DIGITALIZATION IN INTERNATIONAL TRADE AND E-COMMERCE

CONFERENCE PROCEEDING

Chief Editor: Kaoru Natsuda
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PREFACE

The last two decades have seen rapid growth of digital technology in the global economy. This trend is expected to continue with a rise of the Fourth Industrial Revolution. Digitalization, robotization and automation (DRA) are becoming increasingly important in our business and society. It is obvious that these technologies create many new opportunities for the business sector. On the other hand, there are many challenges between DRA technologies and society.

This proceeding is the outcome of the International Conference on "*Digitalization in International Trade and E-Commerce*" (DITEC), held at Zhejiang Yuexiu University of Foreign Language in Shaoxing, China on the 10^{th}-11^{th} January in 2020. The main theme of the conference was to explore the role of DRA technologies in the perspective of business and society in Europe and China under the rapidly growing digitalization era.

This proceeding consists of selected seven papers that benefited from comments and discussions during the conference. The papers examine various topics on DRA technologies including consumer protection legislation and product liability regulations, issues on labor market and education, the role of blockchain in supply chain networks, the role of artificial intelligence-based neuro-fuzzy model in innovation, political relations between Europe and China. This proceeding provides a wide range of analyses on DRA technologies and helps us to understand the current issues and future prospect of DRA technologies. Finally, I would like to express my gratitude to Katalin Csekő, Miklós Gubán, Richard Kása, Péter Csillik, Anna Forgács, László Csonka, Annamária Horváth, Csaba Moldicz, László Budai and Amadea Bata-Balog for contributing to the production of the conference proceeding, which could not have been realized without the support of the Oriental Business and Innovation Center (OBIC).

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"ROBO SAPIENS"
NO HOMO SAPIENS IS INFALLIBLE, NOR IS THE ROBO SAPIENS
NEW LIABILITY ISSUES IN ROBOTIZATION

Katalin Csekő

Abstract

Although robotic technologies have already been used in several industries for the past four decades, the term "robotization" has arisen only in the last ten years. Due to the implications of the 4th generation or robots – of machines having or having not a physical body but using highly sophisticated IT technology such as AI (artificial intelligence) – in businesses and in the global economy, there are new legal and organisational consequences that require appraisal. The "intelligent" technologies in terms of their capacity and capability to make "autonomous" decisions have triggered debates between philosophers and resulted in scrutinizing the adequacy of the regulations on the liability of economic operators such as, for example: strict product liability for damages caused by defective algorithms. This paper aims to give an overview of the initiatives of different nations regarding the principles of the development and use of robots equipped with AI in B2B transactions and B2C interactions. Furthermore, by classifying robotic technologies it attempts to identify the fields where the rules of consumer protection legislation and thereby the product liability regulations need reform. Regarding the true nature of these machines, which is the use of their "cognitive capability" (strong or weak AI technology) in their operations, they can neither be considered as "goods" nor as "services" in the traditional sense. Hence, there is a need to create an international agreement, which lays down the fundamental principles and criteria for the international trade of robots showing simultaneously tangible and intangible features. By describing the inherent risks of trade deals including the sales of robots, this paper endeavours to contribute to the forthcoming international legislation.

Keywords: changes in product liability and warranty, responsibility of robot producers, lack of proper insurance products

1. Robots through the Lens of Trade

International trade includes two cardinal principles regarding the deliveries of goods. First, the contracting parties must define and precisely describe the subject of the deal. Secondly, they must achieve a consent on the place and time of the passage of risks. In a dispute the seller's duty is to prove that the goods and his performance were in full compliance with the agreement. If the risks have been passed on,[1] the buyer bears the burden of proof and has to provide evidence that defects already existed at the time of the passing on of risks.

[1] when the delivery has ended

The adaptation of new IT-technology in terms of AI-systems in machines seems to destroy this fundamental rule of international trade, because neither sellers nor buyers can determine the nature and time of appearance of a fault and thereby, they would like to limit or to be discharged of their respective responsibilities.

Every technological advance creates new risks and problems while satisfying existing or latent societal and economical needs. This holds true especially amidst the ongoing IT revolution of the 21st century, which prompts business actors as well as policymakers to rethink the processes and regulation of international trade. One of the key drivers of change are "smart" robots that are eliminating and creating new jobs by redefining the cooperation between machines and humans.

The sales of robots have shot up worldwide in recent years. According to the report of the International Federation of Robotics (IFR) 2018, the number of robots sold rose by 30% in 2018 compared with the same period in 2017 and reached 381,335 in total. Sales increased significantly in the manufacturing of metal and electronics, although the automobile industry has preserved its first place in industrial robot investments with a 33% share of the total market. 73% of robots sold in 2017 were installed in five countries: China, Japan, South Korea, the United Kingdom and Germany. Since 2013 the most dynamically developing and biggest market for industrial robots has been the Chinese market. Although there have been promising developments in European markets, the integration of robots into production is still at an early stage. Italy, for instance, set a record by acquiring 7,700 robots in 2018, a 19% increase compared with the previous year.

Since robots[2] as unique "goods" have created special duties and responsibilities in their sales, distributions and after-sale services, traders must understand precisely their functions and features. It is vital for them either in national or international transactions to exactly define these goods and the related services because their respective contractual tasks will ultimately be reflected in the price of the robots.

In a publication by Herbert Zech (2016) there is a reference to the first definition of autonomous robots, which was provided by G. A. Bekey in 2005, according to which: "[...] we define a robot as a machine that senses, thinks and acts. Thus, a robot must have sensors, processing ability that emulates some aspects of cognition, and actuators."

According to Zech four development stages can be classified in robotic technologies.

- The first technologies which comprise electronic control units are older than forty years.
- In the second stage of achievement the control units became more complex and were equipped with sensors.
- The period which followed the early innovations is featured by robots being capable of movement.
- Finally, in the fourth stage autonomous robots appear, and they start to revolutionize "robotics."

The companies which use robotic technologies, can be assigned to three categories.

- In the first group, there are those that apply the "standard" robotic technologies in production, such as control units of various complexities.
- The companies that utilize automated robots capable of physical movement but controlled fully by humans (such as drones used in transportation) belong to the second group.
- Finally, the third group consists of pioneering companies that integrate autonomous robots as "equal partners" into their production.

[2] especially the autonomous one

2. A Clear Definition of Robots is Needed

The legislative and operative bodies of the European Union have realized the fast and enormous widespread growth of robots in industry and in commerce and pointed to the necessity of an accurate definition.

The European Parliament resolution of February 16, 2017 with recommendations to the Commission on Civil Law Rules in Robotics (2015/2103(INL)) attributed the following characteristics to smart robots:

- "the acquisition of autonomy through sensors and/or by exchanging data with its environment (inter-connectivity) and the trading and analysing of those data;"
- "self-learning from experience and by interaction (optional criterion);"
- "at least a minor physical support;"
- "the adaptation of its behaviour and actions to the environment;"

Before analysing robot-related liability issues, it is indispensable to depict the following capabilities of robots as to the European Parliament resolution of 16 February 2017 quoted above:

- "… these agents "interact with their environment and are able to alter it significantly;"
- "a robot's autonomy can be defined as the ability to take decisions and implement them in the outside world, independently of external control or influence;"
- The industrial operators and trades have been using the definition laid down by ISO for industrial robots in 2012 – ISO 8373:2012(en) Robots and robotic devices which bear resemblance to the definition set by the European Parliament, highlights the following characteristics of robots. They are:
- "automatically controlled, i.e. it controls itself through automated mechanisms;
- reprogrammable (2.4), i.e. designed so that the programmed motions or auxiliary functions can be changed without physical alteration;
- multipurpose (2.5), i.e. capable of being adapted to a different application with physical alteration;
- capable of physical alteration, i.e. it can undergo physical alteration without change in its software;
- has axes, which can be either fixed in place or mobile for use in industrial automation applications."

The impact of the ISO definition on international trade is twofold. First, a clearly defined term plays an important role in quality assurance and in the fulfilment of contractual obligations of economic operators. Secondly, an obsolete or in part ambiguous definition will create hurdles and uncertainties in legislation and in trade deals as well.[3]

The nature and thereby the legal status of robots was clear while the technology was still in its first and second phase, because these goods were deemed to be automated machines controlled by humans. The robots of an autonomous nature, in terms of those which are equipped with the "intelligent" technology of Artificial Intelligence (AI), however, are reshaping the responsibilities of industrial actors and users and raises several questions of an ethical and legal nature (civil and criminal law). The trade with them is likely to affect customs laws (e.g. duty payable on cross-border online services) and trade and security regulations.

The definition of AI was first created in 1956 by John MacCarty to denote the simulation of human intelligence with software.

[3] For instance, "automated guided vehicles" are not considered by ISO as robots, as the term has long been superseded by the term "autonomous vehicles."

In the European Union report published in 2018, "traditionally Artificial Intelligence (AI) refers to machines and agents that are capable of observing their environment, learning, and based on the knowledge and experience gained, taking intelligent action and proposing decisions" (AI, a European Perspective, 2018. p. 19).

In 2019 due to innovations, experts had to modify the definition of 2018.

According to their opinion published in a study by the European Commission "Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.

AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and facial recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications)" (Definition of AI, 2019, p. 1).

The term AI includes two words which have induced fierce debate among researchers and academics of different fields of science; these are "artificial" and "intelligence". In general meaning, a thing is to be deemed as artificial, if it does not exist in nature, that means it is made by humans. The word "intelligence" refers to and describes the capacity of human beings to make judgements and decisions of their own and adapt their behaviour to the environment by perceiving and reasoning.

Although AI-based systems are commonly referred as being "intelligent" and "autonomous", it might be dangerous for traders to describe the characteristics of these "goods" by these two words because of their manifold meanings and interpretations.

Observing the functioning of AI-systems, "rationality" seems to be the best word to present the unique nature of these applications, notably that they can select the best option from possible decision and action alternatives elaborating on the available information and data, relying upon the set of criteria made by themselves. AI-systems perceive their environment by using sensors that measure temperature, distance, weight, pressure, resonance etc. and utilize built in cameras, microphones, keyboards, websites, smart phones etc. AI-systems can work effectively if the environment (where they are embedded) is perceived and analysed in a technically and legally in a right and fair (non- discriminatory) manner, thereby essential and proper data can be gained and elaborated upon.[4]

The term "rationality" is applied to depict AI-systems' capability to reason data obtained and to convert them for decisions. The data can be structured; it means that they will be elaborated on, built up and classified in accordance with a pre-defined criterion. After having analysed the data sets, a decision will be made and carried out by the system. This decision cannot be considered as an autonomous one, since the AI-system follows instructions, or it is based upon the decision-tree which was programmed in by the software engineer; at the end of the day a human being was the actor, who made the decision at hand.

According to the terminology used in academic literature, these systems are called "weak" or "narrow" AI-systems, since they have only "limited" capacity, namely they can achieve a pre-defined aim (or a set of aims) with technology designed by engineers (for example, machine translators or facial recognition applications).

[4] for example, when the robot vacuum cleaner realizes that the surface is dusty and cleans it

By contrast, the" strong" or "general" AI is intended to be able to accomplish most of the tasks that humans can. General AI is capable of setting goals for itself and acting under uncertain conditions. These capabilities bear a strong resemblance to human intelligence (the ability to reason, decide and act). There is no strict boundary between weak and strong AI. Over the course of time, weak AI will become more and more capable of autonomous evaluation and reaction, which then brings it closer to strong AI. By doing so, both types of AI-systems will have an impact on their environment and will cause changes and in some circumstances, risks.

3. A Clear Specification of Robot-Related Risks is Needed

In the past centuries, buyers and sellers in international trade considered it self-evident that a profitable trade deal cannot be made without a thorough and comprehensive knowledge of the inherent risks of the agreement. Furthermore, it was generally accepted and imperative to apply appropriate risk mitigation techniques.

There are specific operational risks stemming from using robot technology for which both legislators and economic operators must find adequate risk mitigation solutions. The risks of using robots can be classified as to the technological level of the robot in operation.

3.1. Complexity Risk

The category of "complexity risk" refers to the dangerous situations and potential damages which are triggered by the malfunction of software built in robots. These risks are attributable to the defaults in the algorithm. Mitigating the complexity risks, robot producers have already adopted stricter security measures and run regular updates and cleaning of algorithms. At the same time, they contacted insurance companies which provide special products such as "robotics errors and omissions insurance" or "specialized robotics risk management services." [5] Since robot producers have the technological knowledge that enables them to detect any malfunction in time, and they have the means to properly assess and mitigate consequential damages, the liability of the producers both for intangible and tangible damages is indisputable. The fact that after-sale activities are no longer conducted at the place where robots physically operate, since these warranty and guaranty obligations are commonly cloud-based services rendered from distance only strengthen the producers' liability.

3.2. Mobility Risks

The category of "mobility risks" includes those perils which are linked with the physical actions of robots and their movements (for example when they deliver or produce things). Mobility risk arises if the connection of robots with IT networks has interruptions, when the actuators of a robot cause the damage or hinder it to prevent and reduce an accident. The interruption of IT-networks or errors in the functioning of a robots' actuators might result in tangible damages, physical injury or death of human beings. To define the reasons of a damaging activity, the circumstance must be analysed in depth.

[5] See AIG products: Robotics Shield Professional, general and product liability.

Two different situations can be clearly distinguished;

- If a robot works in the operational buildings (in enclosed spaces) of the company, then the danger of its operation can be effectively reduced by traditional work protection means and measures (training, protection tools etc.). There is no need to modify the liability of producers and employers in these cases.
- If a robot moves – either autonomously or directed – in open space, it will bring about new costs and perils. Producers will be required to put into operation appropriate safety and security equipment and to guarantee their perfect functioning. States must finance the establishment of international arrangements, data-bases, platforms and cross-border collaborations by which the movements of robots can be controlled, and the infringement of international regulations can be prevented. The growth of hazardous factors requires legislators to scrutinize whether there is a necessity to revise responsibility fields of users when they operate the robot. The costs and expenses of these additional activities will be imposed on users (private persons as well), who will pay increased prices and a higher tax content for these machines.

3.3. Intelligence Risk

AI-equipped robots which can infer from experiences and interactions with their environment, can significantly alter their original behaviour. Their way of "thinking" and doing cannot be supervised, neither by producers (sellers) or users.

4. The Revision of Civil Law Rules is Needed

Suppliers of robotic technologies that have simultaneously the role of a seller and of a service provider, should provide detailed, accurate and verifiable information about the robot as a thing and about its activities including the expected and measurable results. The lack of proper information on the performance and efficiency of the work the robot does, has serious implications; neither sellers can prove that they have performed perfectly at the time of passage of risk, nor the buyers can rely upon the defectiveness of these goods or inadequate performance of the seller.

The exact definition of robots is a necessary but not a sufficient condition in trade. Traders need much more accurate descriptions than those that have been constructed so far. They must invoke the respective provisions of national civil law and international regulations to give a profound and detailed quality description of a good that is called robot.

The presently effective provisions of the Civil Code of Hungary– in accordance with section 35 of the United Nations Convention on Contract for the International Sale of Goods (CISG) – requires in paragraph (1) of section 6:123 that "at the time of performance, the service shall be fit for its designated use, hence

- it shall be fit for the purpose specified by the obligee, if the obligee informed the obligor of it prior to the conclusion of the contract;
- it shall be fit for purposes for which other services having the same purpose are normally used; […]
- it shall have the characteristics that are typical for the service as set out in the description handed over by the obligor or presented by him as a sample to the obligee; and
- it shall comply with the quality requirements set out by law."

Regarding the suppliers' responsibility to furnish proper information two categories of robots must be distinguished: robots for industrial and for private use. In case of industrial robots, the users – typically economic operators – are expected to have sufficient knowledge to operate the robots with reasonable care and in safety. By contrast, if a robot is designed for households (for example a vacuum cleaner or lawnmower), the legislator cannot expect the user (private persons) to have higher expertise and knowledge which is reasonable and proportional to the planned purpose of use. In addition, private persons cannot be required to be prepared to handle a crisis, therefore, the producers must provide more detailed information (e.g. video films, manuals, symbols etc,) and assume stricter liability for the robots which have the capability to make autonomous decisions in their interactions with human beings.

Since producers of robotic technologies commonly use samples to illustrate the functionality and efficiency of their product, it is worth looking at the rules of the so-called "purchase on sample" deals. As to paragraph (1) of section 6:230 of the presently effective Civil Code of Hungary in compliance with the section 35(c) [6] of CISG, if the parties specify the characteristic of a thing that is the subject of the contract by referring to a sample, the seller shall be required to provide the thing which corresponds with features of the sample that was held out or presented to the buyer. Neither lawmakers nor the traders can be content with the list of attributes that usually describe robots such as its ability to change its position, to behave "smartly" when interacting with the external environment, to create things, provide information, opinion or to make autonomous decisions. If a sample at hand is an AI-powered robot which can alter his functions independently of the producer's original will and knowledge, the producer and all other actors in the distribution chain can hardly use the particular sample as the evidence of their right conduct.

Furthermore, traders need to go one step further and agree on the applicable law which will govern their disputes. This aspect is especially important since the physical appearance is not an inevitable component of robots and therefore robots can be defined as a set of software and services. Whereas for the trade of physical goods there are generally accepted agreements, which have been ratified in national laws, there have only been attempts in the European Union at the standardization of the services and the terms and conditions thereof (rights and obligations of the parties) in international trade.

The quality assurance of the robot as a product and service by an independent third party is not only a technical requirement, but it is a global and national trade compliance issue which needs international legislation. Besides the legal considerations, the future competitiveness and sustainability of global supply chains are dependent on a reliable international inspection and verification system which can produce certificates upon the technical, legal and ethical compliance of robots.

From a moral point of view, a person can be held liable if they are able to keep control of their behaviour and are aware of the consequences and the implications thereof. Moral responsibility is a state (of mind) in which the acting person can assess whether his/her behaviour is right or wrong.

Legal responsibility, on the other hand, means that a person can be held accountable for their behaviour and consequences thereof under the applicable law. The present liability of robot producers and sellers needs to be revisited in both aspects. This study focuses on the legal aspect, especially on the liability under civil law, but underpins the responsibility under criminal law as well (murderous robots).

[6] *(c)* Possess the qualities of goods which the seller has held out to the buyer as a sample or model

Regarding the liability for – AI-powered – robots regulated by civil laws a distinction must be made between contractual and non-contractual relationships. Provisions for contractual obligations under civil law stipulate clear rules for defective performance and warranty for material defects. Defective performance is a special case of violation of contractual obligations; it covers all contractual duties ranging from delivery through to endorsement of ownership to furnishing all relevant information in respect of the use of a product. As to paragraph (1) section 6:157 of the presently effective Civil Code of Hungary, the "obligor performs defectively if, at the time of performance, the service does not comply with the quality requirements laid down in the contract or by law."

The obligor (the supplier) is liable for defective performance. Defective performance is not limited to the violation of a contract where the ownership of a physical good is planned to transfer, but also includes cases where an intangible asset (such as a piece of computer software) does not meet the expectations of the buyer. In general, defective performance refers to any performance which does not meet the requirements stipulated in the contract. In the case of robots – including those that are equipped with AI – deficiencies either in the body of the robot or in the algorithms that control it, can lead to defective performance. However, the warranty obligations can be enforced if a shortcoming occurs subsequent to the performance except the hidden defects. Regarding the nature of robots, the first question to answer is whether they are goods or services. First and second-generation robots are clearly goods or can be considered as goods whereas the classification of cloud-based AI systems as well as all devices connected to the internet (IoT) is problematic and controversial.

In the case of defective performance, the burden of proof lies upon the injured party. The injured party needs to prove that the defect was already present at the time of performance. If the defect is proven, product warranty applies (replacement, repair, price reduction or ultimately withdrawal) and, moreover, the producer needs to reimburse the injured party for the damages. In the case of AI-equipped products, the information asymmetry between the buyer and the producer – usually an IT company – raises concerns. Buyers cannot be expected to prove a defect and the fact that it already existed at the time of performance. For instance, surgeons are not expected to be able to prove the failure of a surgical robot, farm producers are not expected to be able to prove the defect of a device that measures water content in trees.

Producers might also get in trouble when selling AI-equipped robots if those robots make autonomous decisions (see "strong" or "general" AI) because there are currently no generally accepted standards or quality assurance procedures which could demonstrate the reliability and the fitness of the product. If a consumer directly buys an AI-powered product from the producer, it creates a direct legal relationship between them, and product warranty rules apply.

In this case the product is considered defective if it does not meet the applicable quality standards at the time of the delivery, and furthermore, it does not possess the features set out in the product description. In the case of warranty, it is the obligation of the consumer to prove the defect in the goods. Consumers will only be capable of proving any type of defectiveness if they receive a comprehensive and easily understandable product description. That is the reason why consumers may not be satisfied with the present "hedonistic" terms of robots. In addition, the consumers of robots have the right to safety in use, therefore their trust can only be established by the statements of producers which have been verified by state-run inspection authorities.

However, there are a few grounds available for producers for being freed. The producer is exempted from the warranty obligation if the product is not sold or produced in the course of its regular and customary business activity. Furthermore, producers are exempted in case of so-called "innovation risk" as well, i.e. if the defect could not be anticipated at the time of production based on existing scientific and technological knowledge.

It does not matter whether the producer was aware of this knowledge. In a legal procedure, not the subjective knowledge of a producer will be examined, but the court will be interested in whether the knowledge was available and accessible anywhere (e.g. at standard setting organisations) at the time.

The key point of product warranty is the time when a product is put into circulation. This time does not refer to the time when the product at hand entered into the market. The term of putting the product into circulation determines the circumstance at which point the product left the company's control (for example when an import customs procedure has been finalized, the appointed distributor has got physical possession of the product and acquired its ownership). Since producers typically have no direct contractual relationship with consumers, the rules of product warranty will therefore also govern the activity and the liability of distributors including those companies which import the product.

In order to establish universally applicable norms for AI-powered systems and international surveillance, inspection and certification bodies for their controls, first the ethical standards must be formulated. The European Parliament incentivizes the standardization of the existing ethical standards [7] that must be obeyed during the development and usage of robots and artificial intelligence. Producers' liability must be in alignment with the involvement in the development and with the autonomy of the robot. Producers think, the greater the autonomous learning capacity of the robot is, the milder the rules of product liability should be. On the other hand, lawmakers representing the common interest of the public, are of the standpoint that the longer and more complex the training of the robot, the greater the responsibility of producers. As a first step in clarifying these norms, in 2015 the European Parliament initiated the issuance of a code of conduct for robotics engineers. There are a few principles as well as requirements from the recommendation of the European Parliament which robotics engineers must adhere to.

- "Fundamental Rights: Robotics research activities should respect fundamental rights and be conducted in the interests of the well-being and self-determination of the individual and society at large in their design, implementation, dissemination and use. Human dignity and autonomy – both physical and psychological – is always to be respected."
- "Accountability": Robotics engineers should remain accountable for the social, environmental and human health impacts that robotics may impose on present and future generations.
- "Safety": Robot designers should consider and respect people's physical wellbeing, safety, health and rights. A robotics engineer must preserve human wellbeing, while also respecting human rights, and disclose promptly factors that might endanger the public or the environment" (Civil Law Rules on Robotics, p. 20).

Albeit the legal concept of product warranty resembles the rules of product liability in large, with special respect to the parties being interested or the lack of their direct contractual relationship, there are significant differences. The aim of product warranty is to provide remedies for damages which have been caused by defectiveness, on the other hand product liability ensures compensation for losses and damages to health or assets of private persons. The legal institution of product liability lays down rules for damaging conduct in non-contractual relationships. The product liability law – as a part of the complex consumer protection regulations – is in force in the European union, the USA, China and Japan as well.

[7] set by IT-companies such as Microsoft

The Directive on product liability issued by the European Council and in compliance therewith the national laws of Member States includes the following principles:

- the producer has full liability for the damage caused by the defectiveness of its product;
- the producer can be the company which has produced the raw materials used or manufactured the semi-finished or the final product;
- the company which has put its name (brand name or sign) or any distinguishing feature on the product and thereby has indicated itself as the producer, must assume full liability;
- in case of an import deal, the importer is to be considered as the producer;
- if the true producer cannot be identified, all participants in the supply chain of the product will be jointly and severally liable until any of them can name the producer.

The damage caused by the product implies the matters of death, physical or health injury of a private person and covers the losses to the assets in his private property.

The producer must assume strict liability for the defectiveness of its product. The consumer bears the burden of proof, but it only requires the consumer to prove the fact (the existence) of the damages and the causal link between the actual damage and the defect. It is not hard for a consumer to prove the presence of "ordinary" damage. The consumer does not need any sophisticated knowledge to realize the malfunctioning or the stoppage of working of a machine and can prove the defect of the product with ease. By contrast, it is almost impossible for a consumer to prove the presence of a defect in a robot equipped by AI-application (e.g. robot prothesis or implant) with special respect to the robots which are being connected to clouds and are permanently updated. The injured party (the consumer, the claimant) must prove the damage, the physical injury and tangible loss suffered such as disability for working or the burn-out of a flat. The aggrieved party (the consumer) is obligated to prove that he has suffered intangible losses as well, such as the loss of their private documents and data.

There several exemptions from liability ensured for producers; above all a producer is discharged from the liability if it proves that his conduct was not wrongful. The producer will be free of any claim if it can prove that the product had no defect when it was put into circulation, and the defect at hand has appeared later. Producers are not expected to reveal a defectiveness which was not recognisable as to the current stage of the science. Producers are exempted from the liability if the product conforms with applicable mandatory rules issued by authorized governmental agencies.

These rules put hurdles in front of consumers and make it hardly possible for them to present their interests; since today there are no applicable norms and rules by which the current stage of this technology can be defined with certainty.

The consumer does not have to prove that the producer was neglect or faulty in its action, but if the consumer is at fault, the producers' liability will be reduced proportionally. Regarding the fast IT-technological development, it is unavoidable to put the following question: should a producer assume strict liability for its AI-product which was held (thought) to be safe at the time of putting it into circulation, but which later – using its autonomous decision-making capacity – has caused damage.

Applying the rules of the European Product liability directive, a robot is to be deemed flawless if it provides the safety that a consumer is entitled to expect considering all circumstances of the actual or planned use. On the other hand, a robot equipped by AI-application can meet the expectation, if it is able to learn, to develop by elaborating its previous experiences, that means if it can acquire such capabilities which it never had before. (Klein, 2018). A robot is expected to make decisions which could have not been foreseen; it is the true nature of this machine. Besides the serious concerns a simple question arises, namely: is it possible to expect a consumer with average knowledge to know which level of safety must be reasonable and expectable? It holds especially true for children and elderly persons.

The modification of the product liability rules has become necessary and topical for many reasons. The principle of burden of proof must be first revised, since it is no longer reasonable to require a consumer to determine the safety he is entitled to expect from a robot equipped by AI.

Furthermore, it is a difficult technical and legal problem to define and to prove responsibility for the situations where the damage is attributable to more than one person or where it is not caused by the actual user or owner. It is hard for legislators to determine the limits of individual responsibility if for example a drone causes damage by tearing down an electricity line or flying into an airport, because its IT-network connection has stopped working or it has been hacked. The extent of liability must be shared between the producer and the user depending on their true contribution to the damage. If the damage was caused by a defective built-in algorithm of the directing software, then the producer must be accountable. By contrast, the person (user) who is in charge of keeping control of the robots' activity, must assume full liability for its negligent conduct.

If the injured party contributed to the damage, the liability for damage might be shared or eventually the producer might be exempted from liability. Considering the limited knowledge of consumers on robots (which cannot be enhanced quickly and in great masses) and given the complexity of defining the liability rules for damage caused by robots (AI), the European Parliament has proposed the creation of a "user license" and the establishment of new insurance coverage.

According to the recommended principles, the user must acknowledge that he/she can use the robot without putting other people's physical and mental health at risk and that he/she adheres to the applicable rules and ethical norms, which also includes the prohibition of collecting any personal data with the robot unless the owner of the personal data has given their consent.

Since robots are used in cross-border transactions, there will be a need to overhaul current international regulations (for example rules on use of airspace, or on transportation), which necessarily leads to the modification of International Private Law.

Today, consumers must already face the consequences of their missing knowledge in respect of AI, and due to the growing asymmetry in this field they have less chance to cope with the technical defects. There is a strong and clear temptation for producers to get rid of the strict liability in respect of general AI-robots relying upon the current stage of the science and technology and referring to the unique self-learning capability of these machines. From the point of view of producers, the recognition of robots as legal entities will be the best and most convenient solution. Besides this pressure on legislators there is another phenomenon which gives rise for concerns; notably the high concentration of AI-technology in a few companies. The concentrated technological power might hurt the rules of the applicable competition law and enforce the alteration of international trade policy regulations. A robot with AI-application is to be deemed a dual-use product since it can be used both for military and civil purposes. Taking the autonomous vehicle in transportation by air or by sea as an illustrative example, it becomes understandable that the use of autonomous (duel-use) vehicles requires the reconstruction of the rules of international transportation and customs law.

Evidently, the export, import, delivery or related brokerage activity of these machines must be licence-related, but this requirement is not only necessary, but a vital condition. The classification standards of these robots and their respective international registration and tracking process [8] must be established in order to guarantee the safe trade and the compliance with present anti-proliferation agreements. Nevertheless, insurance companies ought to work out suitable coverages for the potential damages caused by “strong AI-robots” both in industrial and private use. The insurance sector should offer a “mass product” to indemnify the injured persons who have suffered damages due to negligent behaviour of private users of robots.

This “mass coverage” must comply with the limited financial resources of private users and must be proportional to their technological knowledge (or better to say to the shortage in it). Insurance companies need to innovate and develop appropriate coverage for “general AI-robots” producers against “mass damages” and thereby to encourage technological development.

[8] including private person users as well

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AN ARTIFICIAL INTELLIGENCE-BASED MODEL FOR APPROXIMATING SUSTAINABLE INNOVATION

Miklós Gubán
Richard Kása

Abstract

By the 21st century it has been widely accepted, that sustainability and economic growth are not mutually contradicting factors of business operations, but rather and preferably they should be considered as hand in hand, interconnected issues. The field of corporate sustainability management in academic researches has gained significant sophistication since the economic growth has been associated with innovation. In this sense, measuring the impact of innovation on sustainable development is crucial. However, measuring innovation is very difficult due to its many soft aspects that are really hard to quantify. Considering these features for approximating and estimating innovation performance of a company, the common methods of statistical inference are very hard to use and have limited results. In this paper, we present a research project that aims to build an artificial intelligence-based neuro-fuzzy inference system to be able to approximate a company's innovation performance and thus the sustainability innovation potential. For this we used an empirical representative sample of a Hungarian processing industry's large companies and created an adaptive neuro fuzzy inference system. This model is able to effectively approximate innovation performance. Having the results of the performance tests of the model it can be concluded, that the best estimation model for the innovation potential is the neutralized fuzzy model. The neurofuzzy model is also the most noise-resistant model: it can easily recognize and filter noisy data while regression models cannot handle them, they just incorporate them into the model.

Keywords: ANFIS, innovation, modelling, neuro-fuzzy system, Matlab

1. Introduction

The complementary technical terms of 'innovation' and ' sustainability' are far from being newcomer in our contemporary global discourse. Already in the 1970s and 1980s, these opposite, but interrelated concepts were introduced in discussions related to the global extension of the economy, the natural limits to economic growth, the implosive reduction of markets, ever-increasing prices and competition between economic actors. However, during this period, social and environmental topics were less intensely discussed. The situation changed in the last decade of the 20th century, due mainly to the Brundtland Report (United Nation, 1987), which initiated a creative debate on topics such as production (or the transformation of resources), innovation processes, and sustainability (Iñigo – Albareda, 2016). Lately, a great number specialists (including Gianni, 2016; Hernandez-Vivanco et al., 2016; Oskarsson – Malmborg, 2005) have become greatly interested in the topics of sustainability as well as in social and environmental awareness. It has also become clear that, in addition to innovation, sustainable development may also represent a significant competitive edge for companies.

According to this new perspective on growth, both financial profitability, seen in a wider context, and long-term sustainable initiatives have to involve environmental and social values as well (Hernandez-Vivanco et al., 2016; Sroufe, 2017). Thus, companies have had to face the challenge of reforming their traditional structures and introducing policies focused on sustainability in their economic approaches (Gianni et al., 2016; Kennedy et al., 2016; Lozano et al., 2016). Nevertheless, the specialist analysis of sustainability in the corporate context can be viewed as a quite new development, along with its focus on the global environment and the various levels of organizational structure (i.e. particular individuals, organizational groups and subgroups, the organizational macro-level, and larger organizational clusters). In other words, it is a relatively new field of studies, related to, but not synonymous with older, related fields of study, e.g., the study of organization behaviour, environmental economics, corporate strategy and the management of change and innovation processes.

2. Theoretical Framework and Literature Review

2.1. Sustainable Innovation

According to Austrian political economist Joseph Schumpeter, innovation may be characterized as the "realization of new combinations" (Schumpeter, 1912). His classical definition was subsequently further developed by other authors focusing on the economic aspects of this encompassing category (Stock et al., 2016), even considered as the growth engine of society as a whole (Trott, 2005). Some researchers have inventoried more than 40 alternative determinations of the same concept (Edison et al., 2013).

How do sustainability and innovation tie into each other on the organizational level? In order to answer this fundamental question, one has to identify the relatively recent way in which organizations have practiced innovation in recent years, subsumed under the technical term of 'sustainable innovation' (Boons et al., 2013; Hansen et al., 2013), a category widely recognized as significant by business specialists, strategic and innovation managers, as well as contemporary economists (Iñigo – Albareda, 2016), many of them considering it the determinant factor for obtaining long-term business value (Bocken et al., 2014; Hart – Milstein, 2003).
Taking their starting point in Martin Heidegger's technological criticism, co-authors Iñigo and Albareda (2016) came up with a new ontology for sustainable innovation in organizations, identifying its following core elements:

1. The material input of sustainable development, the operational element, i.e. the material cause.
2. The collaborative component, associated with the sustainable innovation-generating form, i.e. the formal cause.
3. The organizational element, centered on institutional development, as the achievement of processes inspired by the idea of sustainable development or due to the fact that the company is engaged in sustainable development, i.e. the efficient cause.
4. The instrumental aspect is related to the fact that sustainable development may also be the method for attaining the proposed objective, associated with the envisioned consequence, i.e. the final cause.
5. Finally, the component that probes into sustainable development in the framework of a superior system development and contributes to the spread of a novel paradigm of sustainable development, i.e. the holistic element (cf. the Heideggerian Gestell, or 'en-framing').

