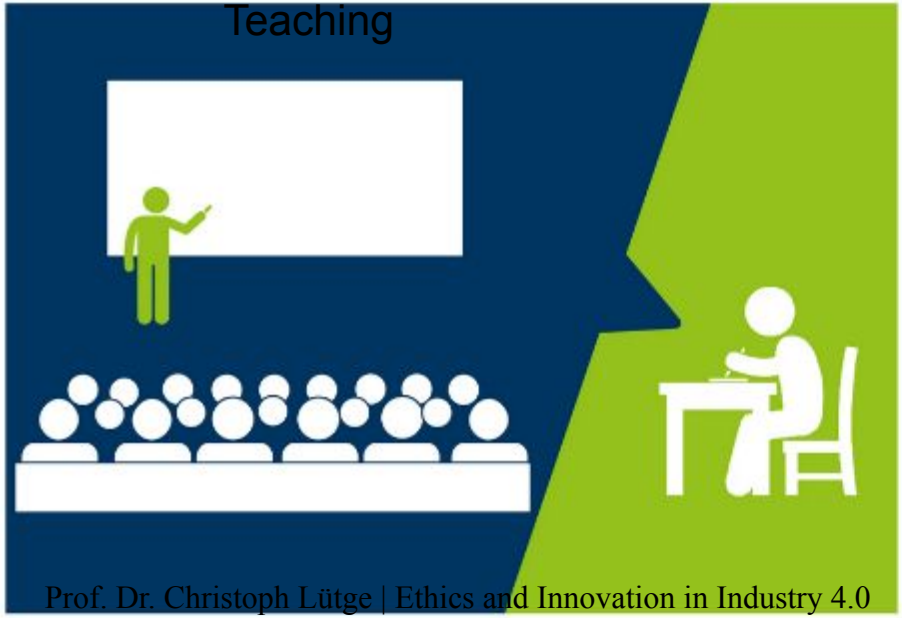
Education 4.0: Chances (1/2)

- Digitization increases differentiation: higher flexibility benefits part-time students and those who aim to better integrate their stay abroad
- Teaching can become more individualized and thus more motivating
- A permanent feedback between lecturer and students is possible even for large groups of students
- Universities can distinguish themselves through excellent teaching across borders
- Unlimited transparency increases incentives to improve teaching

Education 4.0: Chances (2/2)

Time in class can be used more efficiently: Learning content is acquired location-independent and at own speed – presence time is used more effectively, e.g., to discuss contents

Conventional Teaching



Inverted Classroom

Education 4.0: Push and Pull Factors

Society

- Digital Natives
- Diversity of students
- Lifelong learning
- Social Responsibility

Technology

- Omnipresent broadband internet
- Social Media
- Availability of venture capital
- Big Data & Learning Analytics

University system

- Efficiency and cost pressure
- Potential for university marketing
- Potential for revenue diversification

→ **Digitization of university education**

Education 4.0: Privacy Issues

- Digitization of education allows for universal access
- Massive open online courses (MOOCs) have received a significant amount of attention
- Design and scale of university MOOCs create tension for privacy laws intended to regulate information practices exercised by educational institutions
  - Are MOOCs part of the educational institutions these laws and policies aim to regulate?
  - Are MOOC users students whose data are protected by aforementioned laws and policies?

Education 4.0: Market potential

- Absence of study fees is not inherent to MOOCs
- Developing courses requires high investment of resources
- Venture capitalists will have an interest in return on invest
- Many business models are possible, e.g.,
  - Capitalisation of generated data (information on student performances can be used by universities and employers)
  - Fees for content providers (MOOCs become gatekeepers for digital educational opportunities)
  - Product Placement and sales commissions
  - Charged certificates

Education 4.0 and Society 4.0

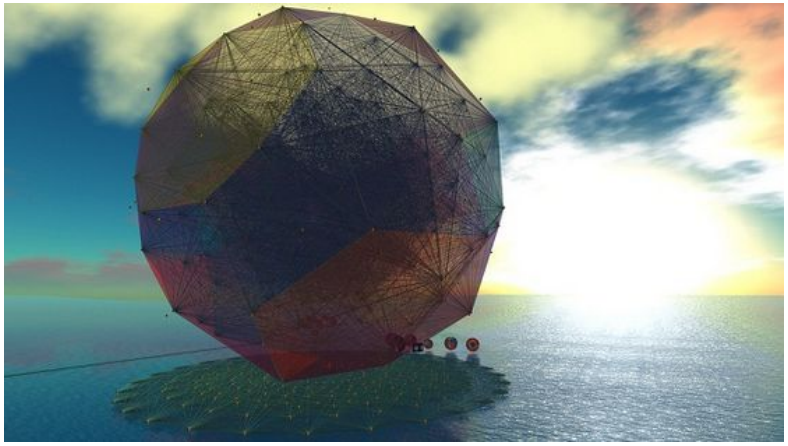
- Knowledge based economy
- Rising levels of education around the globe
- Life-long learning
- Flexible working practices
- Collaborative methods of innovation
- Active Sourcing 4.0

Education 4.0: Challenges

- Recognition of MMOC credits from various education providers feasible?
- Possible disruption of the "traditional" business model of universities
- "Regional" universities may become outdated
- New competencies of teaching staff necessary
- Challenge in the combination of distant and non-distant components

Education 4.0: Perspectives (1/2)

- Geographical distance and proximity between the university and its students are likely to change
- Impact on education in developing countries
- Change of business models
- Shift to more cooperative structures enhancing interdisciplinarity



http://www.opencolleges.edu.au

Education 4.0: Perspectives (2/2)

- New concepts for faculties and departments
- Shift towards new learning infrastructures e.g. increased computing capacities
- New teaching infrastructures (equipment for virtual worlds)
- Digital rights management will become more important

Thank you very much for your attention!