Co-authors Delmas and Pekovic (2008) view sustainable (or environmental) innovation as lying in developmental processes and concrete products capable of lessening the load on the environment (Hellström, 2007; Rennings, 2000; Rennings et al., 2006; Rennings – Zwick, 2002). Thus, sustainable innovation confronts organizations with a hitherto unknown provocation, since it imposes the criterion of increasing company profits while at the same time taking into account the organization's social responsibility (Di Domenico et al., 2009). Innovations related to processes and products, marketing strategies and organizational structures can only be viewed as sustainable if they are capable of protecting our natural environment (Horbach et al., 2012). According to a high number of experts (Boons – Lüdeke-Freund, 2012; Hall – Clark, 2003; Hall – Vredenburg, 2003; Hart – Milstein, 1999; Huisingh et al., 2013; Matos – Silvestre, 2013; Silvestre, 2015; Wüstenhagen et al., 2008), the problems of sustainable development may be handled by finding solutions in the area of innovation. The long-term sustainability of our products and services may be increased through the use of current scientific achievements and new methods of technology management (Hall et al., 2018).

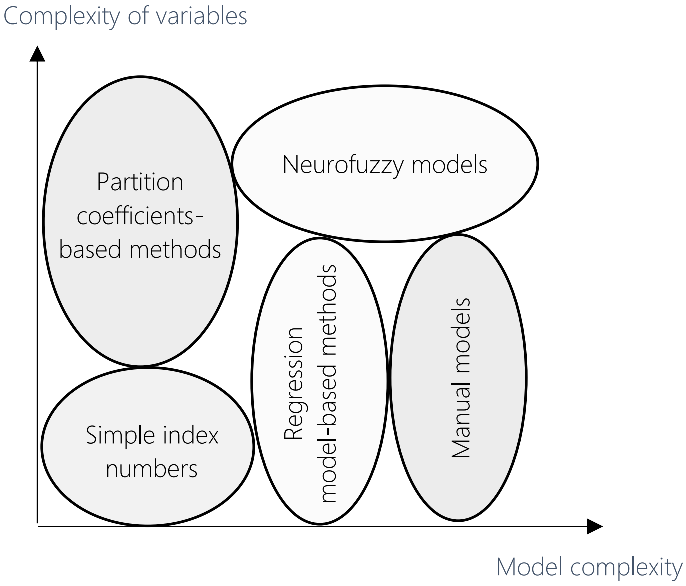
According to Przychodzen and Przychodzen's (2018) review of the existing scholarly literature, the feature that distinguishes innovation from invention consistsin the application of innovative ideas, practices, processes and products (Boons – Lüdeke-Freund, 2013). So what is the additional characteristic of sustainable innovation in this wider context? In addition to the aforementioned features, the innovation also has to present specific social and environmental advantages. Its use of non-renewable resources has to show higher efficiency and lead to greater convergence in society, as well as reduce environmental pollution (Steward – Conway, 1998), simultaneously maintaining an economic growth and increasing profit (Horbach, 2008).

2.2. Assessing the Potential for Innovative Development

Generally, there are two aspects of assessing the potential and performance of innovation, related, on the one hand, to variable complexity as well as to measurement and interpretation complexity in inferences, and on the other hand, to the complexity dimension in the inference pattern that is used, i.e. the way in which it can be interpreted through straightforward linear functions or through more complicated, nonlinear mapping. On the basis of these considerations, I have devised the following methods:

1. The analysis of simple index numbers;
2. Partition coefficient-based horizontal/vertical investigation;
3. Correlation method-based calculus (regression) and the method of standard deviation;
4. Further developed regression methods (manual and path models), canonical correlation, and latent variable methods (principal component, multidimensional scaling, correspondence methods);
5. AI-based models (e.g. neural networks, fuzzy systems).

Figure 1:
Assessment models of innovation achievement



Source: own illustration

As seen in the figure above, there is a great number of criteria for selecting assessment approaches. In this choice process, the basic position for assessing the capacity for innovation and the specific activities to be assessed are indifferent variables. Modernization can consist both in slight alterations of products already on the market or currently developed and in the creation of different products, identifying additional suppliers and market, as well as even in rationalizing the company at the macro-level. As for the processes themselves, these can range from the achievement of new know-how all the way to solving everyday life issues and to innovative solutions for experimenting with and assessing newly implemented methods and even appraising the developmental approach. Irrespective of the chosen method, innovation is generally measurable according to the set of variables. An essential differentiating criterion to be assessed lies in the level of complexity that is characteristic of the innovation mechanism. This is influenced by the two factors mentioned above. Nevertheless, an adequate choice cannot be made solely on their basis (Rappai, 2010). The processes included in the first group are conveniently characterized relying on simple index numbers and via numerical indicators. In another situation, it may be more difficult to characterize innovations via indexes. The process may be such complex and stochastic that the data prevents the transformation to functions and numeric variables.

One should also contemplate the level for assessing the possibilities of innovation. This can be done either on the micro or the meso/macro level, for specific (economic and geographical) regions and individual locations. The interconnections of innovation also influence our chosen method. The question is whether the innovation may be isolated from more encompassing developments and their characteristic correlations. The methodological choice is also influenced by the character and the level of the potential abstraction of the analysis variables. The following abstraction levels may thus be defined: simple abstraction of specific factors influencing innovation processes, abstraction of the individual factors depending on the contextual framework, simultaneously complex and individual abstraction, as well as complex abstraction process with complex innovation. The assessment of these factors may be followed by an adequate methodological choice, i.e. index number generation via simple methods, ratio-based simple analysis, correlation- and regression-model based traditional methods of statistics, as well as manual path models – the strategies hitherto used by traditional investigations for assessing the potential for innovative development.

3. Conceptualizing the Research Problem

The measurement of the sustainability characteristic of innovation processes and achievements is a quite complex problem even at the current state of research. Several popular methods fail as the scholars investigating the topic have to subject themselves to limiting conditions while constructing their models. Traditional modelling processes are often not adequate for issues such as a target function's highly complex character, i.e. our research task when the function is to be analyzed with respect to the optimum or other specific points. It may be possible that the only conclusions that can be established are of an estimative character if a superior level of statistical error is associated with an inferior level of significance. Generally, the stochastic perspective is the source of several difficulties and limitations for social research. The issue under investigation is often difficult to be stated in terms of distinctly perceptible variables. The choice of both the grading instrument and the evaluation strategy may produce disorientation, biases and problems related to handling the function of the outliers. Among the relevant topics of present analyses, an often-encountered limiting circumstance consists in system information of the subjective kind, since the use of quantity principles represents a general premise of traditional approaches to system modelling. Nevertheless, these objective perspectives of quantity are quite rare in social research. Hence, researchers usually turn the assessment principles based on quality into a quantity-centered perspective. But can we be sure that this automatically grants us the desired objective criterion? In fact, the system information of social research, as well as of the business research as a social science, is of a subjective nature, because our human experience has the very same character intrinsically and without exceptions (Babbie, 2001). Irrespective of what positivism teaches, it is highly doubtful whether the social scientist can ultimately be objective in his approach. However, if the system information we have to work with has a subjective nature, but the method we use needs an objective approach (as the requirements of scientific positivism also dictate), then we have to objectivate our subjective data – or else find a method for treating system information depend on subjective value assessments.

The demands posed by linearity are particularly strong here, as the majority of social scientific models use a linear regression. Economic relations are mostly nonlinear in their parameters and/or variables. The scientist thus has to turn the nonlinear conditions studied into a model that is linear (sometimes even accepting the inevitable biases), because the requirements for the prediction of the specifications for such models of the nonlinear kind may be impossible to satisfy, in which cases the variables have to be determined again.

In the regression model, homoscedasticity has to be covered for each probability variable. Thus, each variable will have an identical, finite variance of σ2, and the probability distribution's standard deviation with the target variable will be identical, regardless of the explanatory variables. Hence, the deviation variables' covariance matrix will be of a scalar kind, with the identical σ2 values in the main diagonal. The tests for homoscedasticity will be the Goldfeld-Quandt, the Breusch-Pagan and the White tests.

Our model's analytical variables have to be mutually independent, i.e. no variable may be reproducible via linear combination of other variables. Actually, real instances of such systems, based on stochastic principles, for which the validity of specific criteria does not automatically preclude the possibility of others, are rare. Furthermore, there are numerous limiting criteria to be taken into consideration, contained in most manuals on statistics. For these reasons, the scientific approach to the potential of innovation is itself in need of innovative, AI-based approaches.

As shown in the previous chapter, measuring innovation capability on the micro level has a wide methodological apparatus, however, these methods mostly rely on a classical statistical system modelling basis, which has many limitations and unrealistic conditions which are very hard to satisfy in social sciences (e.g.

linearity, normality, homoscedasticity) (Kása, 2009; Kása, 2011). To bridge this methodological gap of stability and plasticity, exactitude (arithmetical formalism) and significance, precision and flexibility artificial intelligence-based methods seem to be a solution, such as fuzzy-logic based modelling and neural network or even their synergic combination (Szakály – Kása, 2011).

There are more and more positive examples of applications of fuzzy logic to be found in literature, but many of them aim to measure the macro level innovation performance of a region or country (Brown – Harris, 1994; Imanov et al., 2016; Khedhaouria, – Thurik, 2017). There are much fewer findings on corporate innovation measurement, which, however, mainly focus either on the innovation process or on a corporate functional innovation field (Gupta – Barua, 2018; Nilashi et al., 2016; Serrano García et al., 2017; Stock et al., 2017).

Application of neural networks for the quantification of innovation activity is much narrower (Krušinskas – Benetytė, 2015, Wang – Chien, 2006; Wong et al., 2011), however, the method is absolutely suitable for such problems, as it is shown in literature (Fazekas, 2013; Fuller, 1995; Kása, 2011; Kása, 2018).

The combination of the two artificial intelligence methods should result a precise and flexible, and a very stable and arrhythmically well formalized sytem, which is fuzzy and exact at the same time (Brown – Harris, 1994; Jang – Sun, 1995; Johanyák – Kovács, 2005).

In this paper we are to show the effectivity of this combination of the two methods. This has its antecedents as our team has been dealing with this methodological problem for a long time (Gubán – Gubán, 2011; Kása, 2009; Kása, 2011). This current research is a precise and more detailed elaboration of our previous model (Kása, 2015) with a different approach. This will be shown in the following chapter.

4. Methodology

4.1. Sample and Variables

Our empirical observations used in the model stem from a sample with 100 elements (97 of which is applicable) of the population consisting of Hungarian processing companies exceeding 250 employees, containing 207 items, i.e. 46.11% of the total population. Our chosen sample may be regarded as significant both from the perspective of sectorial (Mann-Whitney U-test; $p=0.197$) and geographical (NUTS-2) distribution (Mann-Whitney U-test; $p=0.329$). The innovation potential is estimated by 75 measured variables (on 1-6 Likert scale with 3-3 linguistic statements, showing the agreement with the statement by degree). Specific variables of the model were included into 9 grouping variables and divided into 16 factor elements as follows: motivation, socialization (the specific culture of the organization and the age of the experts), adaptation, strategy, diffusion (stakeholder cooperation, secondary information retrieval, external cooperation), information (internal information infrastructure, external information infrastructure), resources (intangible resources, material resources), technology (technological modernity, push technologies, pull technologies), results (objective, subjective) and action (internal push innovation, external pull innovation) as dependent variables. Our variables are thus in accordance with the Frascati and Oslo Manual.

Table 1:
Input vectors and their aggregation by factor analysis

Grouping variables	Factors	KMO	Bartlett *p*	Σ variance
Motivation		0.749	0.000	69.625
Socialization	Culture	0.840	0.000	71.818
	Age of experts			
Strategy		0.893	0.000	75.332
Diffusion	Stakeholder cooperation	0.741	0.000	63.176
	Seconder information sources			
	External cooperation			
Information	Internal information infrastructure	0.728	0.000	68.112
	External information infrastructure			
Resources	Intangible resources	0.604	0.000	68.401
	Material resources			
Technology	Technology modernity	0.714	0.000	65.085
	Push technologies			
	Pull technologies			
Results	Objective results	0.576	0.000	55.468
	Subjective results			

Source: own illustration

5. The Outline of a Possible Solution

The most important step in developing an intelligent system for the approximation of sustainable innovation is to establish according to *a priori* information how an innovation will take effect in accordance with the company's possibilities and limitations. It cannot be decided in advance, but after analyzing the data at hand, an accurate estimation can be given (Cselényi et al., 2002; Cselényi et al., 2005). An inference system can easily and automatically solve this issue. We already have the variables for the model that has an essential role in the innovation process described above. The number of cases and the number of variables, such as their variance are suitable for the model. A fuzzy inference system provides a simple and good solution. The aim of this research is to show that such a fuzzy inference system (FIS) is able to accurately approximate the sustainable innovative performance of a company. The problem and the set of variables (16 input linguistic variables) consists of a multivariable inference system with few outputs (3 variables).

To conclude, in accordance with the previously described coincidences, a classic fuzzy system cannot be applied only by known linguistic variables and we can also determine the linguistic values associated with each variable (we will usually handle 2-6 language values). The problem is that we have a (statistically) good sample with enough cases and variables, but the fuzzy membership functions are unknown. They are not explicitly available. However, the fuzzy inference sets would be very suitable to draw conclusions in the determination of the sustainability of the innovation potential – not just according to our experiences (Gubán et al., 2012; Kása, 2009; Kása, 2011), but it is also verified in literate (Cheng – Lee, 1999; Fan et al., 2004; Fazekas, 2013; Fuller, 1995; Johanyák – Kovács, 2005; Tsai – Wang, 2008; Deptuła – Rudnik, 2018; Lambovska, 2018) that a FIS would be very useful in the approximation.

FIS is a superb inference system with crisp internal information, outstandingly effective inference method, but it is static. Neural networks, at the same time, are able to learn and may exploit and algorithmize the benefits of everyday human thinking (soft calculation – fuzzy logic) and the learning and adaptation abilities of the neural systems – the synergy between the mathematized everyday human thinking and classical mathematics. However – like a black box – these models do not reveal the structure of the inference mechanism, but their approximation performance is outstanding. The combination of the two would be the best solution for the problem described above.

The idea of fuzzy systems came from Lotfi A. Zadeh – professor of mathematics at Berkeley University – in the 1960s. In the 80s, Sugeno suggested that instead of membership sets, functions should be used for concluding fuzzy rules (Sugeno, 1985). This development is very important for our problem.
Neuro-fuzzy systems appeared in the 1980s and structurally appeared in 6 variants, two of which spread more widely (Johanyák – Kovács, 2005):

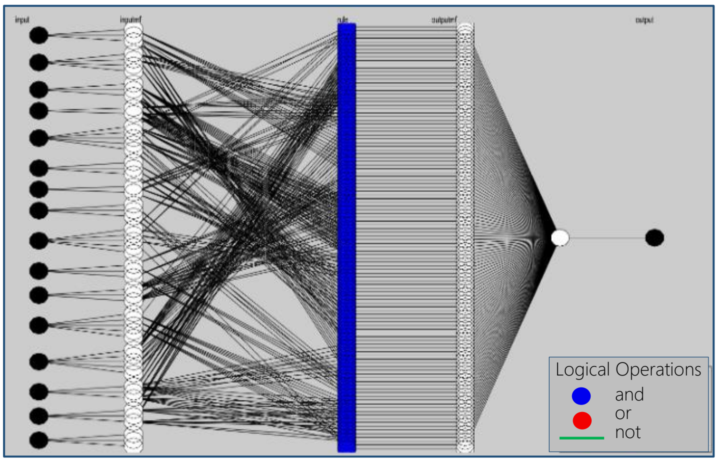
1. The cooperative system in which the basic fuzzy system is tuned with neural network;
2. A single fuzzy inference procedure tailored to a neural network, which contains "fuzzy neurons" and fuzzy weights. The structure of the original fuzzy system can be recognized from the network topology.

For our problem - as explained above - the second method fits the best. Such a method is the adaptive neuro fuzzy inference system (ANFIS). In order to make the ANFIS applicable for the generalized system, we should examine whether it is suitable for a simplified model of the problem.

ANFIS is a 5-layer neural network:

- The first layer consists of the inputs and the associated linguistic variables and values and the according connectivity neurons. Each neuron receives signal from a single input.
- In the second layer, elements of the first layer are associated with the inferential rules. Here the conditions of inference rules and the AND/OR connections between premise elements appear.
- The third layer ensures their normalization (invisible).
- The fourth layer determines the consequences of the rules. Here a zero-order Takagi-Sugeno type inference system will be applied.
- The fifth layer contains only one neuron which determines the final output (Fazekas, 2013; Johanyák – Kovács, 2005).

Figure 2:
ANFIS for approximating sustainable innovation potential



Source: own illustration

In our investigations we discovered what linguistic variables play a role in the approximation of innovation with artificial intelligence (neurofuzzy network). We assigned linguistic values to these linguistic variables denoted by 16 input and 3 output variables. Output variables are the resulting decision variables as follows:

- (Discrete) sustainable innovation potential;
- (Continuous) internal push innovation potential;
- (Continuous) market pull innovation potential.

The following table summarizes the variables and their values briefly.

Table 2:
Linguistic variables and their values

Inputs	Low	Med.	Med.2	Med.3	High
Motivation	x	x	x		x
Strategy	x		x		x
Culture	x	x			x
Technology modernity	x		x		x
Stakeholder cooperation	x		x		x
Seconder information sources	x	x			x
External cooperation	x				x
Objective results	x	x			x
Subjective results	x	x	x		x
Intangible resources	x	x			x
Material resources	x	x			x
Internal information infrastructure	x	x			x
External information infrastructure	x	x	x	x	x
Age of experts	x		x	x	x
Push technologies	x	x	x		x
Pull technologies	x	x	x		x
Outputs					
(Discrete) sustainable innovation potential					
(Continuous) internal push innovation potential					
(Continuous) market pull innovation potential					

Source: own illustration

Output variables do not have sets according to Sugeno. Here all variables will have as many values as many inference rules they have (e.g. the first output has 113 values). In this paper only the first discrete model is described, others are similar.

5.1. Innovation Potential

The Innovation Potential (IP) has a discrete scale (1, ..., 5). For convenient handling, this had been converted to [0; 1] intervals based on the following formula:

$$IP' = IP \cdot 0.2.$$

During processing, this must be converted back and rounded to integer value according to the following formula:

$$IP = round\left(\frac{IP'}{0.2}\right).$$

5.2. The Initial Neuro-Fuzzy Model (Inference Rules)

To the fuzzy system simple IF … THEN … rules are associated.
Three models were generated but, as mentioned above, only the first one is presented in detail in this paper. Thus we specify conclusions of the inference rules (antecedents).

Table 3:
Antecedents of the fuzzy rules

	Motiavation	Strategy	Culture	Technology modernity	Stakeholder cooperation	Seconder info. sources	External cooperation	Objective results	Subjective results	Intangible resources	Material resources	Internal info. infrastructure	External info. infrastructure	Age of experts	Push technologies	Pull technologies
1					Low				Low							
2					High				Low							
3					Low				High							
4					High				High							
5																
6														Low	Low	Low
7														High	Low	Low
8														Low	Low	High
9														High	Low	High
10														Low	Medium	Low
11														High	Medium	Low
12														Low	Medium	High
13														High	Medium	High
14														Low	High	Low
15														High	High	Low
16														Low	High	High
17														High	High	High
18		Low		Low			Low									
19		High		Low			Low									
20		Low		Low			High									
21		High		Low			High									
22		Low		High			Low									
23		High		High			Low									
24		Low		High			High									
25		High		High			High									
26	Low													Low		
27	Low													Medium2		
28	Low													Medium3		
29	Low													Medium4		
30	Low													High		
31	Medium													Low		
32	Medium													Medium2		
33	Medium													Medium3		
34	Medium													Medium4		
35	Medium													High		
36	High													Low		
37	High													Medium2		
38	High													Medium3		
39	High													Medium4		
40	High													High		
41										Low		Low				
42										Low		Medium				
43										Low		High				
44										High		Low				
45										High		Medium				
46										High		High				
47			Low	Low	Low							Low				
48			Low	High	Low							High				
49			Low	Low	Low							High				
50			Low	High	Low							Low				
51			Low	Low	High							Low				
52			Low	High	High							High				
53			Low	Low	High							High				
54			Low	High	High							Low				
55			High	Low	Low							Low				
56			High	High	Low							High				
57			High	Low	Low							High				
58			High	High	Low							Low				
59			High	Low	High							Low				
60			High	High	High							High				
61			High	Low	High							High				
62			High	High	High											
63							Low		Low							
64							Low		Medium							
65							Low		High							
66							High		Low							
67							High		Medium							
68							High		High							
69			Low			Low										
70			Medium			Low										
71			High			Low										
72			Low			Medium										
73			Medium			Medium										
74			High			Medium										
75			Low			High										
76						High										
77						High										
78		Low			Low											
79		Low			Medium2											
80		Low			Medium3											
81		Low			High											
82		High			Low											
83		High			Medium2											
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85		High			High											

86	Low														Low	
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106													Medium		High	Low
107													Medium		Low	High
108													Medium		High	High
109													High		Low	Low
110													High		High	Low
111													High		Low	High
112													High		High	High
113									Low							
114									High							

Source: own illustration

6. Elaborating the Solution of Approximating a Sustainable Innovation Potential

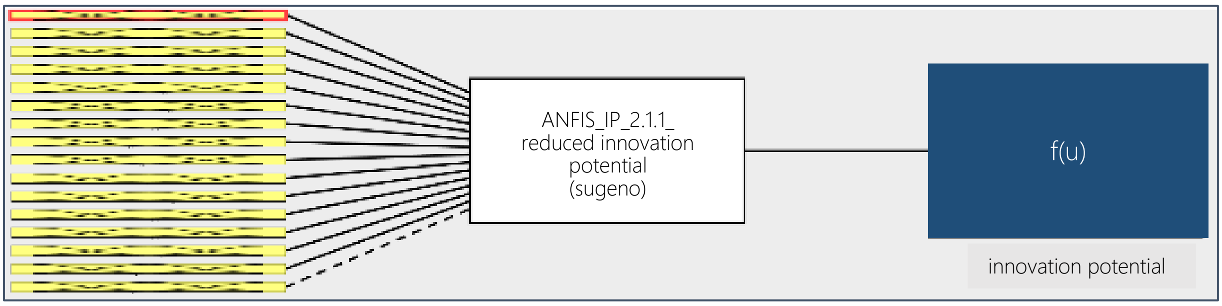
For the chapter of Methodology, it can be clearly seen, that the problem-solving consists of several steps.

1. Based on the specific linguistic variables and the basic inference rules, an initial system is built up which will be the starting point for our neural network.
2. Remark: the application would be able to generate an initial FIS, but the available data should be used for a more accurate and faster learning (training) process.
3. Using the training data, the ANFIS is being learnt to generate the FIS.
4. The resulted FIS now can be used in concrete cases for decision-making.
5. To solve the specific task, we used the MatLab application.

6.1. Building Up the Neuro-Fuzzy Model

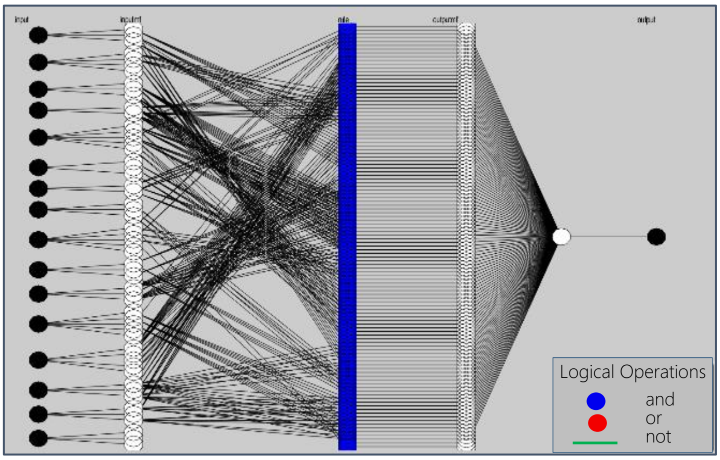
In the first step the system is built on the basis of its structure. The following block diagrams show this structure.

Figure 3:
The external structure of the system



Source: own illustration

Figure 4:
The ANFIS of the problem



Source: own illustration

Using the sample data of the data from the questionnaire survey the learning and control samples were created by randomly splitting the sample in half. A threshold subsample was also created and added to the database as control.

Figure 5:
Training data

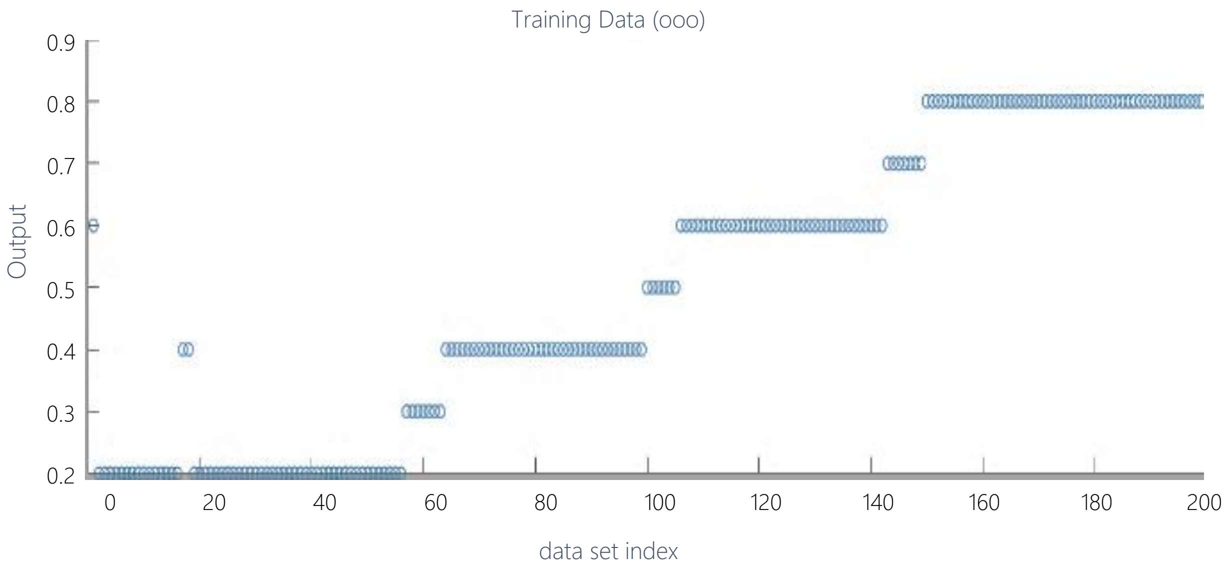


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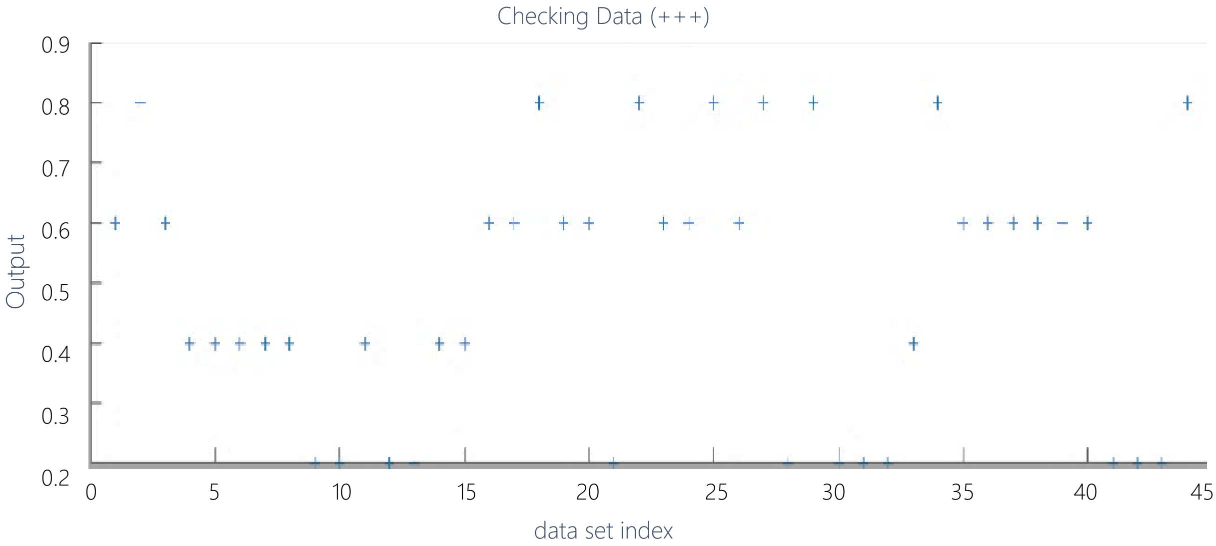
Figure 6:
Control data



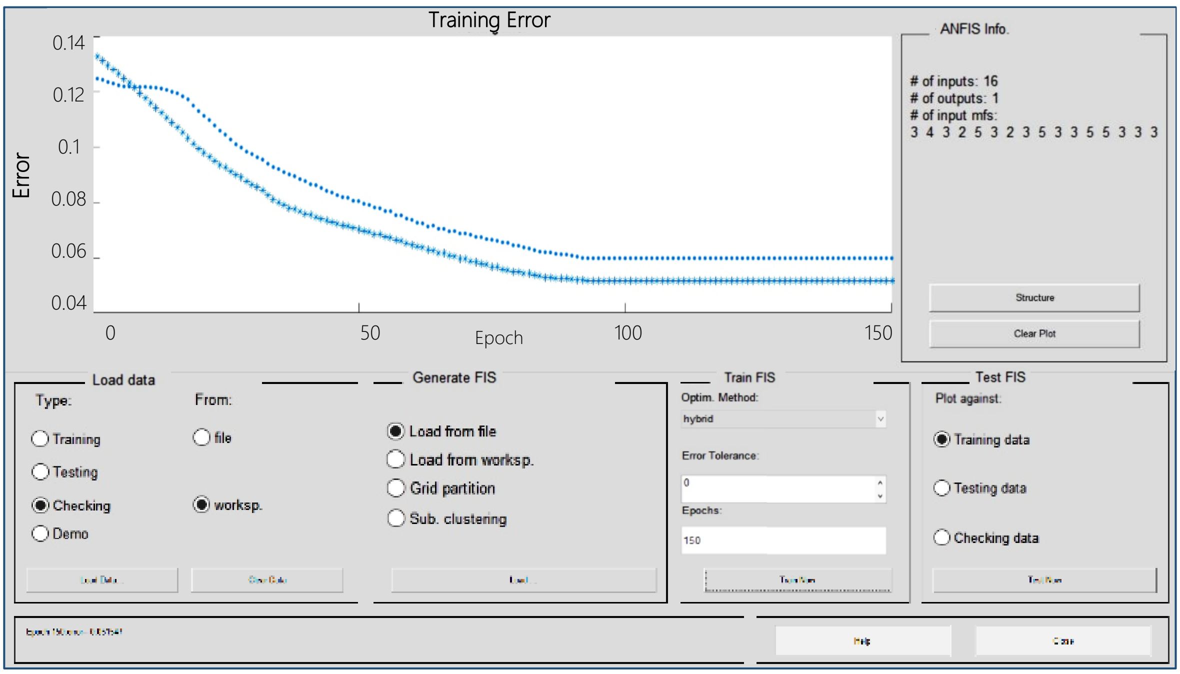
Source: own illustration

The ANFIS module of MatLab was used for training. As optimizing method, we used the hybrid option. The number of epochs was set to 150, but the outcome resulted in less than 100 steps.

6.2. Training the Model

The second step is training. Based on the set parameters, the training process has been started. The result converged during the training process according to the figure below.

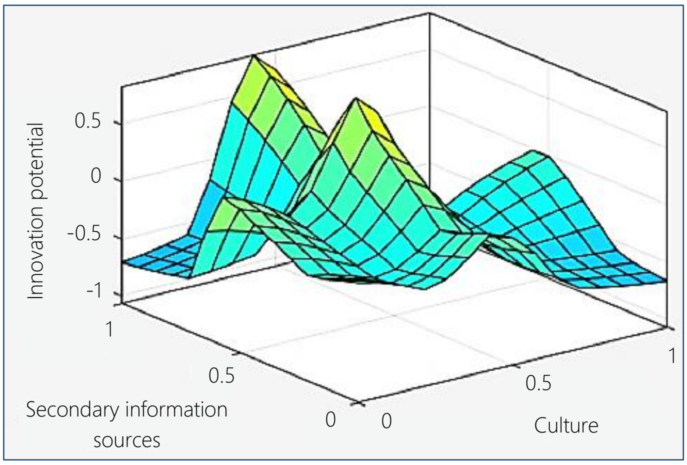
Figure 7:
Training process



Source: own illustration

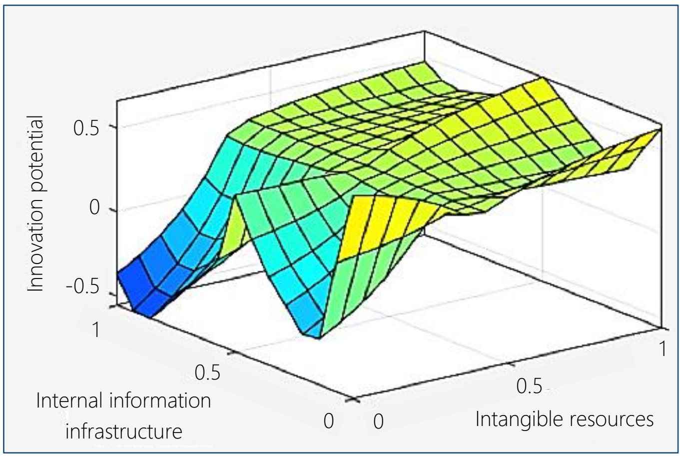
Errors of the final solution:
Minimal training RMSE = 0.052217
Minimal checking RMSE = 0.056194

Figure 8:
The surface of the relationships between secondary information sources, culture and innovation potential



Source: own illustration

Figure 9:
The surface of the relationships between internal information infrastructure, intangible resources and innovation potential



Source: own illustration

The third step is controlling the results on two specified and randomly selected cases. In case 1 the company's innovation potential turned out to be 2 (low innovation potential on 1-5 scale) and in case 2 it resulted in 4 (higher innovation potential on 1-5 scale). The values of the FIS after the training is shown in table below.

Table 4:
The analyzed two cases and the value of their sustainable innovation potential

Variables	Case 1 values	Case 2 values
Motivation	0.927111	0.3
Strategy	1	0.6
Culture	0.451937	0.4
Technology modernity	0.802602	0.6
Stakeholder cooperation	0.391188	0.5
Seconder information sources	0.383006	0.8
External cooperation	1	0
Objective results	0.22918	0.1
Subjective results	0	0.5
Intangible resources	0.6	0.5
Internal information infrastructure	0.8	0.7
External information infrastructure	0.8	0.8
Age of experts	0.8	0.9
Push technologies	0.2	0.2
Pull technologies	0.781396	0.8
Material resources	0.371427	0.3
Sustainable innovation potential	2	4

Source: own illustration

The result of the first case from FIS turned out to be 0.4292. using the conversation formula, this means IP=2. The result of the second case from FIS turned out to be 0.8599. Using the conversation formula, this means IP=4. These results – as expected based on the theoretical background – are equal to the values presented in the last row of the Table above.

7. Conclusion

On the basis of the results of the running model we draw our conclusions on two fields: on methodology and on sustainable innovation potential.

The innovation intelligence decision-making problem is a very complicated task whose structure is unknown (or the exploration would be very difficult). We can only deduce the structure based on a priori experience. However, because of the complexity, this can only be solved with a great computing background. We used a neuro-fuzzy solution to solve the problem, and this proved to be a very good solution. The assembled system has quickly and precisely given results with appropriate accuracy. The results we are getting during the runs (two of them is shown in this paper) in most cases are equal with the expected values. Of course, if we were to expand the data – which can be done, based on experience, we can even fine-tune the system to a certain level. Overall, the produced FISs are close to solve the problem, and our method as a decision-making method is suitable for solving the problem.

We showed in our research that the innovation potential can be efficiently approximated by our 16-variable fuzzy inference system.

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CHINA - A ROBOTIZING EAST-ASIAN DEVELOPMENTAL STATE, ITS RELATION TO THE USA, EU AND CEE – OR WILL CHINA BECOME CHIN-AI?

Anna Forgács
Péter Csillik

Abstract

In our paper we explain China's dynamic development in the field of digitalization, artificial intelligence and industrial robotization by extending the term of developmental state. We first examine the concept of developmental state from the 1950s up until the era of globalization (strong state-weak society, market-based economy pursuing export-oriented industrial policy), and then we go on to examine the state of robotization in the era of post-globalization. We discuss how robot density is linked to multiple factors such as low TFR, high per capita GDP or developmental state.

China was the leading force in technology 500 years ago. We examine the possibility of a once again rising China claiming the lead in the field of technological advances.

Studies show that only the USA will be able to match the speed of automatization and robotization of China up until 2025. By that date, the GDP of China will amount to the sum of the GDP of the EU and the United States. CEE countries may take part in a Chinese push for more global power by the 17+1 formula, while China approaches the CEE countries (which are considered to be the gate to the EU) via the Shanghai – Istanbul – Moscow axis. The level of development of the CEE countries has an impact on their robot density, which is basically determined by German automotive industry and less by their national industry 4.0 initiatives.
Whether a Chin-AI era is coming or not, we cannot say for sure.

Keywords: China, developmental state, artificial intelligence, deglobalization, robot density

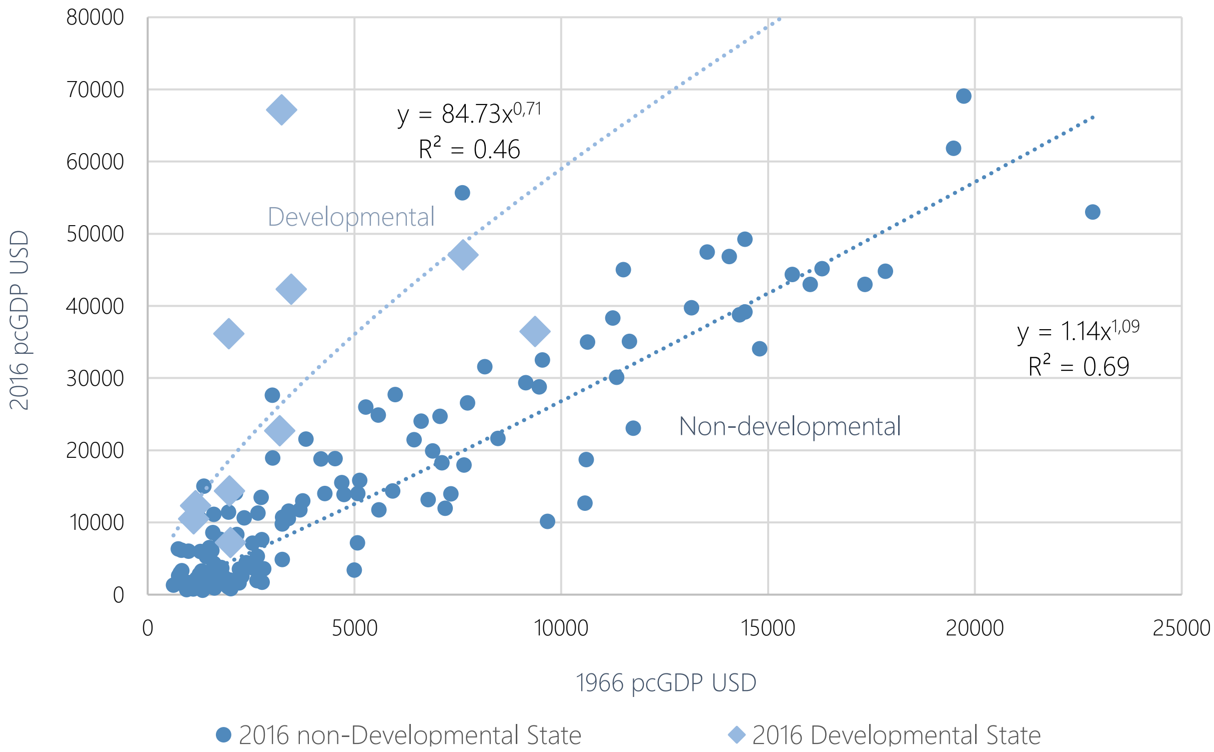
1. Introduction

There are necessarily many approaches to China and digitalization. In this paper, we approach the question from a special perspective, extending the concept of the East Asian developmental state to China, which may help to explain the accelerated pace of robotization. We first analyze the issue of the developmental state as an authoritarian system pursuing export-oriented industrial policy from the 1950s to the end of the period of globalization. Afterwards we examine the situation of post-globalization robotics. Finally, we look at the question of the decades ahead, including geopolitical challenges and answers.

2. The Developmental State in Economic Literature

The East Asian so called developmental countries' GDP grew almost twice as fast as the average of the "world GDP" over 50 years (1966-2016), and have shown a rise from poverty to middle-income and in some cases to wealthy countries. Many scholars are debating the question whether China will ever reach the wealthy country club. Others are asking, if China indeed becomes a wealthy country with its huge population, then will it become also the new leader that "replaces" the US and leads the world according to its own rules? The rise of the "digital leader" People's Republic of China would embody the hope of many and the fear of others. We deal with this question in Chapter 4 and 5., in Chapter 2 and 3. we analyze the real economic situation and the challenges of the recent years and present days. Figure 1. shows that the economic growth of the developmental states was more rapid than that of non-developmental states.

Figure 1:
GDP/cap in developmental and non-developmental states, 1966 - 2016



Source: Maddison Project Database, 2018.

Between 1966 and 2016, the median rate of GDP per capita on an average increased yearly by 2.7% in the non-developmental states and by 5.0% in the developmental states. The figures in the table allows the division of non-developmental states into several groups. To do this we use a 2×2 matrix of states and societies.

Table 1:
GDP/cap in developmental and non-developmental states in 1966 and 2016

	1966	2016		1966	2016		1966	2016		1966	2016
Singapore	3237	67180	Portugal	5978	27726	Egypt	1951	11430	Cambodia	822	3307
Hong Kong	7621	47043	Malta	3011	27612	Albania	2662	11285	Bangladesh	1299	3250
Taiwan	3470	42304	Cyprus	7732	26540	Sri Lanka	1593	11118	Kenya	1597	3214
Japan	9364	36452	Poland	5266	26002	Mongolia	1107	11105	Lesotho	782	3015
Korea	1962	36151	Seychelles	5574	24856	Saint Lucia	3256	10737	Cameroon	1247	2803
Malaysia	3191	22687	Greece	7064	24689	Tunisia	2331	10621	Nepal	745	2586
Thailand	1971	14341	Hungary	6610	24047	Bosnia, H.	1247	10576	Senegal	2279	2544
China	1151	12320	Russian Fed.	11739	23064	Ecuador	3396	10536	Tanzania	1825	2518
Indonesia	1106	10511	Croatia	8467	21625	Barbados	9664	10160	Yemen	1180	2199
Philippines	1997	7223	Panama	3827	21538	Dominica	3248	9773	Chad	1316	2192
Luxembourg	19727	69057	Chile	6435	21446	Paraguay	1573	8605	Benin	1531	2166
Switzerland	19478	61844	Uruguay	6890	19896	El Salvador	2156	8335	Gambia	2693	1950
Ireland	7607	55653	Romania	3020	18913	Swaziland	1749	7641	Afghanistan	2642	1929
United States	22842	53015	Mauritius	4528	18852	Morocco	2757	7613	Uganda	1379	1909
Netherlands	14436	49254	Turkey	4187	18784	Jamaica	5071	7175	Rwanda	724	1741
Saudi Arabia	13523	47474	Argentina	10598	18695	Guatemala	2531	7137	Zimbabwe	2760	1729
Germany	14055	46841	Montenegro	7109	18244	Cabo Verde	1487	6512	Comoros	1703	1713
Denmark	16303	45141	Bulgaria	7645	17953	Lao	736	6324	Guinea	1494	1668
Austria	11495	45010	Mexico	5124	15803	Myanmar	816	6139	Ethiopia	969	1659
Australia	17834	44783	Iran	4690	15529	Bolivia	1546	6118	Haiti	2204	1636
Sweden	15584	44371	Botswana	1357	15015	Viet Nam	988	6031	Mali	1015	1604
Iceland	16011	42980	Gabon	5921	14334	India	1272	5961	Burkina Faso	1992	1561
Canada	17334	42969	Dominic. R	2119	14088	Nigeria	2650	5323	Togo	1615	1515
Belgium	13142	39733	Serbia	4281	14001	Pakistan	1421	5250	Guinea-B.	1294	1354
Un. Kingdom	14440	39162	Costa Rica	5074	13986	Nicaragua	3252	4872	Madagascar	1180	1307
France	14304	38758	Iraq	7325	13976	Honduras	2380	4435	Mozambique	622	1288
Finland	11238	38335	Macedonia	4745	13887	Congo	1599	4310	Sierra Leone	1932	1070
Puerto Rico	11643	35082	Brazil	2738	13479	Ghana	2377	3753	Malawi	1156	950
Italy	10632	34989	Venezuela	6778	13159	Sudan	1776	3750	Niger	1609	906
New Zealand	14796	34040	Colombia	3747	12963	Côte d'Ivo.	2551	3664	Congo	2006	836
Israel	9536	32494	Lebanon	10565	12683	S. Tome, P	1790	3640	Liberia	1103	764
Spain	8144	31556	South Africa	7191	11949	Syrian AR	2801	3557	Burundi	935	692
Czechoslovakia	11336	30118	Jordan	3673	11748	Zambia	2216	3538	Central AR	1328	619
Trinidad, Tob.	9135	29358	Namibia	5584	11741	Djibouti	4989	3394			
Slovenia	9459	28761	Peru	3409	11540	Mauritania	1592	3307			

Source: Maddison Project Database, 2018.

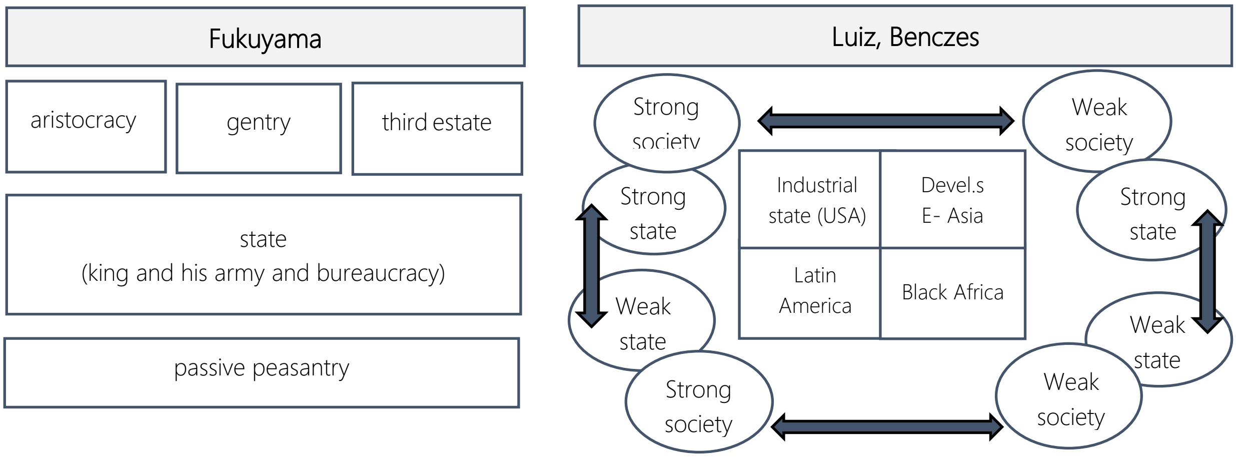
According to Luiz (2000), countries may be classified into the following groups:

a) strong state – strong society (e.g. EU, USA),
b) weak state – weak society (e.g. Black Africa),
c) weak state – strong society (e.g. Latin-America),
d) strong state – weak society (e.g. East Asia)

Fukuyama (2011) used this classification for the Middle Ages and Modern Europe in the following way: the state: a king with an army and bureaucracy; society made up of aristocrats and other noblemen, and city citizens; peasants: 90% of the population provided the passive bases for the changing ruling system above them.

If we want to depict the half-century period, we find that African states have largely remained in the "start-up square", while developmental states have grown faster than "normal countries" and much faster than Latin-American economies.

Figure 2:
State and Society Scheme in the feudalism and afterward



Sources: edited by the author based on Fukuyama, 2011; Benczes, 2009.

The East Asian developmental state model (Japan, Korea, Singapore, Thailand, and Republic of China (RoC) – and Peoples' Republic of China (PRoC) included by many) had ten main components (Ricz, 2018):

1) Economic nationalism and social mobilization. The state forces quick reconstruction after World War II. focusing on industrialization with the purpose of economic convergence, but also requiring the mobilization of society.

2) A strong, centralized, authoritarian state is led by a narrow, determined elite committed to long- term development policy; their intervention is always pragmatic, and their activity can be characterized as a long learning process. The state expects international competitiveness in the selected industrial sectors in exchange for state support. The state enforces market principles. The authoritarian type state's development model is effective in setting goals as well as using measures and indications to achieve them (e.g.: suppression of labor, low wages, stable economic policies independent of political cycles). The legitimacy of the system relies on shared growth.

3) Extensive state interventionism. The state makes plans (in a discretionary and selective way), controls (prices, exchange rates, interest rates), fine-tunes, selects the winners, and manages the transition from import substitute to export-oriented economic structure. The market rationality is limited in line with industrial goals, and incentives, licenses and indications reduce the risk of investors. The selected strategic industries are supported, the rest of the economy functions within the framework of market competition.

4) Extended business groups. Family businesses with traditions implement state oriented industrial policy, and their social (e.g.: lifelong employment, education, health) and political role (e.g.: giving the system legitimacy for political, economic, financial support) is also important.

5) Meritocratic bureaucracy has a historical tradition in East Asia. Its members are carefully selected by competency and values (e.g.: system of competitions, committed to the public good), they also understand the signals of the private sector and market because they have an extensive and living network of information.

6) Agriculture after the land reform. The increase in agricultural productivity provides the basis for the forced industrial development and for the integrated, balanced and controlled development of rural-urban areas. Large landowners are exiled from the socio-political arena, which promotes the social support and background for the developmental state system.

7) Export-oriented economic development strategy is implemented under state control, some say with market comfort tools (Johnson), others say with market distortion (Amsden, 1989) and with market management (Wade, 1990), but in any case, in a (foreign)market-friendly manner. "One eye always focuses on the world market."

8) Repressive financial system: Developments are financed by domestic resources: savings and investments are mainly stimulated and channeled through fiscal instruments to specific industries. The State's guarantee for deposits is an incentive to save. State aid provides lifelong employment in loss-making companies in the selected sector. Safe operation of financial institutions has been achieved by regulated market entrance conditions rather than applying strict rules (foreign financial institutions are not welcomed). Closed, subordinated capital markets. The approach to foreign capital is negative, while domestic savings and capital investments enable rapid growth without foreign capital inflow or with strongly filtered foreign capital inflow (Japan, Korea, RoC).

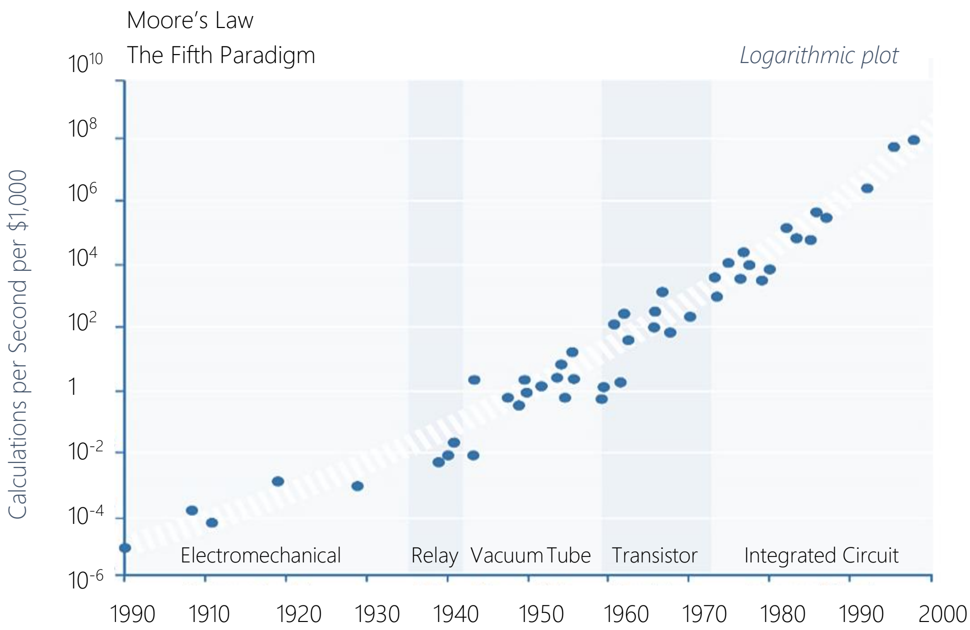
9) Macroeconomic stability. Stable, predictable business environment, low inflation, prudent fiscal and monetary policies, and stable, competitive exchange rates.

10) Shared growth. Relatively homogeneous societies, strong sense of community and social cooperation based on the ethos of the nation/nationalism, significant economic growth, poverty and GINI decline, HDI indicators improve.

3. The Dawn of the Developmental State in the Era of Globalization and Afterward

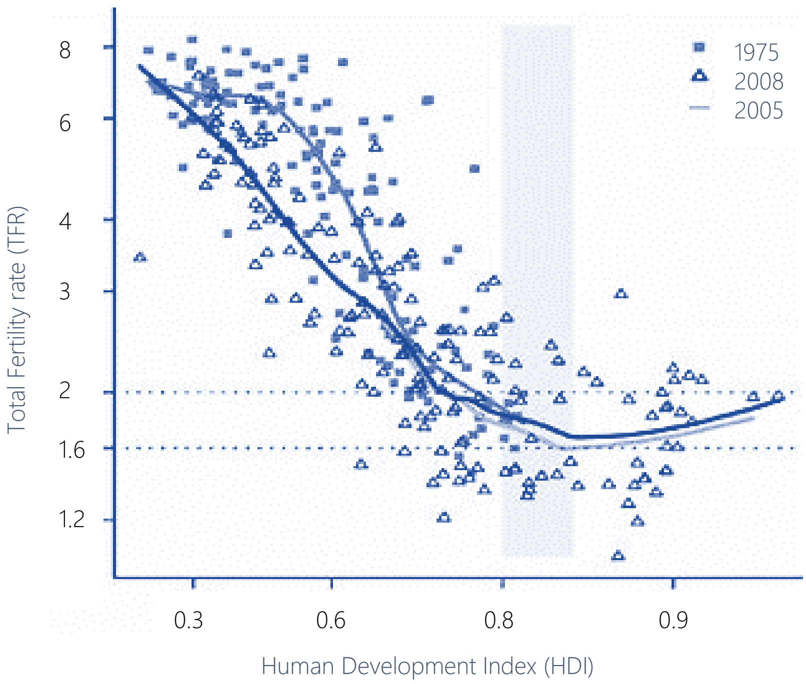
The vast majority of literature believes that the developmental state is no longer a viable model in the age of globalization (when the export-to-GDP ratio increases significantly, due, among others, to almost complete eradication of customs). The greater portion of population has already moved from the countryside into cities, and no longer can be easily subordinated by autocratic rule. Entry to the country is allowed for foreign financial institutions, and free flow of capital is slowly making it impossible for strong state to intervene, while on the other hand society has strengthened. A new element is the twin processes of declining total fertility rate since the 1970s (TFR below 2.1 in many developed and semi-developed countries), and rapid digitalization allowing cheap machine computing (Moore's Law: the transistor density doubles every two years).

Figure 3:
Moore's Law: the transistor density doubles every two years 1900 – 2000



Source: Kurzweil, 2005.

Figure 4:
Cross-country relationship between Total Fertility Rate (TFR) and Human Development Index (HDI), years 1975, 2005 and 2008

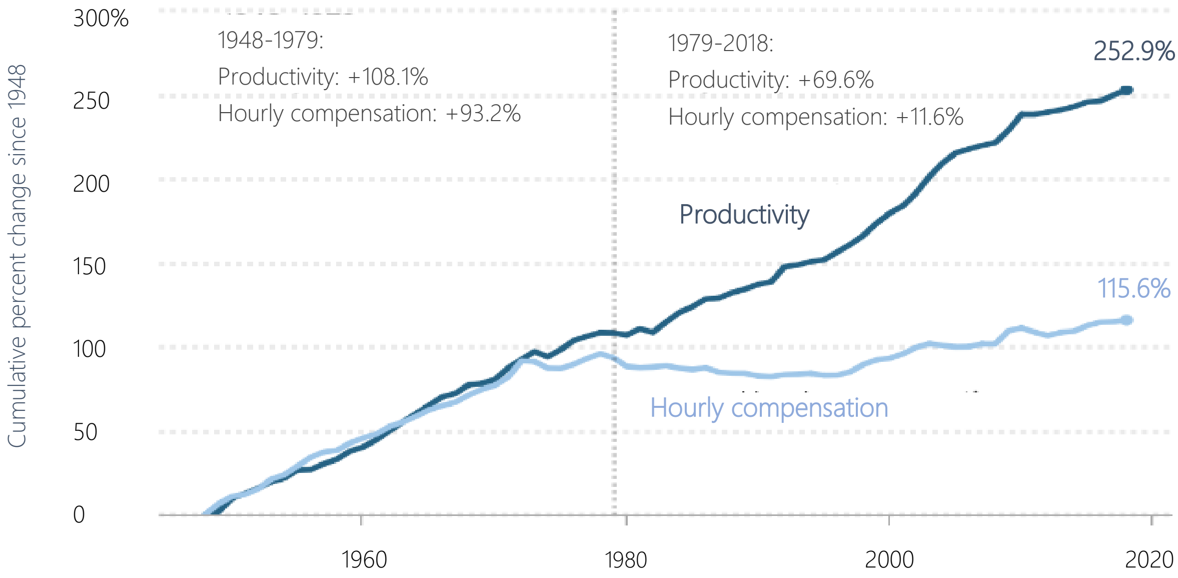


Source: Myrskyla et al., 2011.

In the US, productivity increased after 1970 until 2008, as it did from 1870, but the real wages of blue-collar workers remained unchanged after the 1980s. It was cheaper to outsource production (Stolper-Samuelson theorem, 1941) or to robotize production (the costs of robots are much lower than German wages, while the robots don't get sick and do not strike).

Figure 5:

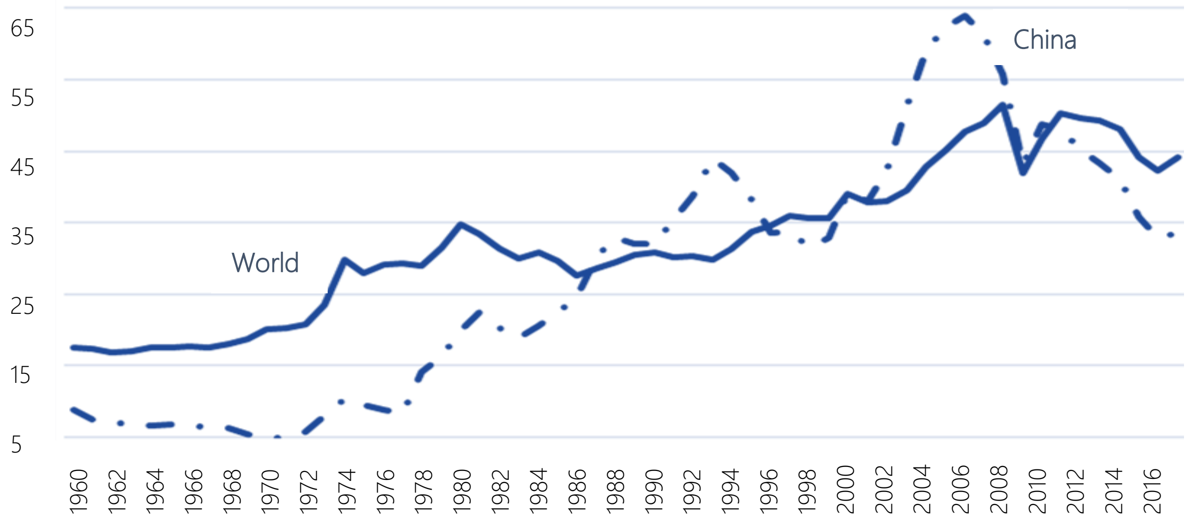
Divergence of American productivity and blue-collar hourly wages since 1979



Source: Economic Policy Institute, 2017.

Figure 6:

Global and Chinese export/GDP grew from 1960 to 2005, but stagnates from 2005



Source: The World Bank Data, 2018.

To sum it up: around 2005, the dynamics of globalization stopped, with robotic sales increasing by 15% yearly and robot density (robot/manufacturing worker) rising sharply. However, robotization has not been spreading evenly around the world. Let's look at the full picture first. Let's examine the assumption that there is a positive relationship between the GDP loss due to the unborn population (low (under 2.1) fertility rate [(2,1-TFR) × pcGDP]) and the robot density (RD). Overall, though not very strong, this relationship can be discovered over the period of 2010-2015.

Table 2:

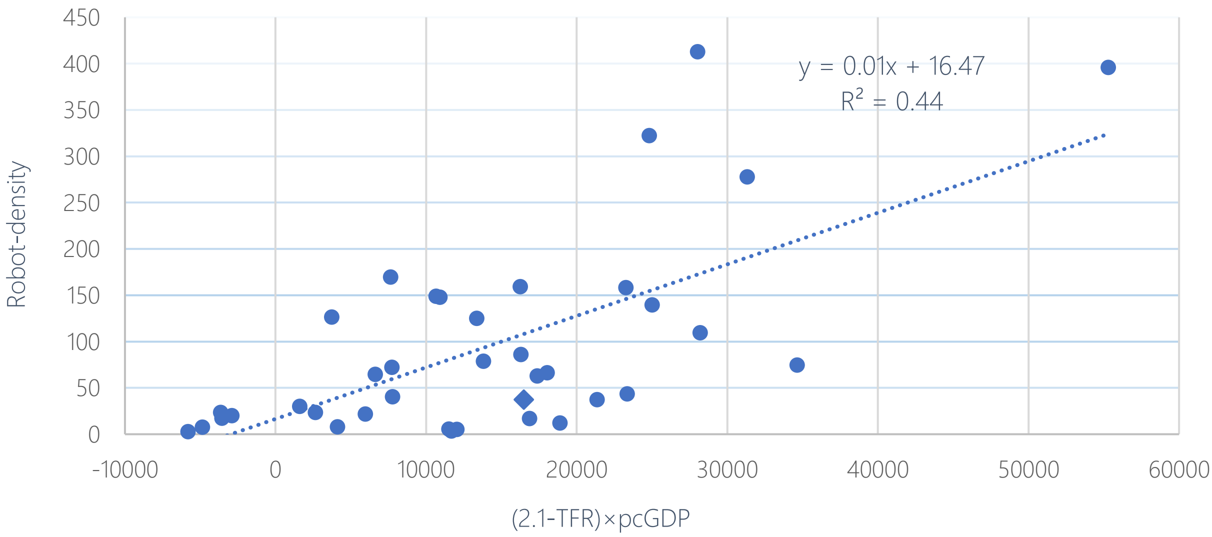
TFR, GDP and Robot Density in selected countries (2010-15)

	TFR	pcGDP	(2,1 TFR) xpcGDP	Robot-density		TFR	pcGDP	(2,1 TFR) xpcGDP	Robot-density
S. Korea	1.26	33369	28030	413	Slovenia	1.37	23802	17375	63
Singapore	1.23	63562	55299	396	Norway	1.80	77845	23354	43
Japan	1.40	35446	24812	322	Thailand	1.53	13632	7770	41
Germany	1.39	44104	31314	278	Portugal	1.28	26050	21361	37
Sweden	1.92	42435	7638	170	Hungary	1.34	21720	16507	37
Denmark	1.73	43916	16249	159	New Zealand	2.05	32321	1616	30
Italy	1.43	34727	23267	158	Indonesia	2.50	9097	-3639	23
United States	1.89	50742	10656	149	Malaysia	1.97	20302	2639	23
Belgium	1.82	38957	10908	148	China	1.55	10858	5972	22
Spain	1.32	32076	25019	140	Mexico	2.29	15224	-2893	20
France	2.00	37307	3731	126	South Africa	2.40	11851	-3555	17
Finland	1.75	38191	13367	125	Poland	1.37	23110	16870	17
Australia	1.47	44778	28210	110	Greece	1.34	24868	18900	12
Netherlands	1.75	46539	16210	89	Brazil	1.82	14683	4111	8
Slovenia	1.58	26548	13805	79	Argentina	2.35	19449	-4862	8
Switzerland	1.52	59716	34635	75	Romania	1.48	18555	11504	6
Austria	1.92	42985	7737	72	Estonia	1.59	23599	12035	5
Czechia	1.45	27449	17842	67	Croatia	1.52	20137	11679	4
United Kingdom	1.92	36757	6616	65	Philippines	3.04	6190	-5819	3

Source: own compilation based on IFR World Robotics, 2017; Maddison Project Database 2018, and World Population Prospects, 2019.

Figure 7:

Robot density as a function of GDP loss (low TFR), 2010-2015



Source: IFR World Robotics, 2017; Maddison Project Database, 2018; and World Population Prospects, 2019.

Now, let's look at this relationship a little deeper, in relation to the East Asian developmental state type countries.

Table 3:

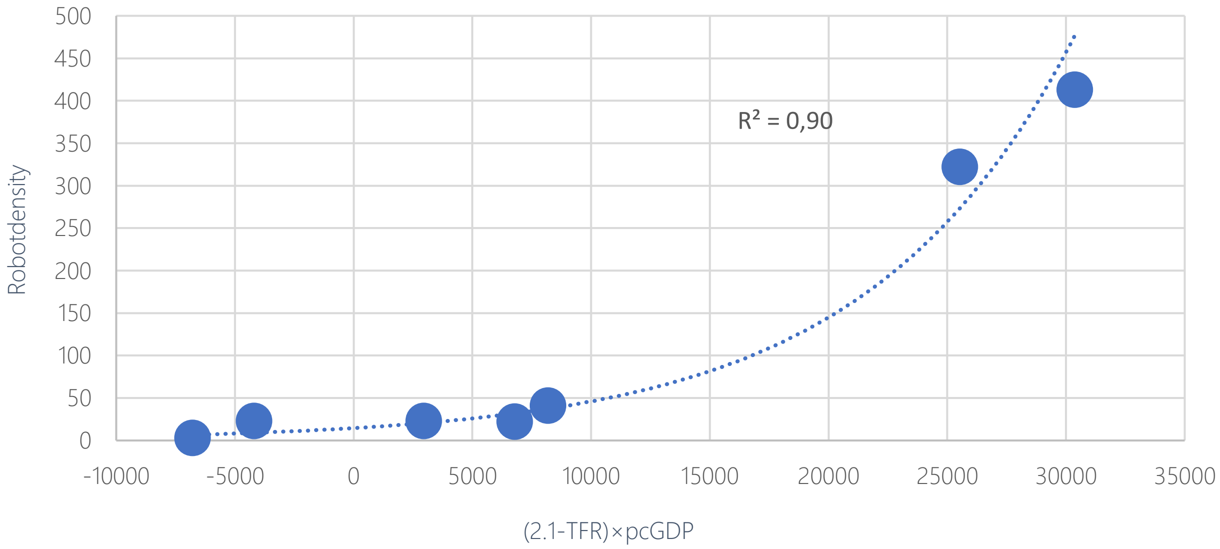
TFR, GDP loss, RD of selected countries in developmental states type countries

	TFR	(2,1-TFR) xpcGDP	RD
Japan	1.4	25516	322
Korea	1.26	30367	413
Malaysia	1.97	2949	23
Thailand	1.53	8174	41
China	1.55	6776	22
Indonesia	2.5	-4204	23
Philippines	3.04	-6790	3

Source: IFR World Robotics, 2017; Maddison Project Database, 2018; and World Population Prospects, 2019.

Figure 8:

Robot density as a function of GDP loss in 7 East-Asian developmental state, 2010-2015



Source: IFR World Robotics, 2017; Maddison Project Database, 2018; and World Population Prospects, 2019.

In the case of East Asian developmental states, there is a stronger relationship between robot density and GDP loss (low TFR). Let's see if developmental states show higher or lower robot density at the same level of development. The Bold (7,18,21,22,26,31,35,39,40) are the developmental states, those not in bold contains some CEE countries that are members of China+17 in the framework of BRI.

In Figure 9 the diamonds are the developmental states and the circular points are the others. 18 countries' population decreased over the 20 years between 1996 and 2006: Puerto Rico and the post-socialist European countries: Albania, Serbia, Montenegro, Bulgaria, Romania, Croatia, Hungary, Poland, Estonia, Latvia, Lithuania, Russia, Belarus, Ukraine, Moldova, Armenia, Georgia. From the Western Balkans upwards along the post-Soviet border, and down into the Black Sea region, we find a region, where the results can be seen of an uncompensated (by migrants) population outflow and a declining TFR.

Table 4:

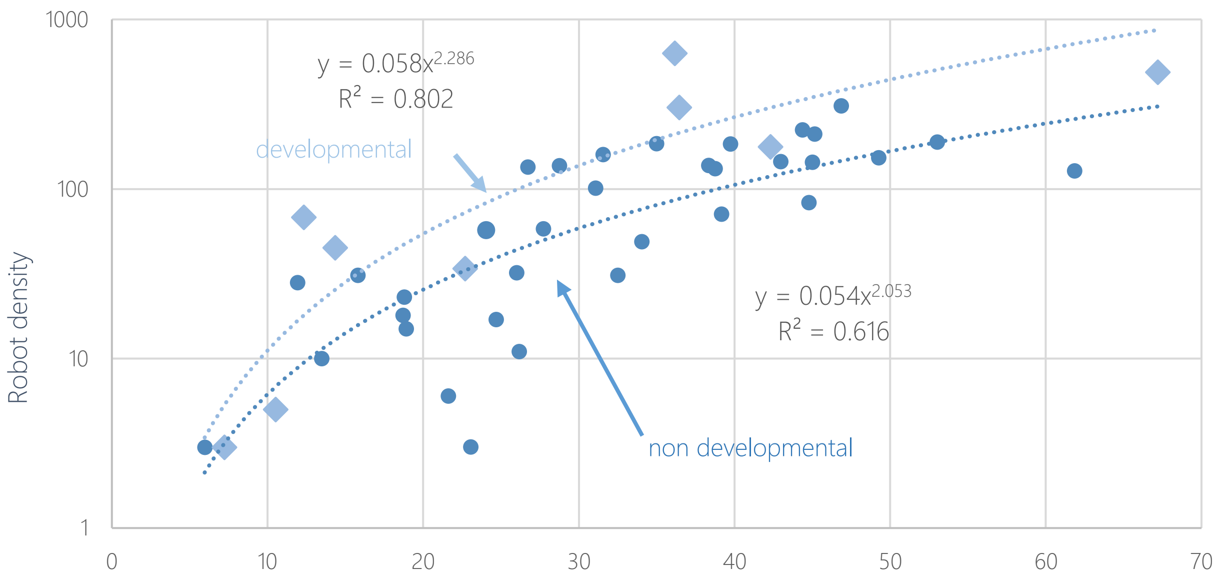
GDP, RD of East Asian development state, CEE and other states

	2016	pcGDP $	RD-nDS	RD-DS		2016	pcGDP $	RD-nDS	RD-DS
1	Argentina	18695	18		23	Mexico	15803	31	
2	Australia	44783	83		24	Netherlands	49254	153	
3	Austria	4501	144		25	New Zealand	3404	49	
4	Belgium	39733	184		26	Philippines	7223		3
5	Brazil	13479	10		27	Poland	26002	32	
6	Canada	42969	145		28	Portugal	27726	58	
7	China	1232		68	29	Romania	18913	15	
8	Croatia	21625	6		30	Russian Fed.	23064	3	
9	Czech Rep.	31089	101		31	Singapore	6718		488
10	Denmark	45141	211		32	Slovakia	26713	135	
11	Estonia	26173	11		33	Slovenia	28761	137	
12	Finland	38335	138		34	South Africa	11949	28	
13	France	38758	132		35	South Korea	36151		631
14	Germany	46841	309		36	Spain	31556	160	
15	Greece	24689	17		37	Sweden	44371	223	
16	Hungary	24047	57		38	Switzerland	61844	128	
17	India	5961	3		39	Taiwan	42304		177
18	Indonesia	10511		5	40	Thailand	14341		45
19	Israel	32494	31		41	Turkey	18783	23	
20	Italy	34989	185		42	United King.	39162	71	
21	Japan	36452		303	43	United Stat.	53015	189	
22	Malaysia	22687		34					

Source: IFR World Robotics, 2017; Maddison Project Database, 2018; and World Population Prospects, 2019.

Figure 9:

GDP, Robot Density of East Asian developmental states, CEE and other states, 2016



Source: IFR World Robotics, 2017; Maddison Project Database, 2018; and World Population Prospects, 2019.

The East Asian developmental states are more robot-sensitive and capable of robotizing their economics much faster than others. Post-globalization robotization seems to once again favor the East Asian model of strong state-weak society. It is no coincidence that Japan is still a one-party political system. In 95% of the elections, the LDP comes to power. (Some CEE countries are approaching this robotics path, including countries where the state is growing stronger and society is weakening, but the East Asian model is not a reality here because of the retentivity of being an EU member, while the US doesn't care. The CEE countries meet robots mainly in German owned automotive factories, while the robotization of domestic economies within the framework of Industry 4.0 is still only a plan.)

The technical development of China for six hundred years (up to 1500) has produced astounding results (Mokyr, 1990). Not only the technical improvement in rice production, but the invention of paper, porcelain, printing, gunpowder and rockets, watches, compasses, iron making in blast furnaces, and the construction of huge ships that were made with compartment technology centuries ahead of European shipbuilding (Acemoglu – Robinson, 2012).

Table 5:
China's Competitiveness in the 14th century (measured, by WEF GCI)

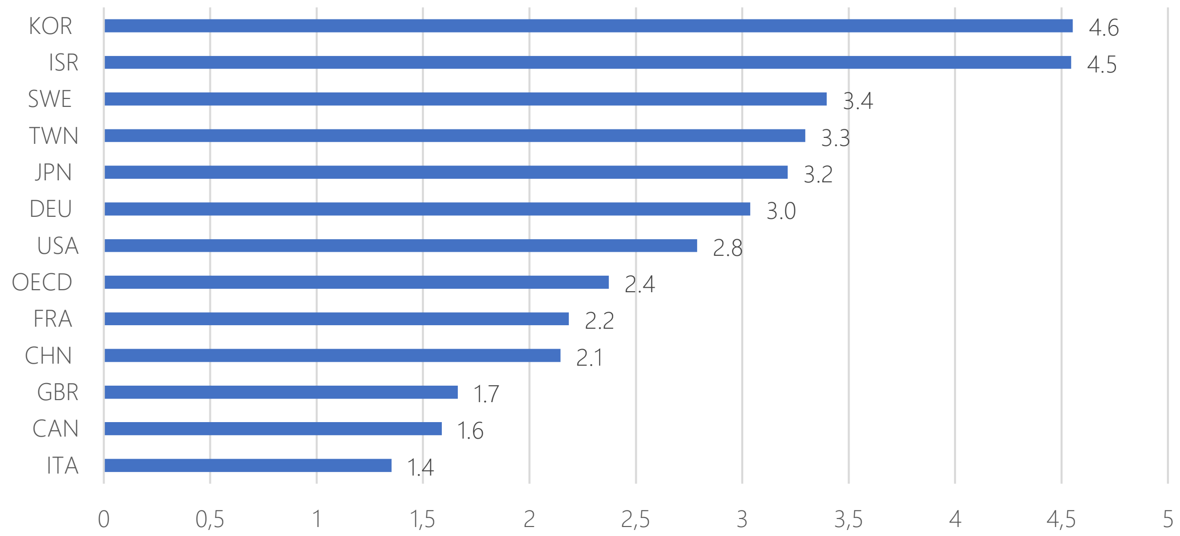
	China in the 14th century
1. Institutions	centralized state, ideology: Confucianism
2. Infrastructure	developed transportation including road and sea transport
3. Macroeconomic environment	single market
4. Health and primary education	developed health care system including the improvement of autopsy
5. Higher education and training	higher education institutions, state exams were introduced BC II. century
6. Goods market	higher level of specialization in agriculture, e.g.: 16 different types of rice
7. Labor market	manors and tenants of remote arable parcels
8. Financial market	financial reform, "mercantilism", banknotes were invented, usury
9. Technology	agriculture reform: barrage, tall-gate
10. Market size	developed international trade, single market
11. Business sophistication	diversified business structure, decentralization of decisions
12. Innovation	banknotes, missile, compass

Source: own compilation

The Chinese fleet also embarked on exploration of far seas in East Africa (Aden). The sea explorations and innovations, previously encouraged by the emperor, were banned around 1500 because the emperor and his bureaucracy decided on deflecting the country from demoralizing outer impressions. There were many sovereign kingdoms in Europe, and if someone did not like the leadership of a country, then one could go to another country and continue experimenting and discovering. England was particularly fortunate, with the introduction of patent law and the banking system in the 1740s, fulfilling the Schumpeterian dual requirement for successful innovation. (England: it has become rewarding to invent something under legally secured circumstances and having the opportunity to find financing for it).

The current Chinese concept of innovation may be radically different from that of the 16th century. China's R&D expenditures to GDP rate is between France's and Britain's, lagging behind Germany but ahead of Italy, and only half a percentage point lower than the four times richer US', but less than half of the two leading R&D countries (Korean Republic and Israel).

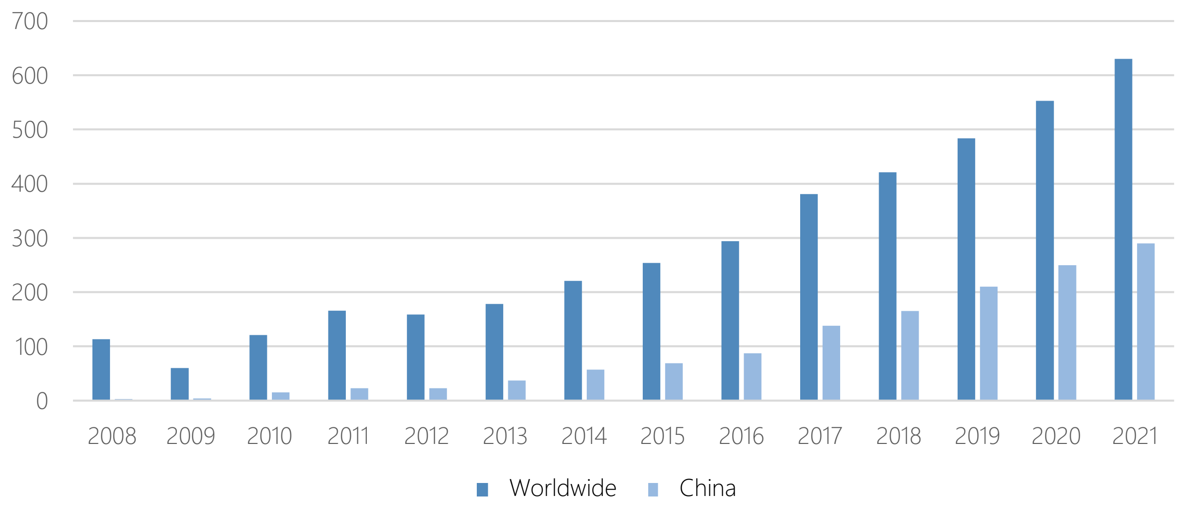
Figure 10:
Gross domestic spending on R&D, Total, % of GDP, selected countries, 2017



Source: OECD Data, 2017.

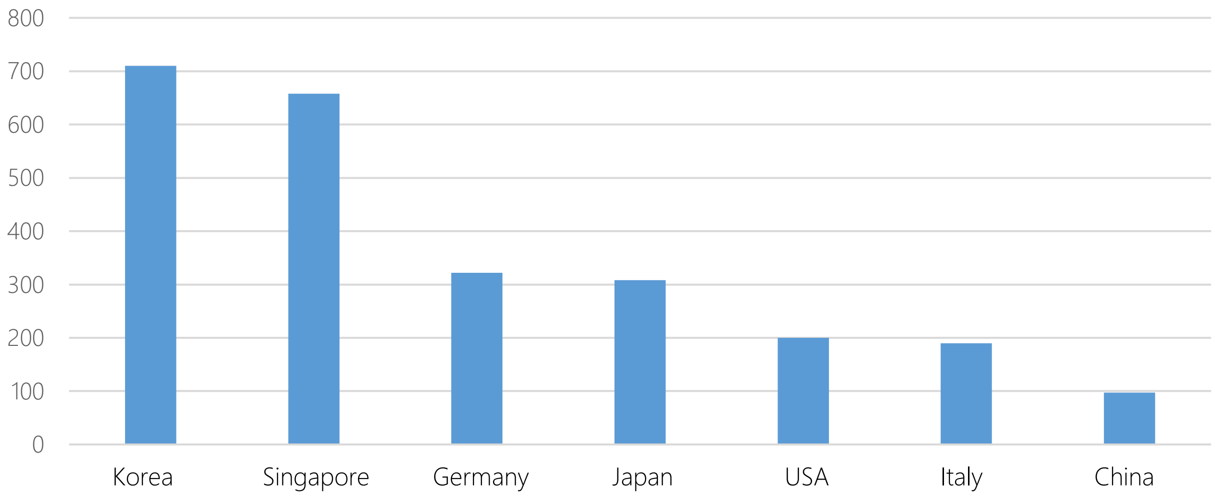
The sharply rising number of industrial robots in China is beyond all imagination. If the growth rate of robotization that characterized China in the last decade is maintained, then China's annual demand for robots (from imports and domestic production) will be the same as the rest of the world in 2023 (increasing by nearly 30% year on year since 2010). The annual average growth rate of robotization in North America is close (20.4%) to that of China (22.1%). According to expert estimates the average annual growth rate will lag in Germany with 7.1%, with 8.7% in Japan, and with 9.4% in Republic of Korea between 2015 and 2025.

Figure 11A:
Growth of Industrial Robotics, Estimated Annual Supply of Industrial Robots 2008-2021



Source: IFR World Robotics, 2018.

Figure 11B:
Robot Density, Robots per 10,000 Manufacturing Employees, 2008



Source: IFR World Robotics, 2018.

4. Possible Future of China until 2100

China is stirring up everyone's imagination, one of the world's oldest civilizations. The population of the People's Republic of China compared to the world is significant, albeit declining in the 21st century.

Table 6:
Population of China and the rest of the world, 1950-2100

	1950	2015	2030	2050	2100
World (million)	2525	7350	8501	9725	11213
China (million)	544	1376	1416	1348	1004
China	22%	19%	17%	14%	9%
	1975-80	2005-10	2015-20	2045-50	2095-2100
TFR World	3.87	2.56	2.47	2.25	1.99
TFR China	3.01	1.53	1.59	1.74	1.81

Sources: UN, 2017, World Population Prospects, figures rounded

The UN (2015) estimates that the world population will exceed 11 billion in 2100 and then begin to decline, as the total fertility rate (TFR) remains below 2.1 for reproduction. China's population will nearly triple between 1950 and 2030 and will decline by one-third in the next 70 years. In 1950, China's population accounted for nearly a quarter of the world's population, falling to less than a tenth by the end of the 21st century. The global fertility rate for the world population was 3.87% in 1950, which has fallen by 1.99% over a century and a half and has not increased since. China succeeded in reducing its TFR from 3.01% to 1.53% between 1975-80 and 2005-10, in a single generation, and it will not increase to 2.1 – which means that its population is shrinking. Demographers have found that along with the rise of HDI (Human Development Index: GDP, education and healthcare system) the TFR rates typically fall to a low level, then rise slowly, but not reaching the reproduction level of 2.1. China is thus facing a shrinking and aging population (60+ in 2015: 16.8%, 2100: 56.1%), while its GDP was 115% of the US's in 2016 and will be 162% by 2030 and 172% by 2050.

Table 7:
GDP ranking of China and top 10 countries of the world 2016-2050

GDP PPP rankings	2016 rankings		2030 rankings		2050 ranking	
	Country	GDP at PPP	Country	Projected GDP at PPP	Country	Projected GDP at PPP
1	China	21269	China	38008	China	58499
2	United States	18562	United States	23475	India	44128
3	India	8721	India	19511	United States	34102
4	Japan	4932	Japan	5606	Indonesia	10502
5	Germany	3979	Indonesia	5424	Brazil	7540
6	Russia	3745	Russia	4736	Russia	7131
7	Brazil	3135	Germany	4707	Mexico	6863
8	Indonesia	3028	Brazil	4439	Japan	6779
9	United Kingdom	2788	Mexico	3661	Germany	6138
10	France	2737	United Kingdom	3638	United Kingdom	5369

Source: PWC, 2017.

The PWC estimates that China's GDP per capita in 2016 was about a quarter of the US's and will be half by 2050. If we look at the question from a different angle, then in 2050 the US and EU will produce approximately as much as China's GDP alone (21% and 20% of world GDP, respectively). China is assertively and self-consciously preparing to become the world's leading power in three decades. This scenario could be averted by an Atlantic Alliance with the European Union and the United States (EUSA), but world politics is not necessarily heading in that direction (Brexit, Trump). The recurring idea of geopolitics is the encirclement policy, which could have a new dimension if the EUSA Alliance and its "natural" democratic allies (India, Japan, Korea, Australia, and many others) intend to regulate the "heartland trio" of China, Russia, and Iran. The three countries try to hinder this process with new waterways, land-based trade roads and gas-oil pipelines. (Meanwhile, the Earth may boil over in the climate crisis, water and food shortages may occur, but robots, artificial intelligence and big data techniques can redraw everything.)

5. Relations between Digitalization and Silk Road (BRI)

Let us start this phase with a geopolitical introduction. After World War I., the US did not engage in active foreign policy until the Japanese attack in Pearl Harbour on December 7, 1941, and a few days later Hitler declared war. From that point China was considered as an American allied and received some support. A few years after the war, the sons of the two nations fought each other in the bloody Korean war. According to the doctrine of Guam island, the Reds (Communists) must be stopped where they penetrate. In line with this doctrine, the US fought and bombed Vietnam, provoking disapproval of much of the world. In 1972 China decided to turn toward the US against Soviet pressure, a move that was welcomed by Nixon. Within a decade China began its great economic march, often at double-digit GDP growth rates relying on export, domestic savings, joint ventures and investments. China's goal was to step forward gradually on the production chain with increasing production and trade. BRI (according to American fears) is a multi-faceted initiative, which helps to absorb the excessive capacities of construction and steel production in China. China provides credit to African countries, supplying China with raw materials, and to less developed EU members, facilitating efficient access to the export market. For a long time, America was delighted to have ended the Vietnam War, and believed that China was detaining the Russians. After the Cold War the US began their international democratization project with some anti-terrorist glaze. Under the Obama administration attempts were made to financially enclose China. The US threatened “bad” countries by imposing financial penalties instead of military operations and using its allies. The US has blamed China and Russian for creating saving gluts, which lead to the outbreak of the financial crisis of late 2007. It was at this time when W. Mitchell developed the concept of enclosure of the three dangerous countries (China, Russia, and Iran). According to the concept the US should support the border countries of the enclosure (independently of whatever they do at home). In this concept, the BRI and the assisting international development institutes (NDB, AIIB, Silk Road Fund) mean an outbreak attempt from the enclosure that should be prevented by the US with every means necessary.

From a Chinese point of view, the BRI is collecting allies, is utilizing excessive capacities, is providing work for Chinese and foreign workers and is channeling existing Chinese financial reserves into a world where the US can no longer be a hegemonic power. If the decades of US’ hegemony are over, what is next? There are several scenarios for it:

a) A Kantian world state - this is the dream of European and American humanists;

b) Integration of developed democracies to the world which is led by China-fears among Rust Belt’s Republican Party fans;

c) New Economic and Cyber Cold War – according to those who were born in the mid-20th century;

d) BRI: larger NATO member nations worry about China connecting Europe, Asia and Africa by financial and transportation means.

In 1820, China's GDP per capita reached 41% of the US’s, it was 4.1% in 1950, and 24% in 2016, in 2050 it will reach approximately 50% of it. When the first Sputnik was launched there was great fear in the US that the Russians would be world leaders, but the economic growth of the one-party Russian planned economy soon faded. There were fears that Japan would be the challenger power. Japan bravely used market and government instruments with a specific Japanese political set-up and won productivity competitions in many (but not all) areas. But the golden ages were followed by a slow down with remarkable domestic debt and high-age dependency. Is there any internal brake in the economy of China that prevents it from becoming the "new leader"? The contemporary American strategic thinkers say it is dangerous if the renminbi becomes the key currency, not to mention that China can build up strategic positions in Europe through the BRI and with the help of Russia. Some American geopolitical experts fear that China will re-think the multi-political system model of one or more cities and countries.

6. Digitalization as the Supporter of Trade and E-Commerce

The global export/GDP ratio (one of the main indicators of globalization) began to increase at a rapid rate (in the 1970s) when digitalization came out. If we look back 200 years in time, we can see that every 10th person's livelihoods stood on firm ground, whereas nowadays only every 10th person is endangered by poverty. The success of sequential technical revolutions – the steam engine, internal combustion engines, electricity and digitalization – have brought such wealth. Previously, these revolutions were accompanied by the widening of the income gap between countries, but with the rise of digitalization, the gap, although still huge, began to narrow.

Have we listed all the important features of the relationship between digitalization and export rate? "Digitalizing everything we can" has led to an important new development path in the framework of today's industry 4.0.

According to the half a century old Moore's Law there is a robust decreasing in the cost of processing one bit of data, year by year. Today is the age of robots that our great-grandparents and grandparents just imagined, robots have become an industrial service provider. The digitalization of the past half century can also be regarded as the story of a gradually narrowing gap of costs between an expensive robot and cheap (export-producing) workforce. In the meanwhile, e-commerce opportunities have increased market opportunities by a magnitude. (The needed socks or cell phones can be ordered with two clicks from anywhere in the world where they are manufactured, put on ships or trains for about a quarter of the store price.) Fortunately, the number of poor people in the world is declining and median wages are similarly rising for exporter countries, while stagnating for importers (following the almost same predictions that Stolper made in his article nearly 80 years ago).

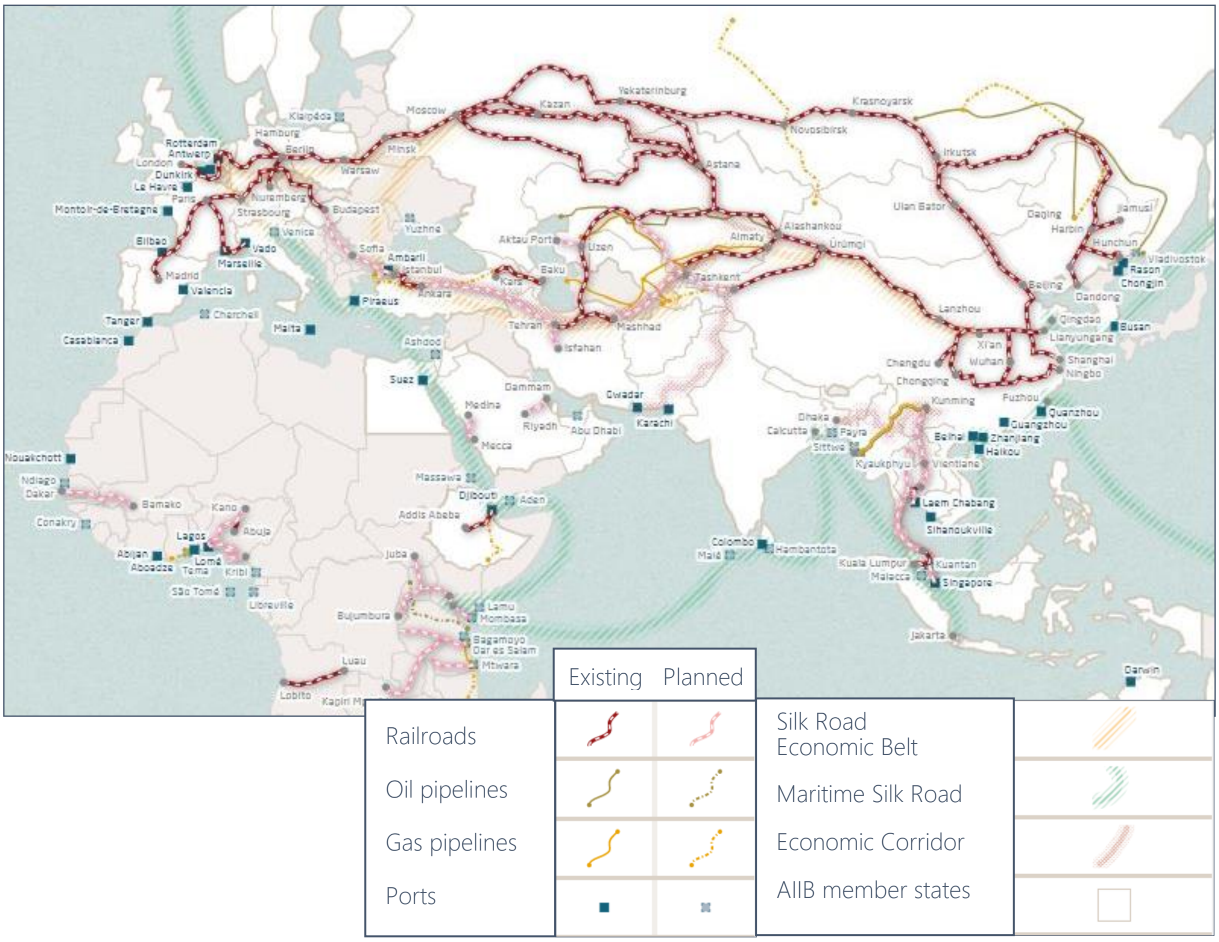
According to our current knowledge, industrial robot sales are growing at 15% per year, while exporters' wages are rising significantly. After 2010 this may have contributed to stagnation or in some cases decline of the (formerly dynamically growing) global export/GDP ratio. Can we do something to prevent the two twin children of digitalization (e-commerce and robotization) from eating each other? We can do it because trade with specialization always provides an opportunity, all it takes is for the old form of trade (of goods) to change and to transform into more of a trade of ideas. It is well-known that the United States – at a particular stage of Japan's and Korea's development in the 1950s, 60s and 70s – treated generously intellectual property laws because of the Cold War. The interests of the United States, country of innovation, was to make Japan and Korea more competitive allies against the Soviet Union in the geopolitical framework of enclosed Moscow. The US behaved quite differently with its main opponent, the Soviet Union. According to a joke from the 1980s, the COCOM list even forbade Eastern European stores from buying a modern import copy machine; in order to prevent the Soviet Union from reusing the chips for other purposes.

The lesson is that, a thing (e.g.: idea, technology, product) can be invented, bought or stolen and it all depends on the situation. Going back 900 years, China was the cradle of every important inventions, giant ships divided by compartments and equipped with compasses, printed paper, porcelain, and gunpowder and the Europeans stole what they could. Then, about 600 years ago, the Chinese emperor, listening to his bureaucrats and guild masters, ordered a stop to the building and operating of the fleet and even destroyed most of the ships, to calm the upset people. The new laws also banned inventions, so the technological development of China slowed down considerably. Half a millennium has passed since and at present China is at the forefront of economic development, using market and non-market conform methods to help the giant country to rise and thus the world economy to grow. It is very much hoped that all the benefits of digitalization will be used efficiently, facilitating the diffusion of information that will stimulate large-scale innovation. In this case, the engine of the new type of foreign trade will spin around the exchange of ideas and not around the socks or the handsets, because they will be produced domestically by robots.

7. Investment and Foreign Trade of China with CEE, CEE Growth and Robotization

Let's start with a map about BRI planned routes from.

Figure 12:
BRI planned routes



Source: merics.org., n.d.

China's new Silk Road on the Eurasian continent leads through the Shanghai-Moscow-Berlin and Shanghai-Tehran-Budapest-Berlin railway lines and the Shanghai- Kenya-Suez-Venice sea route reaching almost all EU countries. CEE (in the 17+1 Initiative) is an EU bridgehead, but Moscow may be given the key role in Eastern Europe as the main route in that region heads from Istanbul up to Moscow and to Berlin. According to a Citi analytical study, Chinese import to the CEE-17 region as a share of GDP are between 2% and 6% respectively and exports between 0% and 1.5%. China's 2016 FDI stock/GDP ratio is between 0-2 % in the CEE region. Within the small numbers, the Hungarian share is high. According to W. Mitchell's theory, CEE countries are mostly border guard countries in the enclosure policy and therefore their activities are strategically important. On the other hand, CEE region is subject to many pressures:

a) Strong foreign trade and technology transfer (robotics) relations with Germany;

b) US weapons systems on the Russian border;

c) Energy dependency from Russia;

d) 17+1 status in BRI and EU in relations to China.

The northern part of the CEE region has typically become more developed, although there is a rapid catch-up in the south (Romania). Inherited (and new) debt from the socialist era explains much of the 30-year dynamics of each country.

CEE countries geopolitically cannot easily stand firm in this quadruple challenge (German economy and robotics, US defense policy, energy dependence from Russia and transit role in China's BRI project). Although the CEE countries are used as "ferry boat countries", because of their centuries-old experience. On the other hand, it is also true that the countries of CEE region did not adapt well to the quadruple challenge.

Table 8:

CEE countries' development relative to German development between 2000-2018

	Slovenia	Czech	Estonia	Slovakia	Hungary	Lithuania	Poland	Croatia	Latvia	Romania	Bulgaria
2000	60%	56%	41%	41%	48%	32%	39%	42%	30%	27%	25%
2001	61%	57%	43%	42%	49%	34%	39%	43%	32%	28%	26%
2002	63%	58%	46%	44%	51%	37%	39%	45%	34%	30%	28%
2003	65%	60%	50%	47%	54%	41%	41%	48%	38%	32%	30%
2004	68%	63%	53%	49%	56%	44%	43%	48%	41%	34%	32%
2005	70%	66%	57%	51%	58%	48%	44%	50%	45%	36%	34%
2006	70%	68%	61%	54%	58%	50%	45%	50%	49%	37%	35%
2007	72%	69%	64%	57%	56%	54%	46%	51%	53%	39%	36%
2008	74%	69%	60%	60%	56%	56%	48%	51%	51%	43%	38%
2009	71%	69%	54%	60%	56%	51%	52%	50%	46%	43%	39%
2010	69%	67%	53%	60%	54%	50%	52%	48%	44%	40%	38%
2011	67%	66%	55%	60%	53%	53%	52%	47%	46%	40%	39%
2012	64%	65%	58%	60%	52%	55%	53%	46%	48%	40%	39%
2013	63%	64%	59%	61%	53%	57%	53%	46%	50%	42%	39%
2014	64%	65%	60%	61%	55%	59%	54%	45%	50%	43%	39%
2015	65%	68%	60%	63%	56%	60%	56%	46%	52%	44%	41%
2016	66%	69%	62%	64%	57%	62%	57%	48%	53%	46%	42%
2017	68%	70%	63%	65%	58%	64%	59%	49%	54%	49%	43%
2018	70%	71%	65%	67%	61%	66%	61%	50%	57%	50%	44%

Source: own compilation based on Central Statistical Office, Hungary

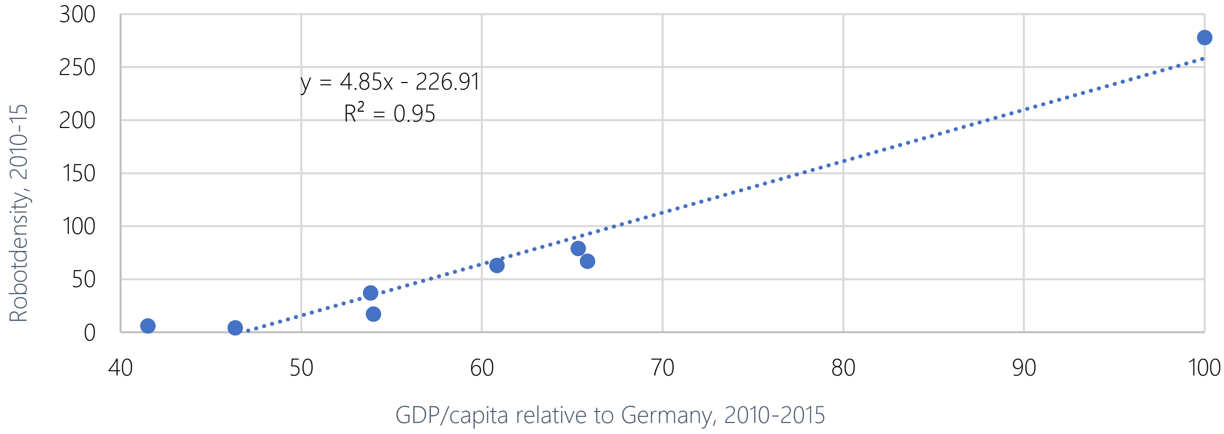
Table 9:

GDP per capita and Robot Density of Germany and the CEE Countries 2010-2015

	pcGDP 2010-15	*Robot-density*	*Robot-density*
Slovenia	65.3	79	
Czech Rp	65.8	67	
Estonia	57.5		5
Slovakia	60.8	63	
Hungary	53.8	37	
Lithuania	55.7		n.a.
Poland	54	17	
Croatia	46.3	4	
Latvia	48.3		n.a
Romania	41.5	6	
Bulgaria	38.7		
Germany	100	278	

Source: IFR World Robotics, 2017; Central Statistical Office Hungary

Figure 13:
GDP per capita and Robot Density, Germany and the CEE Countries 2010-15



Source: IFR World Robotics, 2017; Central Statistical Office Hungary

The different challenges – indirect labor export to Germany, direct energy import from Russia, the US leads NATO's deployment zone, and the 17+China as the EU's GATE – from country to country and from time to time results in complex situations that may not be very well answered. Let's look at how countries in the region have approached German development over the past two decades.

8. Conclusions

In a world, which has formerly rapidly globalized, the increase of export to GDP ratio has paused and countries tend to shift to a new technological path as digitalization and robotization is becoming cheaper and cheaper.

During the rest of the 21st century, the export of goods is expected to be replaced by the idea trade, and cheap (compared to wages) robots will be working at homeland.

Poverty is on his way to vanishing in an increasing part of the world and parallel to that TFR will fall under 2.1 by 2100. New power centers and alliances are likely to emerge.

The structure of the society of the East-Asian developmental states (strong state/weak society) makes those countries capable of adopting robotization and a serious question arises. When will strong state/strong society-like countries take the pace?

Overall, China has been at the forefront of technological advancement for many centuries, but we do not know whether it will return to its leading position, will it become Chin-AI. It has shifted as a developmental state, its export/GDP ratio is likely to remain in the longer term below its peak of 2010. China may shift from being an export-oriented developmental state to being a robot-based developmental state.

From a geopolitical standpoint, BRI may be interpreted as a means for China to achieve the leading role and some may express concerns about this. Others say that by the age of robotization the growth rate of export to GDP ratio will decline and international trade and e-commerce will mainly consist of exchanging ideas. Over the last decades digitalization has reshaped education also, the younger generation operates very differently from older generations.

Let's look at again the competition between Chin-AI and EU-US in 2050, so far, the two sides have an even and open field of play. CEE countries navigate under the four challenges' pressure (German robotization, Russian gas, US weapon system and China+17.

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ROBOTIZATION ATTITUDES IN HUNGARY IN REGIONAL CONTEXT

László Csonka

Abstract

In the past five years the notion of Industry 4.0 has brought into the forefront of research interest the diffusion of cyber-physical production systems. These are based on the observation that the trends of digitalization, automation, robotization are converging and creating a fundamentally new production system. This change has not only technical or economic implications for the companies that are implementing these new cyber-physical systems, but it gives rise to significant social challenges by directly influencing the labour market. There is a growing amount of international and Hungarian literature which provide experts' estimations about the nature and directions of the impact of these changes. However, these estimations are in many cases conflicting or at least indefinite and take a far too general view. Nevertheless, now it is – or should be – apparent for the broad public, that digitalization, automation, robotization will have some kind of influence on where and how people will work in the near future. These changes might be general but not universal. We lack studies and empirical analyses that look into the details how the society or the employees in certain regions perceive the diffusion of robotization and its impact on their everyday life and work. This paper would like to fill this gap. It is based on a quantitative survey conducted in Hungary which focuses on the attitudes towards robotization. The research sheds some light on the fact that the society's interest in robotization is stronger than their actual knowledge. There are certain regional patterns in the awareness and preparedness of the workforce for the coming changes which seem to be related to the presence of industries with the highest share of robotization. It becomes also evident that various stakeholders should take steps to clarify the various ethical, legal and other related issues in order to responsibly support the additional diffusion of robots. Employees seem to be remarkably uninformed about the future diffusion of robots in their own workplace and they seem to be unprepared for this challenge.

Keywords: robotization, survey, Hungary, labor market, regions, Industry 4.0

1. Introduction

The technological development of the past few decades has brought significant changes in practically all aspects of our current life. Knowledge and learning have become the basic building blocks and activities in the current era (Lundvall, 1992). Knowledge economies have started to take shape which are based on the development, diffusion and utilisation of knowledge and information for improving performance and for the general welfare of the society (OECD, 1996). The development of information technology, or more broadly the third industrial revolution has played a key role in laying the ground for the knowledge economies bringing a new technological paradigm (Smith, 2002). In this new paradigm new scientific fields are emerging, previously boundary fields are becoming central for further development and various independent scientific fields are becoming increasingly interconnected. Knowledge-intensive fields are becoming key areas for economic development and competitiveness. Not only high-tech sectors are responsible for an ever growing share of GDP in the developed economies, but also in 'low tech' industries the role of accumulated and utilised knowledge is becoming crucial. In this era innovations have become a key factor of success. Innovations are not only demonstrations of what the technology is capable of, but they are the most important factor of economic competitiveness, while re-drawing the economic framework itself, too. Based on the various digital technologies developed during the past five decades, it seems that a new industrial revolution is starting to take shape.

As the WEF (2016) puts it, the fourth industrial revolution is already here, characterized by the fusion of technologies that is blurring the lines between the physical, digital and biological spheres (see also Dengler – Matthes, 2015). This new industrial revolution is largely built on the previous one, although it has some distinct characteristics, like the speed and the scope of changes or the variety of systems that are impacted by this current revolution. The breadth and depth of changes brings the transformation of entire systems of production, management and governance.

This also means that firms are not only innovating their products and services but also need to rethink their production processes. This trend has been labelled as Industry 4.0 following the German high-tech strategy initiative in 2013. Industry 4.0 is representing a bunch of technological trends vertically and horizontally integrated, such as 3D printing, big data, robotization, simulation, cloud computing etc.. Industry 4.0 offers a more comprehensive, interlinked, and holistic approach to manufacturing. It connects the physical with the digital, and allows for better collaboration and access across departments, partners, vendors, product, and people. Industry 4.0 empowers business owners to better control and understand every aspect of their operation, and allows them to leverage instant data to boost productivity, improve processes, and drive growth (Epicor, 2019). If these technologies are employed, than we can speak of a smart firm which is relying on cyber-physical systems, where the various technologies are strongly interconnected with human workers. The introduction of such changes creates a huge challenge for the companies. One of the most important prerequisites to implement these changes is the availability of workers who can face the requirements of Industry 4.0 or the fourth industrial revolution more broadly.

This paper investigates the preparedness of the Hungarian society to the introduction of such changes into the economy. More specifically, it examines how the robotization is perceived by the society and the employees. What are their main views, concerns and hopes in relation to the diffusion of robotization and automation at the workplaces. The investigation puts into the focus the potential regional differences within Hungary. It looks at the potential link between the industrial structure within the country and employees' readiness for more robots. Next, the paper shortly characterises the main features and challenges in the digital economy and digital society together with the current labour market situation in relation to robotization. The third section summarizes the methodological approach and the fourth presents the results of a survey conducted among Hungarian employees to get to know their views in relation to robots. The responses will be analysed from a regional perspective. The paper finally summarizes the main findings on the regional characteristics of the labour market's preparedness for more robotization in the near future.

2. Digital Economy, Digital Society

One of the main features of digital economy is the central role of digitalized information. The digitally codified knowledge transforms into strategic resource defining competitiveness and success. The economy and the society are organized more and more along various networks which is the basis of information society or networked society. Since the second half of the 1990s, the availability of information has become cheaper and cheaper and the technologies of data storage and transfer has become widely used in the society and in the economy. Based on the general use of information and data, various types of innovations were generated, like organisational, marketing, social or even legal innovations. In turn, these innovations started to transform the labour market, the world of work and finally our private life (EC, 1997). Utilising the results of the third industrial revolution, the amount of available information is larger than ever. This information represents value and profit for the enterprises not only in the digital, but also in the 'traditional' economy. The digital technologies now used in practically all segments of the economy and of the social life after the diffusion of interactive and mobile technologies during the past decade (Valenduc – Vendramin, 2017). At the same time, A. Giddens (2015) warns that due to the growing impact of digitalization, robotization and automation the social model of industrialized states as an all-encompassing and efficient system of social insurance combined with the aspiration to equality and inclusiveness is deteriorating.

In the course of the development of digital technologies, dating back to the 1970s, the 21st century brought numerous new opportunities. The big data analytics and the cloud computing – or even more the fog computing – make it possible to analyse a huge amount of data within a reasonable time. They are also making it possible to collect data from an unprecedentedly large variety of sources: smartphones, GPS data of computers, immaterial goods and services produced in the economy etc. are all potential sources of data for economic utilisation. This vast amount of data is the new basis of the evolving business model in the digital economy. The need to collect and store the available information contributes to the development of data mining and data modelling software, too. The software and various algorithms are developed in order to be able to create economic value out of raw data by analysing the customers' profiles, modelling their behaviour, predicting engine failures and so on. Computer programmes, data utilisation and the development of artificial intelligence also creates way of new types of robots that are capable of conducting complex tasks or capable of collaborating and interacting with humans. So this wave of digitalization is much more than the digitization of the last decades of the 20th century, it is now a transformation of an analogue into a digital era. This rise of digital technologies, or digitalization also influences the whole society (Kieslich, 2019). Not only enterprises, but individuals and the society as a whole have to adapt to the new framework conditions, influencing not only the economic domain, but other societal fields, such as education, politics or private life.

The use of these new, complex technologies, the increasing pace of technological developments makes it necessary for the firms to strengthen their knowledge base. In this effort they not only rely on their research and development (R&D) activities, or that of other partners but they also have to rely on other, non-technological sources of knowledge, like the (tacit) knowledge of the employees. People have to adapt to new tasks and routines as the content of certain jobs, positions is changing (Hirsh – Kreinsen, 2015).

One of the trends that attracts the most interest among scholars, consultants, professionals, is the one that relates to the labour market impacts following the diffusion of digitalization, robotization and automation.

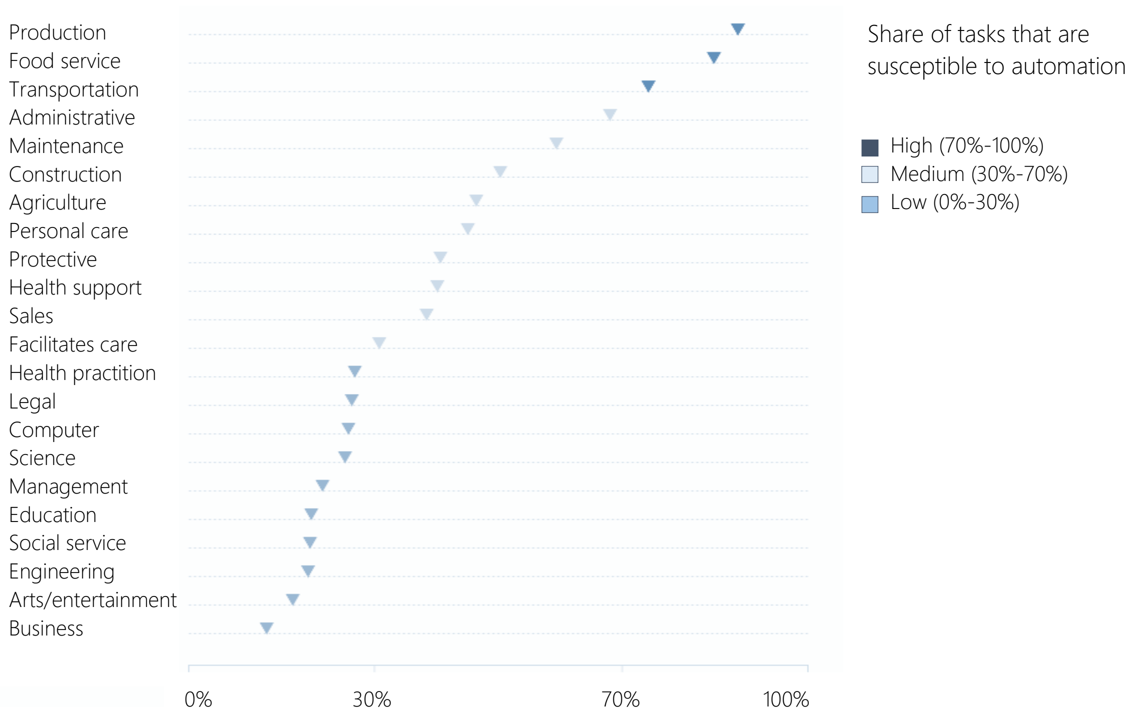
2.1. Labor Market Trends

The quick changes brought about by these technological trends will inevitably bring some negative effects as well in the labour market. The problem is that our technologies are advancing at a very quick rate whilst our skills and organizations are lagging behind. It is crucial for everyone to understand the phenomena and to come up with new strategies so humans do not race against but rather race ahead of machines (Degryse, 2016).

This situation poses great challenges for the individuals and not everyone can cope with those challenges equally successfully. Employees need further education to get a better understanding of technology and the competence to work with them. Sometimes they have to adapt to a serious change in their job profile, since machines can take over a huge portion of their job (Kollmann – Schmidt, 2016; Poschmann, 2015; Kieslich, 2019).

In recent years a debate has been fuelled by studies in the US and Europe arguing that a substantial share of jobs is at risk of digitalisation. Some of these studies follow an occupation-based approach proposed by Frey and Osborne (2013), meaning that they assume that whole occupations rather than job-tasks are automated. Frey and Osborne (2013) analysed the endangering of 702 job profiles in the US through computerization. Building three risk groups (low, medium, high), they conclude that up to 47% of the job profiles in the US belong to the high-risk group. Looking at the jobs, they state that mostly jobs in transport, manufacturing industries but also administrative jobs are highly affected by digitalization (Kieslich, 2019). What they also found was that the risk of automation is a lot higher for low-skilled workers and for low wage occupations, meaning that automation could disproportionally affect these groups of people. According to Muro, Maxim and Whiton (2019), in professions where the requirement in education is less than a BSc, the automation potential is 55%. Positions that do not require higher education face a double risk of loss through digitalization than occupations that do (see Figure 1).

Figure 1:
Automation potential of occupations, 2016



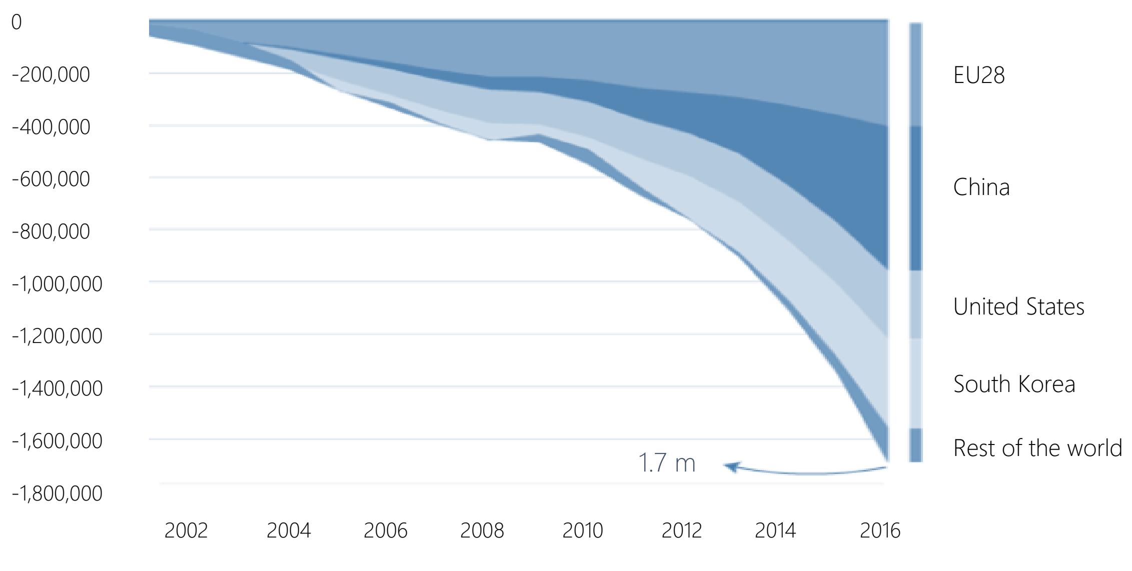
Source: Muro et al., 2019.

Another way to analyse the job market potential of digitalisation is to follow a task-based approach, which is based on the idea that the automation of jobs essentially relies on how easily its tasks can be automated. According to this approach the replaceability of jobs by robots is lower in jobs with higher educational requirements – in line with the findings of Frey and Osbourne – or in jobs that require cooperation between multiple people in-person and where people spend more time influencing others. When taking into account the various tasks within occupations, the results are much less frightening than in Frey's and Osbourne's data. It shows that only 9% of individuals in the USA are subject to high automatability (automatability of at least 70%). This result differs a lot from the previous figures, because if we do not take into account interactive tasks such as group work and face-to-face interactions with customers, clients and so on, it exerts an extensive impact on the estimation (Arntz et al., 2016).

Anyhow, by 2022 more than 54% of workers will require re-skilling or upskilling according to the World Economic Forum's study (Brende, 2019).

Currently, each industrial robot replaces 1,6 human workers on average. Moreover, this number could reach 20 million in total by 2030. This is a serious concern for both less and more developed economies (Figure 2). Countries have to balance between deindustrialization and reindustrialization in the era of post-industrial production. Automation may create opportunity for the developed economies to bring back manufacturing jobs, and the growing interconnectedness of industry and services are also offering new job opportunities in those countries. At the same time, this situation may create new opportunities also for developing economies, if they are able to catch up and elevate their positions in the global value chains.

Figure 2:
Cumulative job loss attributed to automation since 2000



Source: Oxford Economics, 2019.

At the same time, statistical data do not support all these estimations. Currently, industrial robots are overwhelmingly deployed in sectors with middle or higher skills requirements and their penetration is very limited in low-tech manufacturing sectors (e.g.: textile, food, beverage) where the majority of low-skilled are employed and the tasks carried out are easily replaceable by robots also at the current level of technology (OECD, 2019; UNCTAD, 2017).

A growing number of studies on the current deployment of industrial robots emphasize the economic benefits of automation and robotization (IFR, 2018; OECD, 2017; UNCTAD, 2017), while they believe that labour market challenges will not pose such a big problem and will rather bring a shift in the labour market positions than anything else (Craglia, 2018; European Commission, 2018). Today, a new consensus is emerging in the literature, that adoption of industrial robots considerably increases productivity and contributes significantly to economic growth (Cséfalvay, 2019). According to Graetz and Michaels (2018), robot densification increased the annual growth of labour productivity between 1993 and 2007 by 0.36 percentage points across the 17 developed countries analysed. This is a magnitude similar to the contribution of steam engine technology to annual labour productivity growth in Britain during the first industrial revolution. The CEBR (2017) report estimates that between 1993 and 2015 investment in robots contributed to almost 10% of cumulative GDP per capita growth in the majority of the OECD countries. The increase in robot density (measured as number of robots per million hours worked) by one unit was associated with a 0.04% increase in labour productivity. Dauth, Findeisen, Südekum, and Wössner (2017) found that in Germany, the country with by far the highest number of industrial robots installed in Europe every additional robot per thousand workers raised the growth rate of GDP per person employed by 0.5% over the period between 2004 and 2014. What is more, according to their calculation, while in Germany in the last two decades each robot installed has destroyed on average two manufacturing jobs, this loss was entirely offset in the total employment by job gains outside manufacturing.

If the use of robots brings GDP growth and improved productivity, it is crucial for Hungary (and other countries in similar situation) to take part in this process, and take the benefits of digitalisation, robotization and automation. To a large part this depends on the preparedness of the enterprises, individuals and governments.

In this paper the focus is on the individuals' situation in Hungary; whether they are aware of these technological trends, whether they are prepared for the challenges, and how they are facing the fear of job loss. International evidence suggests that employees are not really aware of the potential of job losses because of robotization or automation. According to an international survey, the fear of a job loss caused by technology advancement is in general relatively low (Statista, 2016); though, it is noteworthy that there are some differences regarding to the field of employment. Especially employees in industry report some concerns that their jobs might be substituted due to technology advancement (Kieslich, 2019).

2.2. Labor Market and Automation in Hungary

In Hungary, the labour market has been benefiting from a very positive trend since 2013. The employment rate at that time was below 60% while in the third quarter of 2019 it reached a level above 70%, which is around the European average. At the same time, the unemployment level has been shrinking from an above 11% to a 3.5% level by 2019. During these years the economy has evolved into a situation where the main problem is not unemployment but the lack of sufficient workforce. The potential labour reserve has been depleting at an increased rate and now businesses are forced to employ those who were previously deemed unsuitable. This can be seen also in the average duration of unemployment which has drastically dropped to 13.9 months (GVI, 2016). Hungary has almost emptied its potential labour reserve and is left to use whatever workforce is left on the market, which can be a struggle since this workforce is most likely low skilled with no experience. This can be a significant factor when it comes to large multinational companies investing in the country and thus decreasing its economic growth (Nábelek, 2017).

Currently (2018), there are more than 4.4 million employees in Hungary, of which 32% is employed in industrial sectors (manufacturing, energy, public utilities, construction), 63% in various service sectors and the rest in the primary sector. Within the manufacturing industry the vehicle industry is the main employer with more than

172 thousand people, followed by the food industry (144 thousand) and the metal industry. In the construction industry there are more than 332 thousand workers. In services, trade/retail trade (together more than 548 thousand), public administration (424 thousand) and education (344 thousand) are the largest employing sectors (Hungarian Central Statistical Office, 2018).

According to the European Union's statistics, the employment in knowledge-intensive activities (as a share of total employment) is around 34%, which is slightly below the EU average of 36%. The employment in medium-high and high-tech manufacturing is 9.9% of the total employment which is well above the EU average of 5.8% (European Commission, 2018). This is clearly the result of the many multinational subsidiaries which have settled in Hungary since the transition. (Their impact can also be seen on the share of high-tech export within the total export which is the highest in Hungary among all EU member states.) However, it also has to be seen that in many cases the technologies used by these multinational companies are only superior compared to the technological level of domestic companies, and the employees working at these subsidiaries are performing low value added, assemble-types of work. It is a real threat that these jobs can be replaced in the future by robots as there have already been some news in Hungary that certain companies are laying off employees because of technological developments.

According to a recent study by McKinsey (2018, p. 7), "automation arrives at an appropriate time for Hungary to achieve long-term productivity improvements that are indispensable to its economic competitiveness and ability to sustain growth. The immediate benefit of automation will be to reduce the growing labour shortage that is creating a bottleneck to its economic growth." They state, that while automation could boost economic growth in the country by 0,8-1,4 percent in the next decades, it also means that 49% of Hungarian working hours could be automated with already available technologies, which is around the global average. As in other countries, those jobs are at highest risk that involve predictable and repetitive tasks. At the same time, this trend may create additional job opportunities in high-quality services (Ibid.).

There will be further efforts to be made by the Hungarian economy to be able to benefit from the potential advantages of robotization. Recent Eurostat data shows, that largest shares of enterprises using industrial or service robots were recorded in Spain (11%), Denmark and Finland (both 10%), and Italy (9%). At the same time, the lowest shares were noted in Cyprus (1%), Estonia, Greece, Lithuania, Hungary and Romania (all 3%). In general, enterprises tend to use more industrial robots (5%) – and especially manufacturing robots (16%) – than service robots (2%). The mostly penetrated industries are warehouse management, transportation, cleaning or waste disposal and assembly work. Despite Hungary is generally lagging behind EU countries in the adoption of robots, in certain cases the use of robots are around or above the EU average, as in the case of service robots for transportation or for cleaning/waste disposal.

Hungary includes 19 counties (plus the capital city) and 7 regions. The Hungarian governance (and economy) is rather centralized therefore the regions do not have real power. Economically Budapest (the capital city) is the largest, most important region of the country, 37% of the GDP is produced here, and a further 10% in Pest county which is around the capital. Other counties have very limited economic power, the next largest producer being Győr-Moson-Sopron county, part of Western Transdanubian region, which is responsible for 5% of the national GDP. (This region and county is home to the largest multinational subsidiary, Audi Motor Hungary Kft. There is a strong business ecosystem around this company, which evolved in the past few years.) In Budapest, the service sector is much more important than the national average. 85% of the value added generated here comes from the services, while in other counties their share is below 65%. (In counties with strong industrial basis, like Győr-Moson-Sopron, or Komárom-Esztergom, the share of services in value added is only around 40%.)

Figure 3:
Regions of Hungary

Source: Regions of Hungary. (copyright-free; Wikipedia)

Among the regions, Western Transdanubia and Central Transdanubia and Central Hungary (Budapest and Pest county) are the most industrialized, while in Southern Transdanubia, the Southern and Northern Great Plains agriculture is proportionally more important than in national average. The least developed region of Hungary is Northern Hungary. The development of the peripheral regions in Hungary, like Northern Hungary is hindered by the aging population, the re-settlement of the young habitants to the central region, and, as a result, the spatial segregation of these regions.

Based on these information we may assume that people will be more familiar with and more positive towards robotization in Central Hungary or in Western and Central Transdanubia, where industrial development and penetration are more advanced. However, it may be that even in those places employees are more negative about current technological developments.

3. Research method

Although a relatively large number of estimates on the labour market impacts of robotization, digitalization or automation have been published, we still know very little about the society's or individuals' thoughts, ideas, hopes and fears related to these trends. Therefore in 2018 a representative survey was conducted in Hungary to assess the employees' and the society's attitudes towards robotization and to have an idea about their perceptions on the impact of robotization – impact on life in general and on their jobs. This survey was an online and personal hybrid (CAWI and CAPI) national data collection. It represents the Hungarian population aged between 15 and 69 by gender, age, region, and education. Out of the 1000 respondents 720 are employed currently. Their responses will be referred to as the employees' opinion, in other cases the results show the society's views. This paper focuses on the responses in regional dimension. The survey concluded two main parts. The first section asked general questions about robotization, such as their interest in and understanding of a robot, the acceptance of their distribution in various fields of life, their views on potential impacts, pros and cons of using robots and responsibility for problems caused by these machines. The second part focused on the employees' views. Questions focused on whether they have been already using robots in their work, and what their impact will be in their workplace, and what they are doing to prepare for the diffusion of robots. Due to some limitations in the raw data in this case the paper will analyse the responses using basic statistics. The main aim is to highlight whether there are any significant differences in the answers and thus in the preparedness of the employees, and whether it has anything to do with the (geographical) industrial structure of Hungary. Does the presence of high tech companies in certain regions mean that the employees are more aware of technological trends and are better prepared?

4. Discussion

Although a recent Eurobarometer poll (2017) found that 38% of Hungarian citizens view automation negatively, this was only partially confirmed by our own survey. When we asked about the potential impact of robotization on European competitiveness, 61% responded positively, and 52% were positive about its impact on Hungarian competitiveness. In the first case 20% and in the latter case 30% were neutral, and only 6% and 11% were negative. It is, however, a very interesting difference, that regarding the impact on their own work and salary, only 19% saw the positive and 27% the negative impact. Regionally, people in Pest county (part of Central Hungary) are the most positive about the robotization's impact on their work followed by Western Transdanubia, where 25 and 26% expect positive changes, respectively. In other regions the share of positive responses were between 19 and 25%, except for Northern Hungary, where only 14% of the respondents expected positive changes in relation to their working situation.

It was interesting to see the general interest of the respondents towards robotization. In total, 73% of the respondents reported that they are interested – 22% were very interested, and 51% somewhat interested – in news related to this topic. Higher-than-average interest was recorded in Pest county (81%) and Budapest (77%), and the lowest interest was in Northern Hungary (64%). In Central and Southern Transdanubia the interest was also somewhat smaller (69-69%), which is particularly interesting in the case of Central Transdanubia, a rather industrialized region of Hungary. However, there is a different ranking of the regions if we look only at the share of those respondents, who are very interested in this topic. In this case, the Northern Great Plain shows the greatest interest (28%) followed by Western Transdanubia (27%) and Pest county (26%). It has to be noted, that in the most developed region of Hungary (Budapest) the interest towards robotization is rather average, and the expectations are not outstanding, either. This result might be influenced by the higher share of services in the economy where robotization is not yet that obvious. In none of the regions do the respondents feel particularly well informed about robotization (despite their interest). Again, it is in the Northern Great Plains where people are the most confident about their knowledge (21% know something about robots) and in Northern Hungary the least confident (only 4% know something about robots). People from Western Transdanubia and Pest are also more informed than the national average.

The research also tried to highlight the source of information of respondents about robots. In general, 61% of the respondents have never seen a robot, but 14% did so on an exhibition, and 8-8% in the workplace and during travelling. When looking at the regional data, one may find that in Central Transdanubia 17% of the respondents have seen a robot in their workplace. In Pest county, an even higher share of respondents, 24% reported to 'meet' a robot in healthcare, and a further 15% during travelling. In the most industrialized region (outside Central Hungary), in Western Transdanubia only 5% or the respondents reported to have seen a robot in the workplace, which is the lowest share among all regions. Southern Transdanubia, Northern Hungary and Western Transdanubia are those regions where the highest share of respondents claimed that they have never seen a robot.

When the respondents were asked whether they accept the diffusion of robots in various places, industrial robots proved to be the most accepted type of robots (68%). Other robots are expected in agriculture (59%) and transportation (61%). At the same time, only 26% of people would accept robots in elderly care, 31% in healthcare and 33% in customer service.

In general, 45% of the respondents expect that robots will take on human jobs to a large extent, while 32% believe they will take on only a small part of the jobs. In Northern Great Plains, 14% are expecting that robots will work instead of humans, and 54% expect that they will take a large part of the jobs – both values are the highest among the regions. In Western Transdanubia, also 14% are expecting robot work instead of humans. In the capital city, only 8% expect that robots will work everywhere and 34% believes that they will take a large part of the human jobs. This latter share is the smallest among the Hungarian regions.

There is a more or less general agreement among the respondents, that robots will or need to take over jobs that are dangerous (75%), repetitive or physically exhausting (71-71%). A minor difference can be seen in Western Transdanubia, where people expect robots to work in repetitive (74%), high precision (73%) and dangerous (71%) positions. It is also a general view that people doing blue collar work and less educated are in the most risky positions. In Central Transdanubia and in Pest county, respondents believe that people living in smaller towns are also endangered by the diffusion of robotization.

More than 60% of the respondents believe that those, who lose their jobs because of the technological development need to be supported in re-training, but also 40% would like to ban the use of robots in certain positions. Similar share (39-39%) of the respondents mentioned the need for education about robots in the school and the provision of a base salary. Education was relatively more important in Central Hungary, while in Western and Central Transdanubia a relatively larger share of people (45 and 48%) would ban the use of robots.

In general, employees are totally uninformed whether the diffusion of robots will bring benefits or dangers for their position. 28% of the respondents see both, 13% see more opportunities and 14% see more dangers with more robotization. This balance takes a negative direction in Northern Hungary, in Southern and Central Transdanubia and in Northern Great Plains. People see more opportunities in Central Hungary and in the Southern Great Plains. Among the potential advantages of robotization, people mention less repetitive jobs (55%), higher productivity (54%) and less unhealthy jobs (43%). People from all three Transdanubian regions place higher productivity at the first place, while in Central Hungary the less repetitive jobs was the most important opportunity. Practically, three quarters of the respondents have fears from job loss. This share is highest in the less developed regions, and below average in Budapest (65%), Western Transdanubia (64%) and, somewhat surprisingly, in Southern Transdanubia (69%). There was no clear pattern in the question, who should be responsible for the preparation of the imminent challenges by robotization. Responses were divided between the individuals, the companies and the government. It is a thought-provoking result at the same time, that 51% of the respondents are not preparing for the potential challenges, and only around 16% take part in any kind of education or training. People in Northern Hungary and Pest seem to be the less forward looking, and even in the most industrialized regions only less than 14% of the respondents are engaged in any kind of learning activities, while in Northern and Southern Great Plains the share of respondents is above 24%. This means that the better knowledge or a more industrialized environment does not necessarily mean that employees are becoming interested in learning, obtaining new digital skills or preparing themselves in any other ways for more robotization and digitalization.

5. Conclusions

Hungary is now in a very fragile economic situation. She has been deeply integrated in the global value chains but in positions that are generating less value added. Many multinational corporations have established subsidiaries in the country but the value added and productivity of these plants do not seem to be evolving over time. In the 21st century, the unprecedented speed and scope of technological development bring new challenges when both the most developed countries and the developing economies (like in Asia) are becoming competitors. There is an opportunity for reindustrialization in the developed economies while due to technological upgrading, many more developing countries are able to climb up in the global value chains and obtain new, more advanced tasks.

In this situation, it is crucial for Hungary to be prepared and to successfully take part in technological development in order to be able to maintain international competitiveness. In this task, human resources play a crucial role. The availability of a capable workforce with adequate digital skills might be an attractive asset for all multinational players to maintain and improve activities within the country. Therefore, it is not enough if firms are ready to introduce the innovations of Industry 4.0 or the fourth industrial revolution, but it is equally important to prepare the human workforce for the future world of work.

This paper analysed the current knowledge and preparedness of the Hungarian society and, partly, the employees with regard to robotization. Although during the past decade, or even more in the past 5 years there have been a lot of information published on the potential impact of robotization globally, people in Hungary seem to be less aware of the importance of this change. Although most of the respondents are interested in the topic, their actual knowledge is rather insufficient. This picture is not really modified by the economic environment. Even in regions which are more industrialized, more developed, there are no significant differences in the level of information or awareness. This might be the reason that while globally they see this trend as positive, in their personal life and work position they do not. People are simply not well informed to be able to judge, whether robotization will bring more opportunities or more threats. Interestingly, it seems that in regions that are less developed and where people have fewer opportunities to witness the spread of robots in the economy, a darker future is envisaged and negative effects are expected more than positive ones. However, on the other side, we cannot say that the more developed, more industrialized regions automatically generate a better environment for robotization. Even in these regions employees are not really prepared for the imminent challenges, and in general it is not true that people educate themselves to be able to meet the higher requirements of the future workforce, that is to become capable of working together with robots.

The research shows that an exclusively technological and industrial development does not create a beneficial environment for catching-up and improving the human workforce. The Government has to take active steps in order to share information on robotization, improve the involvement of the local economy in technological development and elevate the quality and capabilities of the human workforce in all the regions of Hungary.

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ROLE OF BLOCKCHAIN TECHNOLOGY ON SUPPLY CHAIN

Annamária Horváth

Abstract

Coordination and collaboration within the supply chain are crucial components of the effective and the efficient supply chain. Supply chains have become longer, larger and more complex, that is why end-to-end transparency is critical in the operations of supply chains. Information processing and analytics can increase supply chain transparency using appropriate technologies such as RFID, IoT and blockchain technology. Blockchain technology has a potential to solve the problem of achieving end-to-end transparency. It represents a decentralized environment for transaction, where all entries are recorded on a public or private ledger that is visible to users. Integrated with other technology, the blockchain technology could be used to create a record of every moment of a product flow in the global supply chain. The purpose of this paper is to present the way in which blockchain technology is likely to use supply chain operations and practices. A further aim of this study is to identify potential fields of supply chain where blockchain technology is recommended.

Keywords: supply chain, logistics, blockchain technology

1. Introduction

On 2 July 2019, Mearsk (one of the world's largest shipping companies) announced that Hapag-Lloyd and the Singapore-based Ocean Network Express (ONE), the world's 5th and 6th largest shipping firms, also joined TradeLens, the blockchain-based digital platform that Mearsk had developed jointly with IBM (MAERSK.com). A year earlier, the Harvard Business School published a case study by Rajiv Lal and Scott Johnson entitled: "Mearsk Betting on Blockchain" (HBR 9-518-089). The question arises why the blockchain technology, which became known upon the appearance of the bitcoin (cryptocurrency), also hit the area of logistics and supply chain. In research conducted by Clohessy – Acton (2019), one of the participating companies said the following: "Blockchain enables you to do something that you have not done before. Therefore, the fundamental question for your business prior to adoption should be: what problem are you trying to solve which can only be solved by blockchain?"

The goal of the study is to provide an outline of the opportunities to apply blockchain technology in the case of supply and logistics chains as well as to specify the areas that may be relevant from the viewpoint of the topic. It is important to point out that blockchain technology not only hits the area of the supply chain (based on its characteristics that are introduced later) but it can also be applied in several other areas like the financial sphere (banks, insurance companies), state administration (e.g. individual identification of citizens, military logistics), health (e.g. medical history, clinical research, health insurance), Chain of Things (Internet of Thing, Industrial Internet of Thing) or Cyber-Physical System (CPS) (Kovácsházy, 2017 and Szarvas et al., 2018).

There is significant interest in the blockchain, as a new technology in supply chain-related areas, both in business and in the academic sphere. This is well shown by the results of the survey of 299 papers by Gurtu and Johny (2019) based on the EBSCO database. In 2016, only one article presented the blockchain research into the area of supply chain and logistics, while in 2018 seventeen articles were published in these two areas (13 on supply chain and 4 on logistics).

The technologies related to Industry 4.0 may promote the development of new business models. Numerous new, digital technologies are emerging in the field of production and the supply chain. It is a great challenge for corporate leaders to know which technology to invest in, and when. Blockchain technology is an important technology and is being applied more and more for process digitalization (Queirez et al., 2018). One of the reasons is that blockchain technology itself helps to solve the problems incurring in supply chains, e.g. controlling more and more complex networks, considering the critical criteria (e.g. transparency, speed, agility) that characterize supply chains these days (Ganeriwalla et al., 2018).

1.1. Supply chain management

The widely accepted definition of supply chain management was defined by the Council of Supply Chain Management Professionals (CSCMP) in the following manner:

"Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies" (CSCMP, n.d.).

As can be seen, the supply chain is nothing else but the entirety of all organizations / companies that directly participate in the supply and the distribution of products and/or services and in the related IT and financial processes, from the source up to the end consumer. However, the supply chain not only describes the network of the organizations active in the supply chain, but it is the conscientious management of the supply chain aimed at improving the joint performance and thus the competitive edge of the participating companies (Demeter, 2014). This is also supported by the a.m. definition that, on the one hand, highlights that the coordination and cooperation of the members of the supply chain, i.e. the suppliers, cooperators, logistics service providers and consumers, also forms a part of the supply chain management. On the other hand, it integrates both the supply and the distribution activities within the company and among companies. In order to work out integration among the members of the supply chain – without the common ownership of the companies – the members need to establish trust among themselves at a level that is able to support the sharing of the available information among the companies. On the other hand, the implementation of information sharing needs IT system(s) that is/are also able to provide this in the global, complex supply chains.

More and more end consumers seek information about the origin of the product, e.g. what raw material the given product was made from, where and under what circumstances was it manufactured. All this presumes transparency of the supply chains, i.e. the companies that are active in the chain should know each other and share the required information (Bateman – Bonnani, 2019), which means that trust should be built among the companies. The need for the transparency of supply chains is all the more justified since they are becoming larger and more complex. The transparency of supply chains can also reduce risks for the members and the final consumers (Zelbst et al., 2019). The lack of transparency in supply chains may also cause business problems, e.g. the given cargo is not permitted to move on if the origin document is missing. Bateman and

Bonnani (2019) raise the question: why is transparency and trust introduced into the supply chain so slowly if they are so important. Their answers are as follows: (1) the supply chains were not designed in that manner; (2) there is no relevant information, it cannot be collected, it does not exist or it is erroneous; (3) the financial investment into transparency does not always meet the short-term necessities.

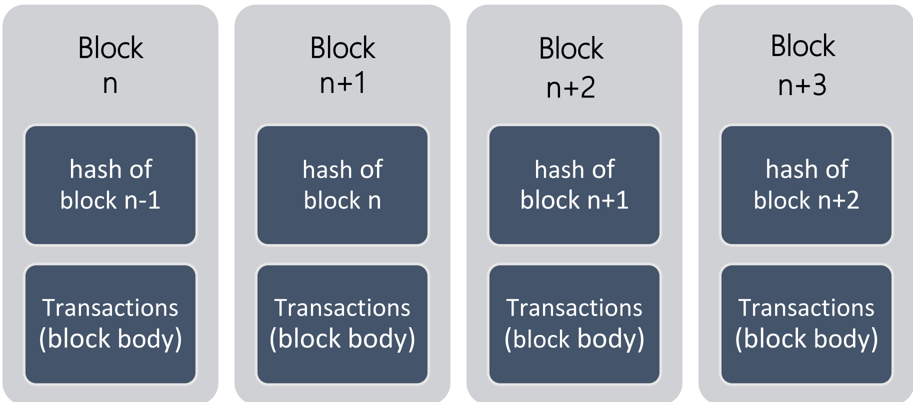
1.2. Blockchain

This term has no generally accepted definition (Seebacher – Schüritz, 2017) regardless of the fact that the foundations of blockchain technology were already laid down in Nakamoto's article (Nakamoto, 2008) in 2008. In his article (2018) Szarvas et al. calls it a half-baked technology and classifies it as DLT (distributed ledger technology). Having gone through the related literature, Seebacher and Schüritz (2017) defines blockchain technology as follows:

"A blockchain is a distributed database, which is shared among and agreed upon a peer-to-peer network. It consists of a linked sequence of blocks, holding time stamped transactions that are secured by public-key cryptography and verified by the network community. Once an element is appended to the blockchain, it can not be altered, turning a blockchain into an immutable record of past activity" (Seebacher – Schüritz, 2017).

Therefore, blockchain is an IT terminology that stores data in blocks and forms a checking code, what is called a "hash" code, which is typical for the relevant data set[1]. This checking code is inserted at the beginning of the next block, then the data set is stored and its checking code is formed in the next block etc. (Sík, 2017), as is also shown in Figure 1. It is an important feature that any data appearing in a digital form can be stored in the blocks (Tarcsi, 2017).

Figure 1:
A simple blockchain setup



Source: Queiroz et al., 2018.

Therefore, a chain of data sets is established in the case of block chain technology, i.e. the blocks are connected to each other, the blocks contain the transactions (data), the timestamp and the hash code of the previous block (individual sequence), which is formed in one way, can be formed from the data of the block but cannot be decrypted. Therefore, the technology is capable of making an irrevocable chain, thus the data cannot be changed retroactively either intentionally or by accident. Therefore, the blockchain is a distributed ledger technology, currently its unique feature is – as against central database technologies – that it cannot be turned

[1] cryptography-based code formation

off, annihilated or modified (Sík, 2017; Lányi, 2018). As a result of its decentralized feature, blockchain is safer than central data storage, and it can be better protected against external attacks. Since the whole database is distributed and exists in several places, the network continues to be operable even if one or more players opt out. In addition, it is permanent, there is only affixing and reading (immutability of data), there is no modification or deletion. It is important to highlight that blockchain technology is open and transparent, i.e. all transactions can be seen in time, they are transparent, can be traced and controlled by anyone, but cannot be necessarily interpreted. The technology is capable of implementing transactions that can be carried out automatically and that can be checked (e.g. smart contract) (Tarcsi, 2017). Table 1 summarizes the main characteristics of blockchain technology, highlighting two main areas, on the one hand, trust and, on the other hand, decentralization.

Table 1:
Characteristics of blockchain technology

Trust	Decentralization
Transparency - Shared & public interaction - Low friction in providing information	Privacy - Pseudonymity of participants
Integrity of data - Peer verification of transactions - Security through cryptography	Reliability - Redundancy of data - Potential use of automation
Immutability - Tamperproof architecture	Versatility - Peers participate in development

Source: Seebacher – Schüritz, 2017.

As is summarized in table 1, trust derives from transparency, data integrity and immutability, while decentralization provides for privacy, reliability and versatility. The listed characteristics of blockchain technology are the ones that make it capable – at a global level – to store documents, transactions and dates produced upon the logistic and supply chain processes and to digitalize the whole process (Lányi, 2018). Concentrating on the supply chain context, Cole, et al. (2019) summarized the characteristics that provide the relevance of applying blockchain technology in the case of supply chains. These are as follows: (1) Distributed and synchronized across networks, (2) use of smart contracts, (3) based on P2P (peer-to-peer) networks and (4) Immutability of data.

1.3. Materials and Methods

This study is a literary and theoretical approach, an analysis synthesizing the relevant sources. Its goal is to explore relations and trends; thus it is suitable for founding primary research.

2. Results and Discussion

2.1. Types of Blockchain Technology

There are several types of blockchain technologies, one group differentiates solutions based on access, i.e. public ("permissionless") solutions, where all transactions are public but the users are anonymous (e.g. bitcoin), as well as private ("permissioned") solutions, where an invitation or permit is required for joining. In the latter case, access control can be consortial (consortium) or controlled by an organization (private) (Wang et al., 2019).

SAP differentiates four types of blockchains based on their control: (1) consortium blockchains, (2) semi-private blockchains, (3) private blockchains and (4) public blockchains. Primarily the consortium and semi-private blockchains are used upon business operations, experience shows that the consortium blockchain is currently the most accepted business model, which is controlled by a group of specific organizations (SAP.com, n.d.)

The feature of a public blockchain is that it has several unknown participants, anyone can read and write and it works based on the Proof of Work consensus. As against this, in the case of a private blockchain solution the participants are known, basically they belong to one organization, the writing and reading authorization can be monitored centrally and consensus is reached through various algorithms. In the case of blockchain-based technologies run by a consortium, the participants are known, they belong to several organizations, the consent of several participants is needed for writing, reading can be public or restricted and consensus is reached through various algorithms (Tarcsi, 2017). Table 2 compares the blockchain types:

Table 2:
Comparison among public, private and consortium blockchains

Key feature	Public blockchain	Private blockchain	Consortium blockchain
Efficiency	Low	High	Medium
Performance	Low	High	Medium
Privacy	Low	High	Medium
Operations cost	Low	High	Medium
Centralization	No	Yes	Partial
Consensus determinants	All miners (permissionless)	One node (organization)	Selected set of nodes
Read permission	All nodes (public)	Restricted/Controlled	Restricted/Controlled
Immutability	Hard to be tampered	Could be tampered with	Could be tampered with

Source: Chang et al., 2019, pp. 1716.

It can be stated in general terms that blockchain solutions applied in business processes, thus also in supply chains and logistics, primarily belong to the types subject to permission, i.e. to private or consortial solutions, by applying various access mechanisms (Cole et al., 2019).

2.2. The Importance of Blockchain Technology in the Supply Chain

In their literature review, Gurtu and Johny (2019) summarized the key features of blockchain technology, which can justify its introduction to the supply chain. These are, on the one hand: the use of smart contracts and the opportunity of supply chain finance and, on the other hand the increased need for transparency and traceability in the supply chain. Global supply chains have multiple participants and all participants have their own abilities and limits that determine their competitiveness. Due to their set-up and operation, the current, traditional, global supply chains have typically several steps, the lead times are very long and require a lot of time, which influences the level of service to the end consumers. Blockchain technology helps to streamline supply chains as the role of some participants is terminated in the supply chain. Each key participant of the supply chain can be integrated into a safe network, thus enhancing the service level of the entire supply chain, which is advantageous both for buyers and sellers.

In a literary review, Wang et al. (2019) concluded that the application of blockchain technology in the supply chain is explained by the following drivers: (1) Trust: reliability and security of information, (2) Supply chain disconnection and complexities, (3) Product safety, authenticity and legitimacy (4) Public safety and anti-corruption.

Szarvas et al. (2018) highlight that blockchain technology is capable of storing logistic events/transactions in a standard form, therefore, it can provide appropriate input for what is called online analytical processing (OLAP[2] – On Line Analytical Processing). Blockchain technology helps to retrieve all data in order to analyze the operation, the reliability and the ability of the supply chain and, based on this, development and transformation projects can be launched to enhance the efficiency of the supply chains.

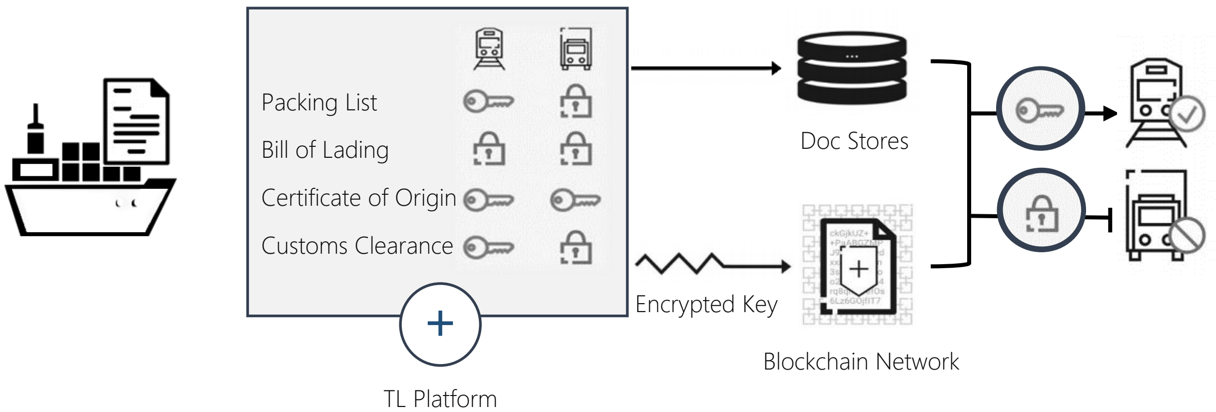
2.3. Blockchain Technologies Applied in the Supply Chain

In their study, Petersen et al. (2017) identified 49 various blockchain-based technologies (applications) in the field of logistics and supply chains, and classified them into three large clusters:

Cluster 1 - "Product Tracking". These solutions are focused on information supply about the shipment or about any other logistics objects, e.g. tracking the product from the shipper to the consignee. The decentralized feature of the blockchain enables the companies of the logistics chain to simply share data, e.g. they can adapt to the changes if a specific shipment is late.

An example of this is the TradeLens platform, jointly developed by Maersk and IBM, aimed at digitalizing global trade, more accurately digitalizing the home-to-home tracking of container shipping by sea. The project had two important pillars: to introduce, on the one hand, a shipping information pipeline and, on the other hand, paperless trading. This enabled the exchange of digitalized documents and increased the transparency of the supply chain. They tried to find a solution that can also be accessed by the members of the eco system connected to sending commodities: carriers, forwarders, ports, shippers/consignees, customs authorities and other shipping companies. Their choice was based on blockchain (Lal – Johnson, 2018). The simplified set-up of the system is illustrated in Figure 2.

Figure 2:
The simplified set-up of TradeLens



Source: TradeLens.com, n.d.

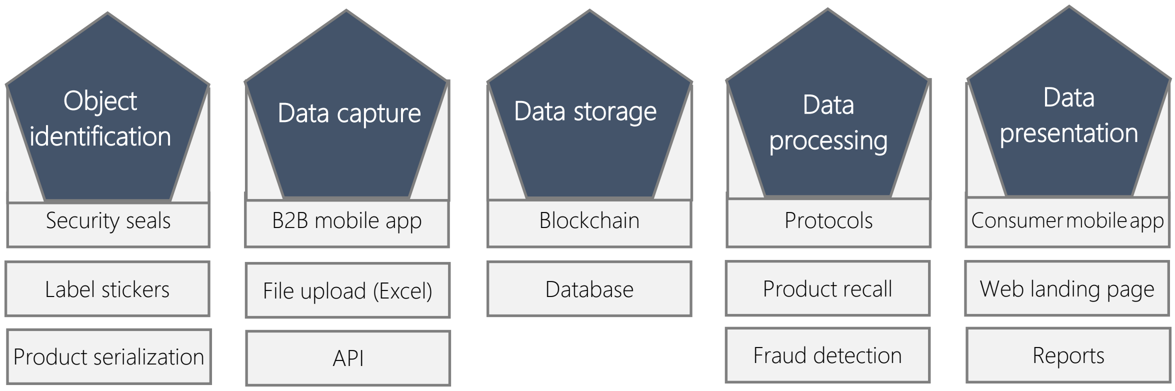
With the application of TradeLens, all data and document information related to the given shipment (container) is written into the blockchain system and the existing contracts are implemented automatically with the smart contract application. After recording the given event, e.g. arrival of the container at the port, the relevant contract gets activated, thus reducing errors, delays or lost documents (Choudary et al., 2019).

[2] The basic task of the OLAP systems is to support decisions, to collect information in the long run and to supply it to the decision-makers. The emphasis is laid on gaining information rather than on data input (Sidló, 2004).

Cluster 2 – "Product Tracing" In this case, the goal is to improve information flow and to trace the product origin using the knowledge of the stages of the route covered. This presumes a system approach. Here, it is required to connect the flow of materials and products with the flow of the related professional information, and they necessarily have to move together. This classically includes tracing medicines and foods, which can be supported by the blockchain solution.

An example for this solution is TE-FOOD, created as a result of a Hungarian development to offer a modern and cost-efficient solution for tracing livestock as well as fresh and finished products, from farms up to the end users. The system is a tracing information system covering the whole chain and containing unified logistics and food safety data – its structure is illustrated by figure 3. The blockchain technology was introduced for data storage in 2018, which rendered it impossible to falsify and modify transaction data (gs1, 2019).

Figure 3:
The structure of TE-FOOD



Source: Te-Food, n.d.

Cluster 3 – "Supply Chain Finance" This means an automated payment process with the help of the smart contract application, depending on e.g. the current status of the shipment. This study does not focus on this area of use, therefore we do not cover it in detail.

Based on the systematic processing of sources, Queiroz et al. (2018) pointed out that blockchain technology can induce numerous changes in the field of supply chain management. It can place product tracing on new bases, thus it can enhance the efficiency of decentralized operation and it can reduce the number of the parties cooperating in the supply chain processes together with the transaction costs. Blockchain technology provides the supply chain members with real time data about the origins of materials, purchase orders, inventory levels, about the date and the data of receiving the shipment and about the related invoices. Since a smart contract can be used with blockchain technology, automated orders can be made and automated payments can be launched under previously accepted conditions (Cole et al., 2019).

The "smart contract" is a program (protocol) providing ready-made schemes for simple cases, automating certain processes like the acknowledgment of orders (Cole et al., 2019). In this case, the parties learn and approve the contracting terms in advance. Modifications are only possible with the approval of all participants. Once the given event takes place, the provisions of the contract are automatically fulfilled as well as the prompt and automated payment process is also carried out (Tarcsi, 2017). It is to be noted here that the elaboration of the smart contract concept is attached to the publication by the Hungarian Nick Szabó, however, he made no implementation for this. His topics were digital contracts, electronic trading, cryptography etc. (Kovácsházy, 2017). Table 3 compares the features of traditional contracts and smart contracts in the case of international trading.

Table 3:
Comparison between smart contract and traditional trade contract

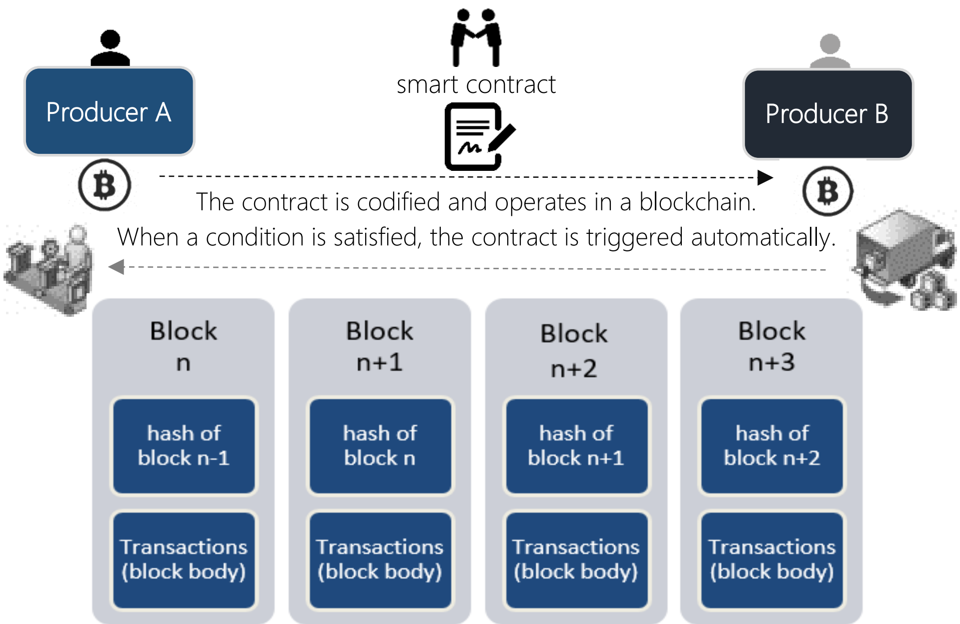
	Smart contract	Traditional trade contract
Execution method (mode)	Automatic execution by preset conditional triggers specified by specific entity, event or time	Execution followed by manual examination and judgement of contract terms and agreements
Execution speed	Within few seconds or minutes	Depending on distance (usually in couple of days)
Data security	Tamper-proof	Vulnerable to tampering, damage and can cause disputes

Source: Chang et al., 2019, pp. 1716.

An important feature of the smart contract is that it allows for streamlining the supply chain and thus reducing its complexity as the number of the cooperating organizations is reduced and certain routine tasks are performed by the system (e.g. checking compliance with the contracting terms), and, as a result, the freed human resource can be re-grouped to value-creating processes. The consequence of automated routine tasks is that the quality of work performance may improve (e.g. by completing more creative tasks) and this may provide supply chain workers with dynamism that can enhance the efficiency also in itself (Szarvas et al., 2018).

Figure 4 gives an overview of the operation of the smart contract. If the parties agree on the conditions, the contract is signed. Then the contract is coded and stored in the blockchain structure. The contract gets activated if an event takes place that complies with the conditions. Afterwards, both the product flow and the payment process are implemented under the contracting terms. This requires no mediating party, so not only the speed of implementing the transaction is increased, but the transaction costs are also reduced and trust among the participants is also raised as the copy of the ledger about the transaction will be available for all participants.

Figure 4:
Smart contract example in the Supply Chain context



Source: Queiroz et al., 2018.

In their study, Cole et al. (2019) also identified and summarized possible ways of further use of blockchain technology in the field of supply chain and operations management. Potential uses for blockchain technology in Operations and Supply Chain Management are as follows:

1. To enhance product safety and security by providing records of safety testing;
2. To enhance quality management by providing visible and easily accessible information about batches, aiding recalls and improving service;
3. To reduce illegal counterfeiting by providing information of the origin of a product;
4. To improve and automate contracts and reduce the need to develop trustworthy supply chain relationships;
5. To improve inventory management;
6. To reduce the need for intermediaries thereby reducing the complexity of the supply chain;
7. To accelerate work on design and new product development by improving efficiency and delivering greater transparency between teams;
8. To revolutionize IT in Operations Management by boosting access to tools and new practices, such as smart manufacturing;
9. To reduce the cost of transactions through automation, enabling real time auditing via time-stamping.

2.4. The Relationship of Blockchain Technology with Industry 4.0 and with Smart Technologies

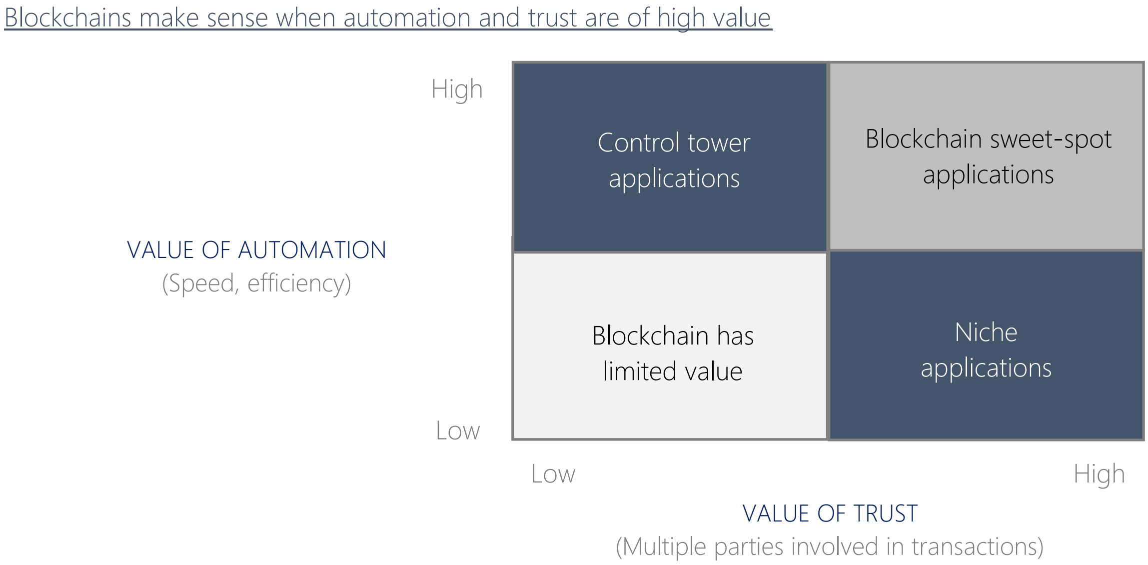
Blockchain technology is not an independent technology, its operation significantly depends on the availability of data in an appropriate quantity and quality, therefore, it is also necessary to jointly apply other tools, e.g. the big data or the internet of things (IoT). To ensure that logistics and supply chain processes are tracked, and their transparency is increased through blockchain technology, e.g. GPS or RFID (radio frequency identification) tools must be integrated into the system to supply input data to blockchain technology. Since the blockchain is a metatechnology, other technologies (e.g. IoT) will always have to be applied (Sheel – Nath, 2019).

The research by Zelbst et al. (2019) highlighted that the RFID technology serves as a basis both for the IIoT (industrial internet of things) and blockchain technology in supply chains. In addition, IIoT technology supports the implementation of blockchain technology. Using the RFID in itself only allows for data collection but if it is integrated with other technologies – e.g. IIoT, which forwards data, and with blockchain technology, through which the data becomes accessible – a whole system is created to support supply chain transparency. The research by van Hoek (2019) processing case studies also pointed out that blockchain technology is a complementary rather than a replacement technology, since it has to process input data by applying already existing technologies like the RFID or the barcode. Cole et al. (2019) also arrived at the same conclusion, i.e. the blockchain is not only a complementary technology but it needs to be combined with other technologies. For example, the RFID will be the system that performs tracing-related tasks (e.g. identification, sensor activities), while the smart contract is automatically checked, and the payment obligation can be fulfilled through the ERP (enterprise resource planning) system.

2.5. Limits of Blockchain Technology

Like any other technologies, blockchain technology cannot always be applied. Ganeriwalla et al. (2018) determined a matrix where one dimension is the value of automation and the other one is the value of trust. Based on this, it can be defined – as is also shown in Figure 5 – in which case blockchain technology should be applied and in which cases other solutions are recommended. Blockchain technology is worth using if the value of automation and trust is high. In this case, speed and efficiency are of prime importance as a large amount of transactions need to be implemented. There are many participants in the supply chain, they may even be exchanged many times, therefore trust must be created among the members.

Figure 5:
Value of trust and automation matrix for blockchain



Source: Ganeriwalla et al., 2018.

Cole et al. (2019) summarized – as follows – the cases where the application of blockchain technologyis recommended and when it is not recommended. Two main aspects were identified: the feature of the product and the complexity of the supply chain. Blockchain technology is recommended if the product carries some critical feature, e.g. its safety is critical (e.g. medicine, food), there is a high risk (e.g. diamond) or withdrawal is possible (cars) or if the supply chain is extended and there is a global, multi-stage and complex product flow and there are many suppliers. This solution is not expedient in a contrary case, e.g. in the case of local, short supply chains.

Ganeriwalla et al. (2018) drew up a checklist to help companies determine whether blockchain technology is suitable for them or not. Blockchain technology is recommended if:

1. The secure capturing of shared data, transactions, records or contracts is required;
2. Many supply chain members/participants give or call data in order to carry out the transactions;
3. The members of the supply chain do not know or do not trust each other and there is no central party to provide this trust, or it would be very expensive;
4. A high-cost or critical product is manufactured in the complex value chain.

2.6. Features of Introducing Blockchain Technology

The research conducted by van Hoek (2019), based on case studies, identified the features that characterize the implementation of blockchain technology in the context of the supply chain. The analysis started out from the framework system of Reyes et al. (2016) and compared it to the introduction of the RFID systems. Table 4 presents the results.

Table 4:
Similarities and differences between RFID and blockchain implementation

	Similar to RFID implementation	Unique to blockchain implementation
Drivers	Customer considerations are important…	• …but less of a customer requirement, more of a market potential perspective; • …but internal drivers are more prominent.
Leadership commitment	Top and middle management support enables implementation of blockchain like it does of RFID…	• …but executive engagement can greatly accelerate pilots; • …and 2–4 engaged partner may suffice initially.
Barriers	• Relevant to consider barriers upfront; • Lack of understanding is equally prominent in blockchain consideration.	• For a pilot a formal business case is less needed and; • There is less upfront investment needed for blockchain.
Implementation	Implementation levels can vary from supply chain to supply chain…	• …but actual blockchain implementation levels are limited to date; • …making it unclear of blockchain will be as scalable as RFID.
Benefits	Visibility and traceability stand out as similar benefits/functionalities, confirming the overlapping functionality and potential to complement RFID with blockchain…	• …less of an inventory tracking and recording focus, more of a dissemination benefit; • …benefits may be more narrowly defined.

Source: van Hoek, 2019, pp. 847.

Table 4 goes to show that the features of implementing the two technologies are mostly identical but there are factors that are only typical of blockchain technologies based on our current knowledge.

Clohessy and Acton (2019) examined the adaptation of blockchain technology along organizational factors, highlighting three factors: organizational size, top management support and organizational readiness. Through their research they processed the case study of 20 Irish companies. Their key finding was, on the one hand, that key decision makers play an important role in deciding whether the organization applies blockchain technology or not. On the other hand, large companies are more likely to adapt blockchain technology than small to medium-sized enterprises (SMEs). One of the reasons for this is that the companies who decided to introduce blockchain technology were basically motivated by the reduction of the complexity of the supply chain and supply chain-related investment costs. Traditional supply chains have typically high costs and time needs for their operation as well as many participants in the supply chain. These are the factors that induce companies to apply blockchain technology. Against this, the SMEs who did not introduce blockchain technology did so because they work in a small supply chain that does not require the introduction of this technology. On the other hand, those companies that introduce blockchain technology were most probably more in favor of IT innovations. Table 5 summarizes the findings of the research.

Table 5:
Summary of main blockchain organizational adoption considerations

Organization	Adopted – deployment and rationale	Non-adopting rationale
Large	Multiple instances of fully deployed and functional blockchain applications; Private permissioned blockchains; Initial blockchain prototyping to create business use cases; Availability of cloud-based blockchain development tools; Supply chain transaction innovation: • cost reduction, • enhanced security, • enhanced transparency, • enhanced efficiency.	Lack of internal IT adoption coordination; Blockchain technological complexity; Lack of specific industry business cases and standards; Lack of government incentives; Lack of blockchain top management awareness; Lack of internal staff with requisite; blockchain skills and competencies; Lack of supply chain organizational buy in.
SMEs	Single instance of a fully deployed and functional blockchain application; Public permissioned blockchains; Provision of new innovative services; Availability of cloud-based blockchain development tools; Availability of publicly available business use cases.	Lack of blockchain awareness; Lack of specific industry business cases; Challenges sourcing employees with requisite blockchain skills and competencies; Challenges sourcing blockchain educational resources.

Source: Clohessy – Acton, 2019, pp. 1474.

It is also pointed out by the research results (see Table 5) that the set-up, type and operation of the supply chain has a major impact on the introduction and the application of blockchain technology in a large corporate environment.

2.7. Possible areas of research into the relationship between blockchain technology and supply chain research agenda

In addition to the presented research work, most of the processed literature also highlighted further research areas for examining the relationship between blockchain technology and supply chain. We emphasize two works, one is focused on supply chain management and the other one jointly deals with the supply chain and the area of operations management. The latter extension is important as the value creating processes cover both areas.

Based on the systematic literature review, Wang et al. (2019) defined possible research areas with regard to supply chain and blockchain technology:

1. Cryptocurrency and supply chain finance (for example payment process, blockchain-based financial service platforms);
2. Disintermediation and reintermediation (for example elimination of intermediaries, extinction of certain types of intermediaries);
3. Digital trust and supply chain relationship management;
4. Blockchain, inequality and supply chain sustainability;
5. The dark side of blockchain (for example governance, ethics, law, crime security, privacy);

6. A design perspective on a blockchain-enable supply chain:
    a. Selecting a blockchain's entry point to the supply chain;
    b. Building a blockchain ecosystem;
    c. Articulating the platform value;
    d. Establishing the governance model;
    e. Exploring legal implications;
    f. Scaling up a blockchain-enabled supply chain network.

Cole et al. (2019) extended the potential research areas not only to the supply chain but also to the area of operations management as follows:

1. Blockchain technology development for Operations and Supply Chain Management;
2. Incentivizing blockchain technology adoption in the supply chain;
3. Trade-off considerations affecting the adoption of blockchain technology;
4. Blockchain technology implementation in complex supply networks;
5. Supply chain relationships;
6. Theory application and development for blockchain.

3. Conclusion

This study has pinpointed the major areas of the relationship between blockchain technology and supply chain. Our review identified the factors that influence the introduction of blockchain technology into supply chain processes. In summary, it can be stated that the opportunities of potentially using blockchain technology in the area of logistics /supply chain are primarily related to tracking some object (e.g. container, shipment) and providing object-related information (e.g. date of arrival of the container at the port). In addition, it may play a significant role in verifying the product origin (e.g. medicine, diamonds, food), i.e. in preventing the marketing of fake products and in identifying the circumstances of manufacturing (e.g. the product was manufactured in a country where no child labor is permitted). In the area of the supply chain structure, the complexity of supply chains can be reduced with smart contract protocol, supported by the blockchain, i.e. streamlining can be carried out by reducing the number of the cooperating organizations or the operation of certain cooperating organizations becomes unnecessary. As a result, the transaction costs and the lead times of the supply chain are reduced, thus raising the service level of the supply chain (Lányi, 2018; Cole et al., 2019). The study by Hald and Kinra (2019) looked at the impact of the blockchain on the performance of supply chains. They specified the following four areas of the blockchain that enhance the performance of the supply chain: (1) information lighthouse, (2) exploitation technology, (3) exploration technology and (4) relationship-building technology. In addition, they also highlighted three areas that may lead to a lower performance of the supply chain: (1) domination technology, (2) straitjacket, (3) deskiller.

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CHINESE DIRECT INVESTMENTS IN THE EU AND THE CHANGING POLITICAL AND LEGAL FRAMEWORKS

Csaba Moldicz

Abstract

This paper seeks to shed light on the key geopolitical interests of European countries (EU members) in technology transfer from China and to China. The paper focuses on the policies of the key EU members (Germany, France, Italy and the United Kingdom). The paper focuses on these countries because on the one hand, these European countries are the main recipients of the Chinese FDI in Europe and offer attractive business environments for Chinese tech firms, on the other hand, these four countries have measurable geopolitical clout and large markets, too. The EU dimension cannot be neglected in this analysis, however, the presumption of the study is that the main features of the national foreign policies are defined by the countries themselves, not the EU. The general question of this paper is how these countries perceive the potential role of Chinese tech firms in their economies. Since the paper mainly focuses on geopolitical questions, it cannot avoid raising the dilemma, how the Transatlantic Alliance will be affected by the recent US foreign policy.

The paper intends to raise and answer the following questions: (1) What are the basic European interests regarding international technology transfer? (2) What are the key differences in the interests of the significant European countries? (3) What does the sectoral distribution of Chinese investment tell us about China's intentions? (3) How is the transatlantic alliance affected by the recent twists and turns of the US foreign policy?

As for the paper's methodology, we must underline that the study seeks to deliver a comprehensive analysis of the geopolitical interests, while relying on existing theoretical papers, policy papers of the countries' governments and already existing data sets of Chinese investments.

Keywords*:* geopolitics, critical technologies, Germany, France, UK, China, US, Transatlantic Alliance

1. Introduction

The European Union's foreign direct investment screening regulation was adopted in 2018 and entered into force in April 2019. The regulation created a new coordination mechanism where the European Commission and the Member States can exchange their information and if necessary, raise concerns regarding specific investments. There is no doubt that the regulation and the national legal frameworks have the potential to significantly influence Chinese investment in the Single Market. The likelihood of substantial effects is growing when the direct investment targets tech-firms which are front runners in technology development.

At the same time, we should add that the EU implemented a liberal policy approach (compared to other OECD countries). when setting up the screening mechanism which is a platform for the EU countries to cooperate on. Since the implementation of the framework, significant comparative research has been conducted on the national regulations. This paper focuses on the long-term motivations of these countries, then it looks at the sectoral distribution of Chinese investments in the selected four European countries. As the first step, let us examine how Chinese firms and especially Chinese investments are perceived in the West.

2. The Perception of China's Technological Development and its Growing Economy: Literature Overview

When we go back a few years, the capability of the Chinese firms to innovate was generally evaluated as very low in the West, the widespread skepticism about the innovative nature of Chinese enterprises dominated the literature. Despite this fact, the Chinese outward investment soared significantly in the early 2000s and peaked in 2016, just a few years ago, and an assumption that the Chinese were unable to innovate was made in literature. Abrami, Kirby and MacFarlan (2019) explained it this way:

> *"Certainly, China has shown innovation through creative adaptation in recent decades, and it now has the capacity to do much more. But can China lead? Will the Chinese state have the wisdom to lighten up and the patience to allow the full emergence of what Schumpeter called the true spirit of entrepreneurship? On this we have our doubts. The problem, we think, is not the innovative or intellectual capacity of the Chinese people, which is boundless, but the political world in which their schools, universities, and businesses need to operate, which is very much bounded"* (Abrami – Kirkby – McFarlan, 2014).

As we can see, the authors establish an alleged link between the capacity of societies to use and innovate new technologies and the nature of their political institutions. In other words, in their opinion, the rapid technological development ultimately requires the introduction of the Westminster type democratic institutions,[1] though the amazing speed of the Chinese technological development contradicts this assumption. (At this point, it is worth underlining that the paper does not intend to specify and describe this technological development in detail, however, given the fear expressed in the American and in several European countries' foreign policies, we take it or granted.)

By referring to Mao's ideas on scientific and technological advancement, Gewirtz explains on the one side how deeply technology is embedded in the Chinese economic development strategy and, on the other side, he argues that there is a strong link between the technological strengths and geopolitical power:

> *"He [Mao] envisioned the socialist world's "overwhelming superiority" in science and technology and came to see technological strength as central to economic, ideological, and geopolitical power – the view of catch up and surpass that CCP leaders continue to hold today"* (Gewirtz, 2019).

He is certainly right about the existence of the link, however, causality matters, since in many interpretations, the underlying idea is that Chinese investments throughout the world are motivated by ideological reasons, and the acquisition of advanced technology (e.g. in Europe) serves the purpose of extending its geopolitical power and strengthening the ideological superiority of the Chinese model. These ideas can be only corroborated if we could prove that Chinese investments ignore the aspect of profitability. At the same time,

[1] This is a very old argument. Lipset (1959) was the first social scientist who connected economic success to democratic pluralism, thus provoking a debate which has never subsided since then. A modern version of this argument is attributed to Ferguson, who summarizes all these important elements of (West-European) success under six headings: competition, science, property rights, medicine, the consumer society and the work ethic (Ferguson, 2011, p. 12).

there is a flaw in the logic, too: only the technological strengths of a country can lead to growing geopolitical power, not the other way around.

In some cases, critical remarks contradict each other. Gewirtz points out the problems of the top-down, CCP-led technological innovation, while he also finds that China could swiftly move up in the value chain:

> *"But China has quickly moved up the value chain, creating world-class industries in everything from 5G and artificial intelligence to biotechnology and quantum computing. Some experts now believe that China could unseat the United States as the world's leading technological force. And many U.S. policymakers view that prospect as an existential threat to U.S. economic and military power"* (Ibid.).

Later, he says:

> *"Top-down, CCP-led technological innovation brings its share of challenges. Many observers correctly cite the risks of misguided government-steered investment, which has led to waste and massive oversupply, or the challenges of supporting small entrepreneurs and researchers without heavy-handed interference"* (Ibid.).

Not only do these ideas contradict each other, but each argument needs some substantial amendment:

(1) The criticized top-down technological innovation is not a novelty. The Asian development state model has the heavy intervention of the state at its core. Japan, South-Korea, and Singapore implemented a very similar approach and policies in this field.[2]

(2) The assumption that China's rise is a threat to the West, is flawed, since neither do the Chinese have relevant geopolitical interests in Europe, nor do the European countries in Asia. The development of trade and investment are the channels where they have common interests. In contrast to this picture, the US and China have significant conflict of interests in the Asian-Pacific region. In other words, the rise of China is much more a threat to the US, than to Europe. (Even in the American and Chinese case, the development of trade and investment would be a common interest, … at least in theory.)

To sum it up, it is rarely emphasized that European and American interests – despite being allies as NATO members – are not the same and can contradict each other in China's case. It must be added that this is the case not only due to geopolitical considerations, but also due to the different market positions of their firms. The fiercely debated case of Huawei has different dimensions in Europe. Goldman maintains that the European competitors simply don't have the necessary capacity in terms of research to compete with Huawei and the end products of Ericsson, Nokia, and Huawei are so intertwined that banning Huawei from the Single Market would affect European customers and put the development of the 5G technology on halt for a few years, causing significant damages to Europe (Goldman, 2019).

In general, it can be emphasized that Europe needs a more nuanced China-strategy than the US has developed recently and has tried to force European allies to follow. As Zhenglein and Holzmann put it:

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[2] The Chinese economic model is unique because of its size and the country's historical development. However, it does bear strong resemblance to the original developmental state model of the advanced Asian economies. The model can be efficiently utilized, when depicting the Chinese economy, and the resemblance is more striking when one considers how much the world economy has changed over decades. Therefore, in our understanding, the Chinese economy can be considered a special case of the developmental state in the 21st century. The differences between China and the three analyzed Asian economies would not be outstanding if one did not consider the freedom of maneuvering room for economy policy which comes from the size of the economy (Moldicz, 2018, pp. 81-106).

"Compared to a geographically distant Europe, China's immediate neighbors are already experienced in dealing with China. Europe can learn from this approach and their experiences. China's East Asian neighbors must manage a far more sophisticated set of challenges: they depend strongly on China economically and at the same time need to consider issues of national security. This is reflected, for instance, in a restrictive approach to investments from and research cooperation with China. Compared to Europe and the US, Chinese investment flows with East Asian countries are largely a one-way street. Taiwanese and Japanese investment in China is 26 and 35 times larger, respectively, than Chinese investment in both countries" (Zenglein – Holzman, 2019).

As we could see in this chapter, opinions and assessments of how Chinese investments impact the European markets are divergent, and no mainstream flow of ideas can be observed. Moreover, in some cases contradicting ideas are being entertained to emphasize the growing Chinese economic presence in Europe. Based on the literature overview and our assessment, we can formulate the following basic statements as to the nature of the growing activity of the Chinese firms:

1. European countries and China don't have basic conflicts of geopolitical nature. However, these kinds of tensions and problems are palpable in the American and Chinese relations.
2. It is argued sometimes that European NATO countries are allies of the US. This argument fails to recognize that the NATO was not only established for self-defense purposes and that it is restricted geographically. See article 6 of the NATO treaty! [3] In other words, any kind of American and Chinese dispute – especially the so-called trade war – does not require Europeans to side with the Americans.
3. At the same time, European countries and China have conflicts of economic nature, which can be more easily solved than geopolitical problems. Nowadays, it has become clear that Chinese firms have the capability to come up with genuine ideas, products and they also have the financial means to launch and sell them.
4. Technological development along with the interventionist economic development policy can put European firms under pressure, forcing them to adjust to the new conditions. At this point it must be added that an industry policy in the Single Market would be the right response to the Chinese challenge, though given the political conditions the launch of an industrial policy seems to be very unlikely.
5. Multinational companies have naturally developed by internationalizing and going abroad, as the Chinese firms have done in the recent years, the only difference being the strong state leadership in this process, however, this again is not new in Asia, since countries such as Japan, Korea, and Singapore used the same tactics in the 70s, 80s and 90s (see the literature on the Asian development states.) However, there are two differences in the recent process: (a) the magnitude of this internationalization stage, completely transforming the world economy, creating new challenges to both European and American firms, (b) the fact that this rapid change was triggered by a state-led economy perplexes the ideologically biased observers who do not question the efficacy of the existing Western model.

[3] "For the purpose of Article 5, an armed attack on one or more of the Parties is deemed to include an armed attack: on the territory of any of the Parties in Europe or North America, on the Algerian Departments of France on the territory of Turkey or on the Islands under the jurisdiction of any of the Parties in the North Atlantic area north of the Tropic of Cancer; on the forces, vessels, or aircraft of any of the Parties, when in or over these territories or any other area in Europe in which occupation forces of any of the Parties were stationed on the date when the Treaty entered into force or the Mediterranean Sea or the North Atlantic area north of the Tropic of Cancer" (The North Atlantic Treaty, Washington D.C. 4 April 1949).

3. Chinese Investments in the European Markets

Chinese investments peaked in 2016, since then significant decline characterized the market. The total value of Chinese investment transactions totaled to 17.3 billion Euro in 2018, which is less than half of the 2016 sum (37 billion) (Hanemann – Huotari – Kratz, 2019). In 2018, the bulk of Chinese investments flowed into the United Kingdom (4.2 billion Euro), Germany (2.1 billion euro) and France (1.6 billion Euro). As a result of these trends, we can single out four European countries where most of the Chinese FDI poured into. Between 2000 and 2018, the UK received 46.9 billion Euro. During the same period, Chinese firms invested 22.2 billion Euro in Germany, 15.3 billion Euro in Italy and 14.3 billion in France (see table 1).

Table 1.
Chinese investments in Europe between 2000 and 2018

Country	Billion Euro	Country	Billion Euro
United Kingdom	46.9	Poland	1.4
Germany	22.2	Denmark	1.2
Italy	15.3	Austria	1.0
France	14.3	Czech Republic	1.0
Netherlands	9.9	Romania	0.9
Finland	7.3	Malta	0.8
Sweden	6.1	Bulgaria	0.4
Portugal	6.0	Croatia	0.3
Spain	4.5	Slovenia	0.3
Ireland	3.0	Cyprus	0.2
Hungary	2.4	Estonia	0.1
Luxembourg	2.4	Latvia	0.1
Belgium	2.2	Lithuania	0.1

Source: Hanem – Huotari – Kratz, 2019.

The decline of Chinese investment in Europe has several explanations:

(1) Brexit. Since most of these investment transactions were related to the United Kingdom, Brexit and the ensuing uncertainty must have made the Chinese investors more cautious than before, and the question of how British firms will have access to the Single Market after Brexit left some investors doubtful.

(2) Trade war. The trade friction between the US and China dampened the mood in the world markets. Since success in the negotiations cannot be predicted due to the American president' negotiation strategy, the confidence in every sector seems to be weak. (In August 2019, he attacked the Chinese president as the "enemy" in a Twitter post, then just a few days later he called President Xi "the great leader".)

(3) German fears. The backbone of the Germany industry is the automotive industry, which is caught up in a transformation process, challenging the flagships of the German economy. Furthermore, we can also add that new technologies (digitization, internet of things, 5G communication etc.) are about to transform economies around the world, and the transformation process has winners and losers as well. The German economy built around the technologies of the later 20th century doesn't seem to be fit for the challenges which can be already observed in the newest data, which make Chinese investors uncertain while, at the same time, German politicians seem to be more worried about foreign acquisitions in Germany.

(4) The adoption of an FDI screening EU regulation. It is most likely that the German fear contributed to the proposal of the European Parliament in 2017, which suggested to draft an EU directive to strengthen the screening of the foreign direct investments of third world countries. The Regulation (EU) 2019/452 establishing the framework for the screening of foreign direct investments into the Union can be described as follows: (a) Until now, the EU did not have any regulation for this purpose, though other countries have frequently used this policy tool; (b) The regulation only sets up a cooperation mechanism, the real screening mechanism must be established at member state level, according to the country's need for economic development, thus decisions are kept at member state level, too; (c) The regulation does not apply to procurement transactions, and it can only be utilized based on security and public order concerns; (d) The cooperation mechanism will apply from October 2020 (European Commission, 2019a).

To this date, the following countries implemented a screening mechanism: Austria, Denmark, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Spain and the United Kingdom. As it can be seen, all four main FDI recipients – the UK, Germany, Italy and France – are among these countries, thus it can be assumed that the EU regulation is most likely to exert significant effects on Chinese investments.

The European Commission published a report on the foreign direct investment in the EU this year (European Commission, 2019b). In the report, the European Commission pointed out the increase of investment from China and Russia, along with the surge of state-owned enterprises' acquisitions in the EU. Though 80 percent of FDI still comes from the traditional main investors (the US, Japan, Canada, Australia, Norway and Switzerland), the report raises the alarm about the share of Chinese SOEs in the foreign direct capital flows:

> *"While state-owned companies represent only a small proportion of foreign acquisitions, their share in the number of acquisitions and their assets have grown rapidly over the latest years. Russia, China and the United Arab Emirates stand out in this respect with a total of 18 acquisitions in 2017, three times more than in 2007"* (Ibid, p. 2).

At the same time, the same report also acknowledges that just 3 percent of the assets in the EU were held by non-European investors in 2016, and the share of the US, Switzerland, Norway, Canada, Australia, Japan in foreign-assets was 80 percent!

It is difficult to assess how the European enterprises will be influenced by Chinese investments. Zenglein and Holzman try to summarize the effects as follows:

- *"The ability to offer more competitive prices for technology that might not be top-notch but that is good enough will put pressure on European companies in a broader set of industries, also in third markets.*
- *Companies have started to divert R&D to China, especially in emerging industries. Europe will feel the heat of this shift: Carmakers like BMW, VW and PSA have already opened up facilities for electric vehicle R&D in China.*
- *Fierce competition from Chinese companies might erode the profitability of European companies and limit their ability to fund R&D. This could slow innovation in Europe, allowing Chinese companies to close existing technological gaps at an even greater pace"* (Zenglein – Holzman, 2019, pp. 13-14).

This evaluation emphasizes the adverse economic effects, however, it also points out that they mainly derive from the weak competitiveness of European firms in certain economic factors.

Growing uncertainties (trade war, Brexit) might have been the main cause for the decline of the Chinese investments in the EU, which might have been exacerbated also by the media in recent years. At this point it is worth pointing out that the media voices and opinions were not necessarily considered by European decision makers, and the adopted EU cooperation mechanism to strengthen FDI screening won't be a significant barrier in the way of Chinese direct investment, although county-level restrictions can be. The basic question is how the main countries implement the screening tools. The next chapter focuses on how the UK, Germany, France and Italy evaluate these investments.

4. Member States Level Screening Mechanisms and Attitudes toward Chinese Investments

4. 1. The United Kingdom

In the United Kingdom, the Enterprise Act 2002 regulates the screening of foreign direct investments (Tauwhare, 2018). According to the act, the minister can intervene if necessary, based on national security, financial stability and media plurality concerns. At the same time, the intervention is only possible if the annual turnover is more than 70 million Pounds and/or the acquired enterprise has 25 percent or larger market share. The very liberal approach to foreign direct investment was changed when the UK government published its White Paper on this matter in 2018. The triggering point became the case of the Hinckley Nuclear power station, where the Chinese firm, the China General Nuclear Power Group became part of the funding. In this case, the Government voiced concerns that it did not have the legal power to screen the involvement of the Chinese firm on security grounds.(Bell, 2018a) For a while, Prime Minister Theresa May delayed the approval of the project, but since then green light has been given to the Chinese involvement.

In 2018, the Government introduced reforms allowing to scrutinize deals of a much smaller value (1 Million Pound). The proposals of the UK Government came from a Green Paper commissioned by the Department for Business, Energy & Industrial Strategy. The amendment of the Enterprise Act 2002 clarifies what the Government understands by the notion: relevant enterprises. These firms are those involved in "military or dual-use goods that are subject to export control; computer processing units; and quantum technology" (Bell, 2018b).

Despite the fact that the United Kingdom's has traditionally been one of the most liberal approaches as for foreign direct investment in the world, the public mood has changed over the course of the recent years. The same public mood led to the withdrawal of the United Kingdom from the European Union; the referendum held in 2016 reflected the rise of populism in the British politics. Since then, the political spectrum became more nuanced and complicated, because the traditionally main parties (the Labour Party, the Conservative and Unionist Party) lost support among the voters, while left-wing and right wing Euroskeptics became stronger. The Brexit referendum and the ensuing political chaos put the drafting and the implementation of every long-term political and economic strategy in the UK, including the China-strategy of the United Kingdom on hold.

The last visit to China paid by the British Prime Minister was Theresa May's trip in 2018, which followed Xi's UK visit in 2015, when the two countries launched their *"China-UK global comprehensive strategic partnership for the 21st century and the Golden Era of China-UK relations."* Though since then the *"Joint UK-China strategy for science, technology and innovation cooperation"* was launched, Theresa May did not endorse the Belt and Road Strategy formally, suggesting the country still has concerns about China's political objectives (Elgot, 2018).

Table 2.
Sectoral distribution of Chinese investment in the United Kingdom between 2005 and 2018

Sectors	$Million	Share (%)
Finance	17.940	21.2
Real estate	15.940	18.8
Logistics	13.790	16.3
Energy	9.440	11.2
Technology	6.480	7.7
Tourism	5.100	6.0
Agriculture	4.130	4.9
Entertainment	3.620	4.3
Transport	3.320	3.9
Health	1.950	2.3
Metals	1.790	2.1
Utilities	1.120	1.3

Source: own compilation based on American Enterprise Institute, The China Global Investment Tracker, 2019.

According to the Global Investment Tracker, Chinese firms invested around USD 86 Billion in the United Kingdom between 2005 and 2018, which makes Britain the top target country of Chinese investment in Europe. If looking at the distribution of these investments, it seems to be clear that the main motivation of Chinese investments is profit, since they heavily invest in strategically less important sectors, and technological orientation is far from mainstream.

At the same time, the traditionally strong sectors were targeted by Chinese firms – finance and real estate. The Chinese Investment Corporation (CIC) invested substantial funds into one British firm in logistics (Logicor), which is relevant in international trade. The involvement of Chinese firms in the energy sector is substantial, however, it must be added that these transactions rarely led to significant stocks in strategically important firms. (The 1 percent ownership in BP cost the Chinese firm, SAFE 2 Billion USD, which is almost half of the Chinese investment pouring into this sector.)

To sum it up, the investment climate does not seem to be favorable for Chinese investments now in the UK, though the legal framework is liberal, which doesn't create sectoral barriers to the inflow of foreign investment, in particular to technological investments. We must admit that at this point the end of Brexit cannot be predicted, and that is the reason why the way Britain leaves the EU might change the incentives for Chinese firms to invest in UK's technology firms substantially.

4.2. Germany

Between 2000 and 2018, Chinese firms invested around 22 Billion Euro in Germany. Though these investments are significant, they are not in comparison with the investments of Germany's main partners. According to Santander data, China cannot make it to the group of the top ten investors in Germany.

Like the UK, the German legal framework for foreign direct investment screening is liberal. Although the government can check any investment projects in sensitive sectors, however, this kind of validation is not typical.

The German government adopted a new version of the German Federal Act on Foreign Trade and Foreign Ordinance, which became effective in 2013. Based on the new legal framework, the Ministry of Economics and Technology can review and prohibit an investment if the buyer is not located in the EU. The Ministry can investigate the investment, if the acquisition of voting rights in the firm is at least 25 percent. It is very important to highlight that not only the direct but the indirect participation of at least 25 percent of the voting rights can be screened and prohibited by the Ministry. Moreover, this same law can be applied if the foreign buyer already owns a firm with at least 25 percent participation located in Germany and this firm acquires a third company in Germany.

However, making foreign participation the only criterion is not enough to apply this law. The transaction must involve the aspect of the endangerment of the public order or security as well. According to the law,

> *"the transaction must either affect material legal interests such as the existence, function and supply of the German population, or substantive issues regarding national and international security, in particular the operation of the German economy, German institutions, important public services and the survival of the German population"* (Engelstaedter – Gernoth, 2014).

As we can see, technology related issues are not mentioned in this description, although the sentence allows for a flexible interpretation.

Table 3.
Sectoral distribution of Chinese investment in Germany between 2005 and 2018

Sectors	$Million	Share (%)
Transport	17020	40.4
Real Estate	6460	15.3
Technology	6010	14.3
Finance	3710	8.8
Energy	3640	8.6
Other	2410	5.7
Health	1260	3.0
Metals	680	1.6
Logistics	440	1.0
Utilities	220	0.5
Transport	130	0.3
Entertainment	110	0.3

Source: own compilation based on American Enterprise Institute, The China Global Investment Tracker, 2019.

The review process must start within a three-months period after closing the deal. After receiving the necessary information and documents from the foreign buyer, the Ministry has maximum two months to conclude the screening process. On the one hand, the buyer is not obliged to inform the Ministry about the deal but on the other hand, it can request a clearance certificate from the Ministry that the transaction does not present any threat to public order or security. After receiving the certificate or the two-month investigation period, the transaction cannot be banned by the Ministry.

Taking a look at the data, we find that the pattern of Chinese investments in Germany is very different from the British one, where finance, logistics and energy sectors dominated the landscape. In Germany, Chinese firms mainly invested in the transport sector which practically means investment in the technology-intensive automotive firms (see table 3). More than the half of the 17 Billion USD was concentrated on the 10 percent share acquisition in Daimler (USD 9 Billion). A similar concentration is to be observed in the technology sector, where 77 percent of the funds spent in this sector was used to purchase the KUKA firm, specialized on industrial robots.

This later acquisition of the Chinese firm, Guangdong Midea was the acquisition that attracted media attention and became fiercely discussed in Germany. Ewing summarizes the story this way:

> *"In Germany, the takeover of Kuka – frequently cited by politicians as emblematic of the country's future economic development – has drawn particular attention. The economics ministry examined the takeover of the company by Midea Group in China, which already owns 95 percent of Kuka shares, but eventually decided the deal did not meet the strict criteria for a formal review"* (Ewing, 2016).

The concentration of Chinese investments on two key economic sectors in Germany (automotive and technology) is one of the main concerns of German politicians, however, there are two arguments to add to this picture:

- Germany's performance is excellent in traditional technologies, however, the country lags behind countries that are front-runners in digitalization, technologies related to big data, internet of things, etc. That is probably why Chinese investment disturbs the German industry so much.
- Ironically, what happens to the German industry now (new foreign capital, technology infusion, and firms entering the German market), is very similar to what took place in Eastern Europe two decades ago, when German firms were the foreign buyers. Eastern European countries benefited from this process, and the same could happen to the German economy as well.

Basically, we can argue that the German perception of China's role in the foreign policy is multi-layered, since they perceive China as a key partner in trade. Indeed, China is being assessed as the key target country of German direct investments and yet, Germany is reluctant to recognize the role Chinese firms could play in the German economy. At the same time, we must point out that the frequency of how often the German chancellor visits China clearly shows that the German political elite is aware of China's economic relevance to the German industry, too. To the external observer, the obvious solution seems to be strengthening the trust between the two partners and then building business upon the mutual understanding of each other's point of view and interests. In our understanding, Italy tries to implement a similar approach to China and its technology firms in Europe.

4.3. Italy

Italy is the only country in this group which joined the Belt and Road Initiative. The memorandums of understanding signed by the partners in April 2019 were wide-ranging, covering the banking sector, logistics (ports), agriculture and construction. We may ask the question why Italy's approach differs so much from that of other European countries. There are four basic answers to this question:

- Italy's economy has not improved too much since the Global Financial Crisis hit the country. The permanent government crisis coupled with high public debt not to mention that the traditional North-South divide and the problems of the banking system makes Italy extremely vulnerable and can make the country the center of a European crisis. Thus, similar to the Eastern European countries, the country – needs capital import and new technologies.

- Since the Italian economy specializes less on the development of cutting-edge technologies, Italian firms in general are no front-runners in this area. Therefore, fears of Chinese firms 'stealing' Italian technology are not widespread among Italian decision-makers.
- In contrast to Germany, the United Kingdom and France, Italy traditionally has been recipient of FDI, thus the public opinion and the decision-makers are more willing to accept and recognize the need for capital import.
- Italian politicians recognized that while in South Europe there is need for economic incentives, the maneuvering room is minimal, and in North Europe there is still maneuvering room for economic stimulus. However, the economic policy doesn't want to use this tool. In other words, they can't expect the rescue to come from the North, since it seems that, in line with the German economic policy, North European countries don't want to expand their aggregate demand. Thus, Italy must look for other markets. This need was pointed out by Luigi di Maio, Italy's minister for economic development, who, after signing, said that Italy's goal was "rebalance an imbalance" in trade (EuroasiaTimes, 2019).

Though the Italian stance on foreign direct investment is more liberal than the German, the Italian government adopted the so-called Decree-Law Number 22 that significantly extended the power of the government, thus the lax (entered into force on 25 March 2019) declares 5G technology strategic. It requires an ex-ante notification of any contract/agreement related to design, construction, maintenance, management of the 5G network, if foreign entities (outside the European Union) are involved. The government can either prohibit the transaction or require certain conditions from the involved parties (Giarda, 2019).

The general FDI screening mechanism is provided by the Decree Law No. 21 of 15 March 2012 in Italy. Scassellati-Sforzolini and Loice maintain that after the six years of application, the law did not deter foreign firms from investing in Italy. As a rule, the following sectors are considered strategic: defense and national security, energy, transport, communications or high-tech are subject to a prior review procedure, mentioned above (Scassellati-Sforzolini – Ioice, 2018).

According to Hanem et al. Chinese firms invested 15.3 Billion Euro between 2000 and 2018, thus Italy ranks the third in the European Union. According to Chinese investment data between 2005 and 2018, published by The Global Investment Tracker, Italy's ranking is slightly worse, considering that it ranks the fourth. Based on this data set, we can also see the sectoral distribution that might give us a clue about the motivations [4] of Chinese investments in Italy (see Table 4).

[4] Le Corre-Sepulchre define the following basic motivations of Chinese firms to invest in Europe: (1) They argue that Europe is less politicized than the US; (2) Europe needs Chinese capital more than the US. As for their investment strategies, they point out the following version: (1) the desire to go from cheap products to more sophisticated goods and services; (2) the desire to diversify "out of the low-margin Chinese market into higher-margin foreign ones"; (3) the goal to acquire technology to strengthen their domestic and international position; (4) the goal to serve Chinese customers better in Europe, typical in the hospitality industry; (5) the intention of big state-owned enterprises (national champions) to expand internationally and take positions of global market leadership (Le Corre – Sepulchre, 2016).

Table 4.
Sectoral distribution of Chinese investment in Italy between 2005 and 2018

Sector	$Million	Share (%)
Transport	8600	35.0
Energy	6480	26.4
Technology	4040	16.4
Finance	2810	11.4
Entertainment	840	3.4
Others	790	3.2
Health	720	2.9
Logistics	200	0.8
Real Estate	87	0.4

Source: own compilation based on American Enterprise Institute, The China Global Investment Tracker, 2019.

In contrast to Germany and the United Kingdom, the real estate and logistics sectors are under-represented in the statistics, which is most likely to change after signing up to the Belt and Road Initiative. The bulk of the transport sector investment (USD 8.6 Billion) comes from one investment transaction (Pirelli – USD 7.8 Billion). In the technology sector, again one Huawei investment dominates the picture, but in this case the acquisition of Vimpeo stocks did not lead to significant Huawei ownership share in the company. The second most import target sector of Chinese investors has been the energy sector between 2005 and 2018, where the biggest investment was carried out by the Chinese State Grid and SAFE (both transactions' value was 2.7 Billion USD).

In Italy's case, it is more difficult to discern patterns or trends in Chinese direct investment. We assume that logistics and real estate will be more likely included in the data, since the first sector is important due the country's geographical location, and the second can be more important, since, being a top tourist destination, the country can easily attract real estate investors. At the same time, it is highly unlikely that technology segment will ever be as strongly targeted as in the German case.

4.4. France

France has been a case of tightening rules of FDI screening in recent years, however, this is the only country where the new measures do not necessarily have an anti-Chinese tone, as they also react to American acquisitions in the same manner.

The first law empowering the French government to adopt and implement specific regulations regarding foreign direct investment, was the 1996 French law on foreign exchange. This act was amended, and the Law No. 2004-1343 was adopted in December 2004. This version of FDI screening allowed for policing FDI in certain business sectors. The latest evolution in the legal framework was the Decree No. 2014-479, extending the authorization of the government. At the same time, we must point out that this tightening was most likely not the last step in this direction.

The French government discussed a business bill in autumn 2018 that proposed to widen the scope for government and increased the usage of the so-called 'golden shares' [5]. According to the proposal, those firms not seeking ante-ex approval in strategic sectors could be fined as high as 10 percent of the company's annual revenue.

[5] Golden share is share held by the government which can outvote all other shares under certain circumstances.

Ultimately, the government adopted the decree No. 2018-1057 on 29 November 2018, and once again the scope of FDI screening was widened to include the next sectors:

- space operations;
- cybersecurity;
- artificial intelligence;
- robotics;
- semiconductors and additive manufacturing;
- data hosting;
- systems utilized for capturing computer data or intercepting correspondence;
- IT systems for public authorities in the field of national security;
- information systems utilized in crucial industries;
- research and development of dual-use goods and technologies (UNCTAD, 2018).

As this specialization shows, the decree specifically targets technology-intensive sectors. When it comes to the public mood for foreign direct investments, it must be clear that the trend of tighter FDI screening rules is part of the bigger picture, and the result of a different economic policy in France. The French President, often praised as a globalist, clearly wants to strengthen the EU and represent Europe with one voice. This was his attitude regarding the Belt and Road Initiative, too. He argued that the EU should implement a coordinated approach and negotiate with China about the terms of BRI. At the same time, when the Chinese President visited France in 2019, he signed a 30 billion Euro deal with China about the sale of Airbuses.[6] This sharp contradiction between rhetoric and action was pointed out by Koenig:

> *"Yet, surprise-surprise! On President Xi's next stop, Paris, coming from Italy, Macron rolled out the red carpet for the Chinese President and, according to RT, went on to sign billions worth of new contracts with the Asian leader. If this looked like a Macron U-turn, it was a Macron U-turn"* (Koenig, 2019).

As we argued in the abstract, we analyze these processes at country-level, since attempts to implement coordinated approach in issues where country interests are different tend to fail. Economic benefits of the cooperation with China matter in the long run, however, countries such as France and Germany have more to lose in this process than Italy, which is much more reliant on external financing, or the United Kingdom, whose economic competitiveness is strongly dependent on the outcome of the Brexit story.

Table 5.

Sectoral distribution of Chinese investment in France between 2005 and 2018

Sector	$Million	Share (%)
Energy	6600	25.7
Tourism	6540	25.4
Technology 3370	3370	13.1
Transport	2540	9.9
Other	2400	9.3
Agriculture	1650	6.4
Real Estate	1150	4.5
Chemicals	700	2.7
Entertainment	570	2.2
Health	190	0.7

Source: own compilation based on American Enterprise Institute, The China Global Investment Tracker, 2019.

[6] 290 planes from A320 Family aircraft and 10 planes from A350 XWB Family aircraft.

Looking at the sectoral distribution of Chinese investments, energy and tourism sectors stand out as the main targeted industries. In tourism, the Accor and Auchan deals constituted 54 percent of the transaction value in this sector, and in the energy sector only 2 transactions meant 90 percent of the aggregate value. (See table 5!) In France, like Germany and Italy, investments are rather concentrated, and they target sectors in which the country is traditionally strong, and that probably is why we cannot say that Chinese FDI would focus on technology-intensive sectors.

5. Conclusions

As we could see in these analyses, the top three European destinations of Chinese FDI strongly differ in their interests. Though the stance on Chinese FDI and the legal framework has been toughened in the UK in recent years, the uncertainty caused by Brexit will sooner or later require a more sophisticated approach from the British, even though the pressure of the American foreign policy would give different incentive to British decision makers. In the case of the United Kingdom, we cannot see why and how investment would be more difficult for Chinese tech firms than any other types of firms, however, given the traditionally strong link between the US and the UK, it would not be surprising if the US exerted a strong influence on British decision-makers. What might be advisable is to show gestures to the British in the period after Brexit, creating more trade opportunities with China and changing the British approach to Chinese investments.

Germany provides the Chinese investors with the toughest legal framework, and Chinese investments face the greatest challenges here, though we must also point out that the strategic benefits of the investment can be the biggest here, since the acquired companies in the transport and technology sector are front-runners and highly competitive in the international market. The fact that the German chancellor maintains regular contact with Chinese decision-makers is positive, and it shows the practical attitude of German politics. However, as mentioned above, the benefits of this cooperation will become evident for the German leadership when trade becomes more balanced between the two countries.

In France, the picture is very similar with regard to the economic effects of Chinese investments, though the political approach is very different. The confrontative style of the French president creates a hostile environment, and at the same time, the rhetoric underlining European values, a concerted European approach towards Chinese stands in sharp contrast with actions, showing which negotiating strategy should be pursued by the Chinese. The French case is the only one out of the four analyzed countries, where hostility is directed against foreign investors in general, since the anti-American tone is equally as typical in these debates as the anti-Chinese investment comments.

Table 6.
Characteristics of Chinese FDI and the legal framework

	FDI screening adopted?	FDI screening's legal framework changes recently? When?	Any discernible pattern of Chinese investment?	The two main targeted sectors	Aggregate share of the targeted sectors within the Chinese direct investment	The aggregate value of Chinese investments in the countries between 2005 and 2018 (Billion USD) *
France	Yes	Yes, 2018	Yes	Energy, tourism	51.1 %	25.77
Germany	Yes	No, 2013	Yes	Transport, real estate	55.7%	42.09
Italy	Yes	Yes, 2019	No	Energy, transport	61.4 %	25.35
United Kingdom	Yes	Yes, 2018	No	Finance, real estate	40.0%	87.45

Source: own compilation based on American Enterprise Institute, The China Global Investment Tracker, 2019.

In need of more capital and better technology, Italy is apparently the country that could benefit most from the cooperation with China under the BRI framework. This is the country where the concentration of Chinese FDI is the highest regarding sectors, and maybe the one where Chinese capital is needed the most. At the same time, that is the only legal framework in the four countries, where special attention is paid to 5G frameworks.

Legal frameworks across the analyzed countries have been changing from a more liberal approach to a more sophisticated one, which can be considered more suitable for their economic development goals and national interests. However, one must ask if the strategic decisions are made without an ideological bias and with reference to national interests. Because on the other side, less globalization would affect global growth in the medium and long term, and thus not improving economic ties with China would be a strategic failure, since these countries don't have profound geopolitical conflicts. Pieke argues that:

> *"Europe needs to disentangle itself from this spiral of aggression driven by binary, winner-takes-all perspectives. As it does not aspire to be a superpower, Europe can deal with Beijing with more nuance than the US – China is indeed a threat in some areas but remains a positive force in others. This is not an economic or a military challenge – it is a political one. How does Europe decide what to share and withhold? It needs to answer that question – not isolate China"* (Pieke, 2019).

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INDUSTRY 4.0 TECHNOLOGICAL SOLUTIONS AND THEIR EDUCATION CONCEPT IN THE BOSCH SMART SHOP FLOOR LABORATORY

László Budai

Abstract

The development of the Smart Shop Floor logistics simulation laboratory started as a flagship of collaboration between the Budapest Business School and the Robert Bosch GmbH, in 2018. The assumption is that the students and those interested in the laboratory can carry out and conduct impact assessments through exact industrial study cases as far as the complete procedure is concerned. After about a year and a half of development, the laboratory is ready to fulfil its function: to enhance students' knowledge and competences in a "traditional" education environment.

As a teacher, our main duty is to teach today's students to think and to prepare them for future jobs. At present, we can only hope to guess the challenges of tomorrow which will appear as a consequence of the present high-level digitization, robotization, and automatization. Thus, in this fast-changing world, the teachers of today have to prepare the students at high level under increasingly difficult circumstances. What is already certain in our present situation is that students need to be able to think, solve problems as effectively as possible and polish their digital abilities to a very high level, if they want to be successful.

Keywords: i4.0, digitalization, digital transformation, BOSCH, AR, laboratorial education

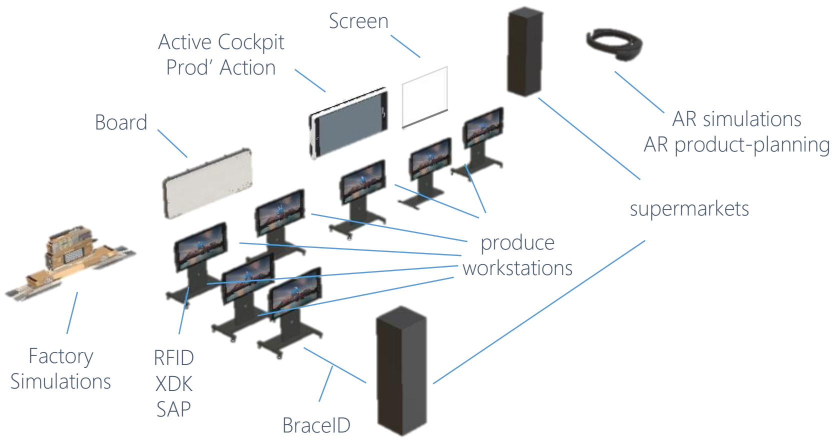
1. Introduction

According to research (Brusilovsky, 2001), as a result of robotization and automatization, 75 million jobs will be lost within 5 – 10 years, and 133 million new ones will emerge. The question is what type these jobs will be. We usually entertain the preconception that robotics and artificial intelligence will not only affect the factory workers but, according to the research of WEF, financial analysts, bookkeepers, auditors, bank officers, statistical analysts, insurance agents, administrators and assistants are to face the same risk. It is true that the assemblers and the drivers are in the most endangered category. Those workers will be needed mostly who are able to develop these systems, take part in the automatization of the processes or work in fields where machines are of no use, for example the improvement of the users' experience.

As a consequence, the knowledge of the industry 4.0 technologies will be indispensable for the employees of the future. They can learn it either in a sharp environment which is not always possible, but the second-best solution can be working under laboratory circumstances. Thus, for example, in the robotics laboratory one can find the smaller version of the same industrial robot that works in the sharp environment with the same programming and operation, user environment, so, if they acquire the relevant knowledge in the laboratory they will find a way around in the industrial sharp environment. At the same time, if students do not receive the suitable level of education in connection with the digital revolution of today, they will start with a huge disadvantage on the labor market (too).

On this basis, we consider the education under laboratory circumstances very effective. In what follows, I introduce the units of the laboratory, which simulate the production processes first of all, both from the professional and the education methodological points of view, and we also present some experience, opinion on the basis of the pilot educations.
Figure 1 shows the spatial and methodological division of the laboratory:

Figure 1:
A Smart Shop Floor setup of the laboratory



Source: own illustration

2. Screen

Students can learn the theoretical material of the laboratory with the flipped classroom method, which means that the students prepare from the theoretical knowledge in advance what is needed for the laboratory and they can go and see the practical aspects of all these too, making the use of the practice-oriented opportunities more effective.

The theoretical connection of the given device/method is continuously displayed on the screen which the students have checked with the above- mentioned method, thus, making the integration of their theoretical and practical knowledge more effective. Besides, they strengthen the flipped classroom method this way, too.

3. I4.0 Factory Simulation

Entering the room, we can see the whole factory simulation 4.0 of the Fischer Fabrik to the left of the door which can help those very much who have not yet been in a factory.

Factory simulation from fischertechnik is a training model, consisting of fischertechnik modules, which simulate a small factory. This consists of several individual models, such as the "automated high-bay warehouse", a "multi-processing station with oven", a "vacuum gripper robot" and a "sorting line with detection". By linking several stations, the processes can illustrate a produce line.

The model has four 24 Volt printed circuit boards and can be controlled via any conventional PLC. This way you can create a completely unique program and with the aid of the assignment plan directly control the inputs and outputs. However, the individual programs must be matched to each other, so that it does not lead to a collision.

The process of the following sequence is provided through the structure of the model. The vacuum gripper robot loads the rack feeder of the automated high-bay warehouse with workpieces. This stores the workpieces in the high-bay warehouse, sorted according to color. Finally, the workpieces are taken out of storage again, brought to the multi-processing station and machined there. After this the machined workpieces are sorted in the sorting line according to color and conveyed into storage locations. From there the workpieces are picked up again by the vacuum gripper robot and transported back to the high-bay warehouse.

After you have unpacked the "Factory Simulation" and removed the transport locks, perform a visual inspection to see whether any components have come loose or been damaged during transport. If necessary, put the loose components back in the correct place. Compare your model with the comparison pictures of the "Factory simulation", which is stored on the eLearning portal. Check whether all cables and hoses are connected. Using the assignment plan, the unconnected cable can be connected correctly.

3.1. Vacuum Gripper Robot (VSG)

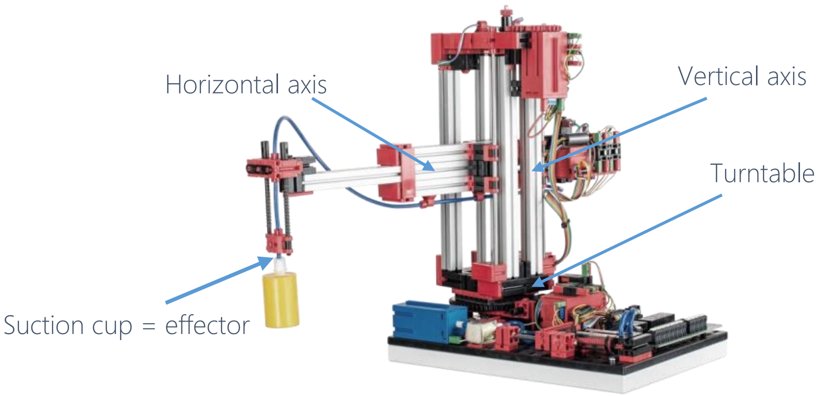
What are robots?

The Society of German Engineers (VDI) defines industrial robots in VDI guideline 2860 as follows:

“Industrial robots are universal handling systems with several axes whose motions with respect to movement sequence and paths or angles are freely programmable (i.e. with no mechanical or human intervention) or sensor guided. They can be equipped with grippers, tools or other means of production and can perform handling and/or production tasks.”

The 3D vacuum gripper robot is therefore an industrial robot that can be used for handling tasks. A workpiece can be picked up with the help of the vacuum gripper robot and moved within a workspace. This workspace is the result of the kinematic arrangement of the robot, and it defines the area that can be reached by the robot's effector. In the case of the vacuum gripper robot, the suction cup of the effector and the workspace correspond to a hollow cylinder whose vertical axis coincides with the robot's axis of rotation.

Figure 2:
Kinematic arrangement of the 3D vacuum gripper robot



Source: Fisher Technik

The geometry of the workspace is the result of the kinematic setup shown in Figure 2 and comprises one rotary axis and two linear axes.

The typical job for this type of robot can be broken down into the following work steps:

- Positioning the vacuum gripper at the workpiece location;
- Picking up the workpiece;
- Transporting the workpiece within the workspace;
- Setting down the workpiece.

Positioning the vacuum gripper or transporting the workpiece can be defined as a point-to-point motion or as a continuous path. The individual axes can be controlled sequentially and/or parallelly. This is significantly influenced by the obstacles or predefined intermediate stations present in the workspace.

It is practical first to integrate a reference run in the program in order to establish the absolute position or the absolute angle. To do this, the three axes of the robot are moved to their reference positions and then their positions or angles are set to zero. Now the position of the workpiece can be approached, and the workpiece picked up.

The following steps can now be carried out sequentially:

- The gripper robot moves to the alternate position;
- Set the workpiece down;
- The gripper robot pauses at this position;
- Pick up the workpiece again.

For the position control the pulse count of the encoder and the direction of rotation of the motor is combined and, since this is a monotonous movement, can thus approach positions or angles precisely. During this movement the three axes can be controlled parallelly, as long as there is no obstacle present in the workspace.

For this purpose, the following measurement and set point values are required:

- Target position or target angle;
- Actual position or actual angle;
- State of reference switch;
- Motor direction of rotation;
- Measured encoder pulse.

During the suction process of a workpiece the suction cup must first be lowered, in order to create an airtight connection between the workpiece and the suction cup. Then a vacuum must be created in order to temporarily fasten the workpiece on the suction cup. Now the suction cup can be lifted with the workpiece. The function for setting down the workpiece can also be divided into three sections. First, the suction cup is lowered, then the air is removed from the cylinder, eliminating the vacuum, and finally, the suction cup is raised again.

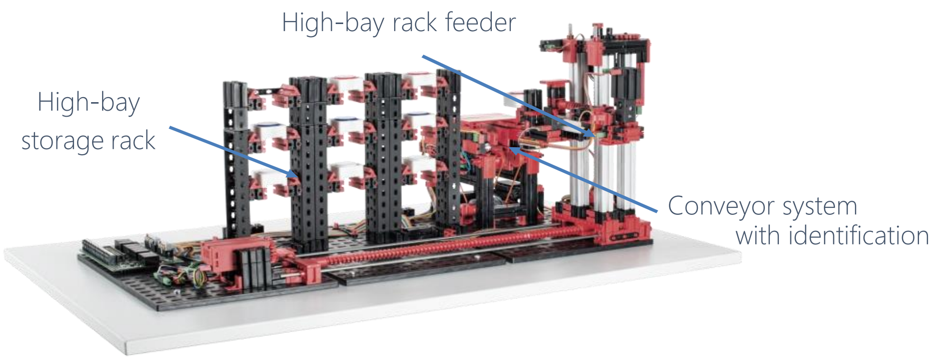
3.2. Automated High-Bay Warehouse (HRL)

What is a high-bay warehouse?

A high-bay warehouse is a space-saving storage area for storing and retrieving goods. In most cases high-bay warehouses are designed as pallet rack storage systems. This standardization provides for a high level of automation and connection to an ERP (Enterprise Resource Planning) system. High-bay warehouses are characterized by superior space utilization and high initial capital costs.

Storing and retrieving goods is handled by rack feeders that move in a lane between two rows of racks. This area is part of the receiving station, where the identification of goods also takes place. Using conveyor systems, such as chain, roller or vertical conveyors, the goods arrive and are transferred to the rack feeders. If the rack feeders are automated, no one is allowed to enter this area. In the case of the automated high-bay warehouse, the goods are transported on a conveyor belt. The goods are identified by a barcode.

Figure 3:
High-bay warehouse areas



Source: Fisher Technik

Goods are frequently stored based on the dynamic warehousing principle. There is no fixed arrangement between storage position and goods, so the goods to be stored are placed in any free spot. This ensures path efficiency. The warehouse management system saves the position of the stored goods, making them available. A (partly) automated identification of goods, which is usually done using FRID chips or barcodes at a central location called the identification site, and standardization of storage areas (same external dimensions, same permitted unit weights) are indispensable.

The ABC strategy, in which the warehouse is divided into three zones at varying distances from the storage/retrieval area, is used to further streamline the pathways. Frequently required goods are placed in the A zone, which is directly next to the storage/retrieval area. Correspondingly, rarely needed goods are stored in the C zone, which is far away from the storage/retrieval area.

With the automated high-bay warehouse you can demonstrate both the dynamic and the static storage. In the case of static warehousing, for instance, each row is assigned a color. For instance, the top row is assigned the color white, the middle row is assigned red and the bottom row is assigned blue. The individual colored rows are filled from the position closest to the pre-loading zone to the position farthest away from the pre-loading zone.

Regardless of whether you want to use the static or dynamic warehousing, it is practical first to integrate a reference run of the high-bay rack feeder. To do this move the vertical and horizontal axes to their reference positions and then set their positions to zero.

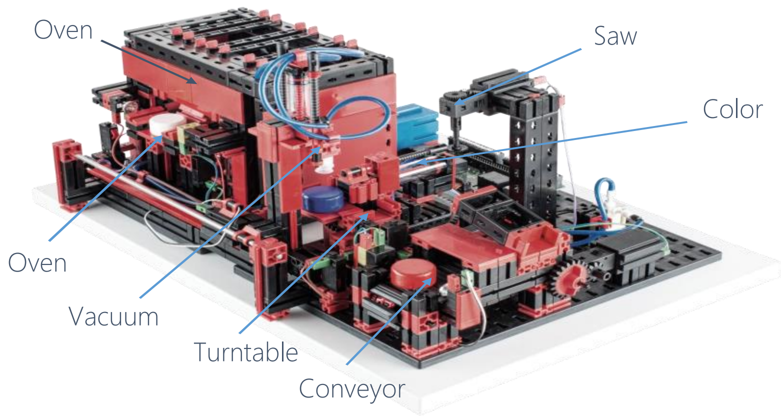
For the factory simulation the static warehouses are suitable, since the workpiece carrier is already in the high-bay warehouse and the workpieces are sorted from the sorting line. If the rack management is now designed so that the high-bay warehouse is filled in sequence, the workpieces are automatically stored sorted by color, since the VSG picks up the sorted workpieces from the storage locations of the sorting line. Thus, the white workpieces are stored in the top row, the red workpieces in the center row and the blue workpieces in the bottom row. For this no signals of the track sensor are required, which simplifies the program.

While the vacuum gripper robot transports a workpiece from the storage locations to the HRL, the rack feeder simultaneously picks up an empty workpiece carrier from the high-bay warehouse and places on the conveyor belt of the "conveyor system with identification". The conveyor belt should now transport the workpiece carriers to the other end of the conveyor belt. When the VSG has placed the workpiece in the workpiece carrier, the workpiece carrier including the workpiece should be conveyed by the track sensor and placed on the extension of the rack feeder. Then the rack feeder stores the workpiece on the corresponding storage location. To remove from storage the rack feeder removes the loaded workpiece carriers and transports them to the conveyor system with identification. From there the vacuum gripper robot can remove the workpiece again.

3.3. Multi-Processing Station with Oven

In the case of the multi-processing station with oven, the workpiece automatically runs through several stations that simulate different processes. These processes use different conveyor systems, such as a conveyor belt, a turntable and a vacuum gripper robot. Processing begins with the oven. The processing starts as soon as the vacuum gripper robot places the workpiece on the oven feeder. The light barrier is interrupted when this happens, thus opening the oven door and drawing in the oven feeder. At the same time, the vacuum gripper is called, which brings the workpiece to the turntable after the firing process. Following the firing process, the door of the oven should be opened again, and the oven feeder move outward again. The already positioned gripper robot should pick up the workpiece as with the VSG, transport it to the turntable and set it down there. Provisions are made that the turntable positions the workpiece under the saw, waits there for the duration of processing and then moves to the position on the conveyor belt. There the pneumatic actuated ejector pushes the workpiece onto the conveyor belt, which conveys the workpiece to a light barrier and then transfers it to the sorting line with detection. Crossing the light barrier should cause the turntable to return to its starting position and the conveyor belt to come to a delayed stop.

Figure 4:
Areas of the multi processing station with oven



Source: Fisher Technik

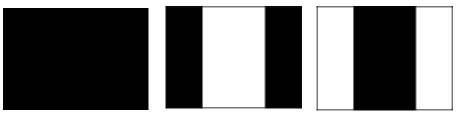
The program sequence can be controlled due to the many inputs and outputs present. Therefore, it is practical here to divide the program into three units: oven, vacuum gripper robot and turntable. The particular processes should communicate with each other and thereby ensure that no collisions occur.

However, if a dynamic warehousing is desired, the signal of the track sensor must be implemented. In addition, the barcodes shown in Figure 8 must be placed on the workpiece carriers, so that they can be differentiated on the basis of the three colors (white, red and blue).

The workpiece is identified by the automated high-bay warehouse using a simple barcode. The workpiece carriers have a code on them, which is assigned the color white, red or blue. This code is analyzed by a trail sensor. Here the track sensor registered light/dark differences and now these must be assigned a color.

The time interval is limited through the two light barriers before and after the identification unit. Since undesirable reflections can occur on the edges of the workpiece carriers, these must be dismissed in order to avoid false interpretations. This can be dealt with if the width of the light areas (reflective points) or the number of sequential time increments are interpreted as light. So then, for example, the light areas which include more than five sequential time steps can be evaluated as marking, and those which have less than five sequential time steps as reflection. Thus, the defined minimum width limits the number of patterns to be distinguished which can be used to identify the workpiece, but it is sufficient for coding the three colors.

Figure 5:
Color codes



Source: Fisher Technik

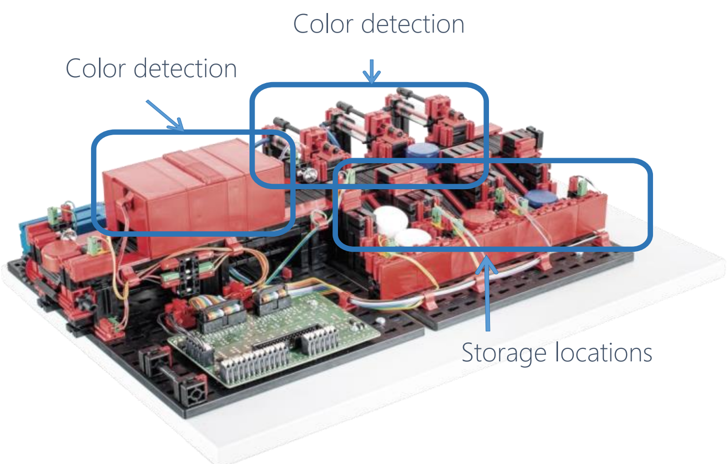
Figure 5 shows the assignment between the codes used and the respective colors. These marks are applied to the workpiece carrier side facing the trail sensor, thus allowing assignment of a workpiece carrier to a colored workpiece.

In the factory simulation the vacuum gripper robot (VSG) is the interface to the other models. Here the vacuum gripper robot is to pick up the workpieces from the storage locations of the sorting line with detection and transport them to the "Conveyor system with identification" of the automated high-bay warehouse (HRL). The VSG should first pick up the workpieces from the first storage location (white), until the light barrier located there indicates that there is no more workpiece in the storage location. After this the other workpieces should be picked up in the same manner. It should now place the workpieces in the ready standing workpiece carrier on the conveyor system with identification. If all 9 workpieces (3 white, 3 red, 3 blue) are stored in the high-bay warehouse, they should be taken out of storage sequentially and brought to the multi-processing station. For this the VSG should remove the workpieces from the standing ready workpiece carries, transported to the "oven" of the multi-processing station and there placed on the extended oven slider. After the workpieces in the sorting line have been sorted according to color, the vacuum gripper robot should transport these back to the high-bay warehouse.

3.4. Sorting Line with Detection

The sorting line with detection is used for the automated separation of differently colored building blocks. In this process, a conveyor belt conveys geometrically identical, yet differently colored components to a color sensor, where they are separated according to their color. The conveyor belt is powered by an S motor and the transport route is measured with the help of a pulse switch. The ejection of workpieces is handled by pneumatic cylinders, which are assigned to the appropriate storage locations and are actuated by solenoid valves. Several light barriers control the flow of the workpieces and whether the workpieces are in the storage locations.

Figure 6:
Areas of the sorting line with detection



Source: Fisher Technik

During this process, color detection is handled by an optical color sensor, which emits a red light and can detect their color based on a surface reflection. Technically speaking, the color sensor is therefore a reflective sensor which indicates how well a surface reflects light. The sensor's measured value is therefore not proportional to the wavelength of the measured color and even the assignment of color coordinates or color spaces (e.g. RGB or CMYK) is not possible. In addition to the object's color, ambient light, the surface of the object and the distance of the object from the sensor influence the quality of the reflection. For this reason, it is imperative that the color sensor is protected from ambient light and the surface of the objects are similar. In addition, it is important that the sensor is installed perpendicularly to the object's surface. Threshold values that limit the measured values of individual colors differentiate between the colored workpieces. Since the value ranges of different color sensors differ, these limit values must absolutely be determined.

The process should be started, and the conveyor belt switched on as soon as a workpiece is transferred from the processing station to the conveyor belt of the sorting line and in the process interrupts the light barrier. For the color detection the workpiece runs through a darkened sluice, in which a color sensor is installed. During this time interval the color should be measured, and the workpiece assigned. Meanwhile, the measured value should be compared with two limit values to assign the workpiece the color white, red or blue. While the first limit value (for example "limit1") can be used to distinguish between white and red, the second limit value (for example "limit2") can be used to distinguish between red and blue. These limit values must be determined with the aid of tests. Ejection can be controlled with the help of the light barrier located before the first ejector. Depending on the color value detected, the corresponding pneumatic cylinder can be triggered with a delay after the light barrier is halted by the workpiece. This is where the pulse switch comes in, which senses the rotation of the gear wheel driving the conveyor belt. Unlike a time-dependent delay, this approach can withstand disruptions in the conveyor belt speed. The ejected workpieces are fed through three chutes to the particular storage locations. Simultaneously, the storage location, which is found closest to the detection is assigned the color white, the center the color red and the furthest away the color blue. The storage locations are equipped with light barriers that detect whether the storage location is filled or not. However, the light barriers cannot tell how many workpieces are in the storage location.

From this storage location the vacuum gripper robot can now pick up the workpiece once more and transport it to the high-bay warehouse to store it there again.

The Logistics Laboratory enables the simulation programming of the Fischer factory too. The PLC-s are intelligent industrial controlling systems which make sure that the same device (hardware) fulfils several controlling duties according to the uploaded program. This is a very important aspect, if we think of the fact that the present market requires that a product or a technology producing a product should be flexible, meeting the customers' demands. This means that, if the production technology of a product must be changed, one does not have to buy a new controller by all means, but it is enough to reprogram the already existing one according to the new procedure. This procedure does not function in case of the traditional wired controls, or it can only be solved in a very complicated way. Consequently, the designers of the modern control systems rather use the PLC-s which are getting cheaper and cheaper. The name originates from the Anglo-Saxon naming of Programmable Logic Controller. After the German literature, SPS (SpeicherProgrammierbar Steuerung) or PEAS (Programmierbar Eingang-Ausgang System) AR simulations are also used.

4. AR Simulations

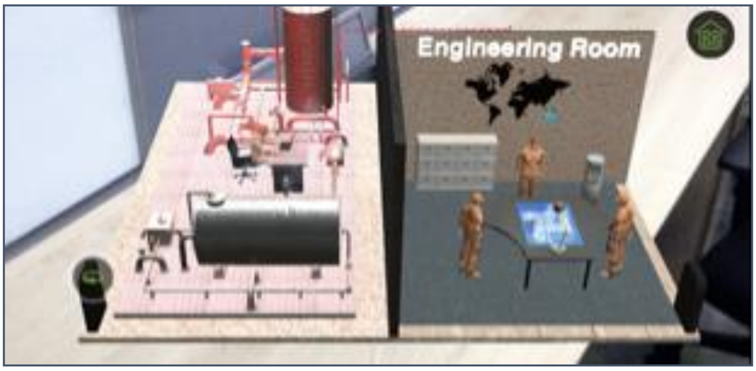
The Laboratory has several AR simulation possibilities which – just like the Fischer industry 4.0 production simulation – also strongly develop the digital competences of the students. Such AR simulation systems are going to be introduced which used by all modern Digital Logistic, AI conferences, workshops and in the smart industrial environment.

Digital twin

The basic idea is that with the assistance of the internet of the subjects we can create the digital twin of the physical client based on the data of the parts of the device and the measurements of further sensors. The digital twin in the cloud enables many new functions and solutions, for example the predictive analysis. If we combine it with the software warehouse in the cloud, the digital twin can also support the development of the new applications. Its main advantage for the developers of the applications is that they do not have to switch to the client and download the data. Instead, they run the applications in the safe sand box created in the cloud and regulate the data access of each application. Since, the applications do not run on the client but just in the cloud, the sand boxes can decrease the safety risks.

Finally, this approach cuts down on the development costs dramatically, so, one can develop new applications for the internet of the objects with the speed that is expected in the days of clouds. A good example is a vehicle safety application that is based on the usage habits: instead of building a cheap telematics unit into the vehicle of each client, the application can be run in the cloud and with the assistance of the digital twin the individual driving points of the driver can be calculated in real time (Figure 7 and Figure 8).

Figure 7:
Digital twin in the factory in AR 1.



Source: own illustration

Figure 8:
Digital twin in the factory in AR 2.

Source: own illustration

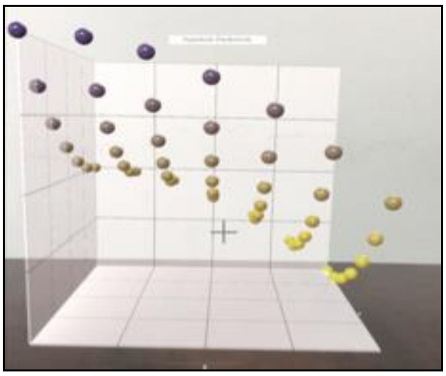
4.1. Graphmented

Create stunning charts and dashboards using augmented reality and share it live in AR with your colleagues. Graphmented transforms your desk and walls into a dashboards workstation. Drop sheets, charts, presentations and website shots on your desk or walls as if they were real objects and make use of your whole room. With Graphmented you can:

- Show your charts as never before;
- Record stunning videos of data and 3D charts exploration;
- Stream the app to screens, projectors or Apple TV through Quicktime;
- Supports data CSV, Excel files, and Google Sheets;
- Supports PDF Presentations;
- Share your dashboard live as if were magically in the air;
- Supports adding screenshots from any website to the dashboard;
- Place dashboards on horizontal or vertical surfaces, or even show dashboards without any surface.

Graphmented establishes a new era for dashboards. We have tons of features in our pipeline, so please don't hesitate to send us your feedback and leave us a review. This is the fuel that will keep us adding more great features.

Figure 9:
3D diagram in AR



Source: own illustration

4.2. Virtual Factory

Step into the exciting world of industrial innovation and digital reality with the Internet of Rubber Ducks! See a smart factory come to life through Deloitte Digital’s Virtual Factory app, an interactive demonstration of real-time problem-solving that can uncover hidden value in the factory with Internet of Things-enabled technology.

Using an example production line for rubber ducks, the in-app augmented reality experience allows you to see firsthand how pairing industrial assets and systems with IoT sensors and gateways can enable a digital supply network and unlock measurable value across an entire production system.

Open the app, download the Target Image, then point your mobile device camera at indicated markers to begin optimizing your factory today.

Figure 10:
Virtual i4.0 factory in AR

Source: own illustration

4.3. AR Smart Factory

Welcome to the next industrial revolution, where machines communicate with technicians and assembly lines offer insights through meaningful data. We invite you to explore our interactive factory, where you can learn more about IIoT systems and how TE sensors are building the future of manufacturing. Follow the instructions below for the TE AR Smart Factory experience:

1. Download the free TE AR Smart Factory app on your AR-compatible iOS device;
2. Open the TE AR Smart Factory app;
3. Point your device's camera at a horizontal surface that has stable and moderate lighting;
4. An AR model factory will appear on your screen;
5. Explore the model factory by tapping the areas along the right side of your screen;
6. Move your device around to zoom in/out and focus on the different areas.

Figure 11:
AR Smart Factory

Source: own illustration

4.4. Augmented Workstation

Take a look at one of our example configurations or configure your own robot cell. Thanks to the ARCore, you can place and rotate the robot cell freely in the room, or even adjust its configuration afterwards. Test how the Advanced Robotic Workstation fits into your production and simply change individual components as needed. To see your chosen robot moving, start the simulation. Augmented Workstation saves your last configuration so you can reload your last state when you restart the app. To load a configuration from the ESSERT Online Configurator, simply use the integrated QR code scanner and scan your generated code from our website. Useful tips for placing: When placing the workstation, ensure good lighting conditions and a textured background. If you have a monochrome floor without a pattern, use an artificial marker. For example, put a flat book on the destination or put a cross on the floor to give the app a visual anchor. Point your camera from the hips to the ground until it creates a white grid. The robot cell can be placed on this surface. Enlarge the grid by filming more floor space. Then tap in the grid where you want to place the Advanced Robotic Workstation. As our workstations become more configurable, you will always be kept up to date in this app.

Figure 12:
Augmented workstation

Source: own illustration

4.5. Torch AR

Start designing in 3D in minutes. Design and share augmented reality experiences with no special equipment or skills.

Built especially for mobile product designers who want to start adding AR features to existing apps or design new, standalone experiences, Torch's familiar gestures and tools make it easy for you to use your existing skills to design 3D experiences without prior 3D knowledge.

Place objects in space, modify their properties, add complex interactions, run through the entire prototype in Play mode, and invite friends to collaborate in real-time – all without ever leaving 3D.

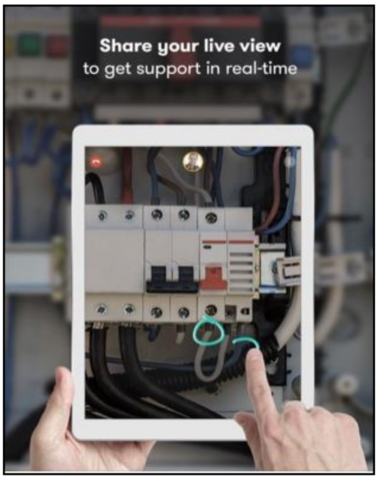
Design on the device. Build prototypes that take advantage of ARkit features. No need to constantly switch between desktop, headset, and device.

Work together in real-time from anywhere. Share for feedback with any device.

Torch's interactions system lets you go beyond simple AR sticker apps to build powerful multi-scene augmented reality experiences that engage and excite.

Add 2D files and 3D models with a simple gesture. Add complex interactions with a few taps. All without code or prior 3D experience.

Figure 13:
Torch AR



Source: App Store – Torch AR

4.6. Chalk Vuforia

Vuforia Chalk facilitates AR remote assistance between your experts and field technicians. It's an easy way to solve complex or unfamiliar problems.

Your organization can benefit via reduced repair time and travel costs, as well as better knowledge transfer from an aging workforce to new employee technicians, with the devices already in their hands.

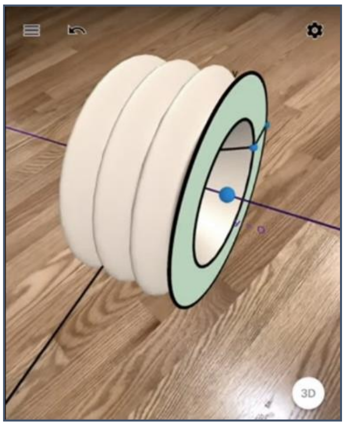
The powerful remote guidance experience of Vuforia Chalk combines live video, audio and the ability for both the remote and local participant to annotate their live shared view. Annotations in Chalk accurately stick to real-world objects, even when people move around, utilizing advanced augmented reality developed on the best-in-class Vuforia AR platform.

Vuforia Chalk enhances troubleshooting and support far beyond simple "see what I see" apps. What will you 'Chalk' first?

5. AR Product Planning

Students, having become familiar with the complex operation of the industry 4.0 factories and with the AR space with the assistance of the simulations, can use the notions and apply the different industry 4.0 methods confidently. The next step is the designing of products in the AR environment. We apply the GeoGebra 3D AR software here and the trial and student versions of CREO 6.0.

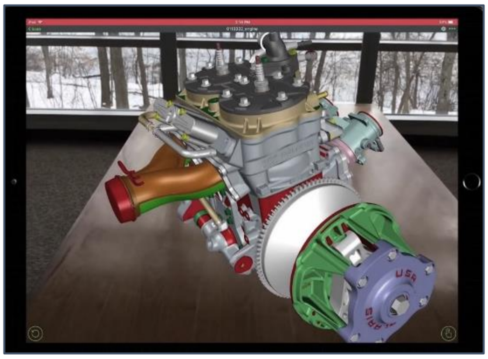
Figure 14:
Product design in GeoGebra 3d AR environment



Source: own illustration

Creo is used by thousands of leading design and production companies in the fast-changing world of product development so that they can produce better products faster. The engineers can enhance innovation with the embedded simulation to a new level and can form their ideas into connected, intelligent products with the plans controlled by IoT. Moreover, they can also communicate with their partners, customers in real-time with the assistance of the integrated outspread reality all over the world.

Figure 15:
Product design in the Creo 6.0 AR environment



Source: 3HTi – Creo 6.0

PTC started the renaissance of design. The companies create their products digitally and all over the world several thousand of companies turn to Creo in order to apply the real-time simulation, additive production supporting design and the safe, cloud-based extended reality that involve people in the processes.

Creo Simulation Live, that has been announced lately, provides a real-time feed-back on the results of the design decisions that enable the design controlled by the integrated simulation. Creo Simulation Live is a simulation that is fully integrated into the Creo, modelling the environment which software is quick as lightning and easy to use, it can yield results within seconds because it runs in the background. The designers can iterate faster from now on, they can detect the problems quicker, make their working processes less complicated, cut their costs, try several versions and they can design better products faster.

AR improves the design and cooperation working practices of the engineers. This cloud-based technology gives a new, effective and spectacular device into the hands of the engineers so that they can share the designs with their colleagues, partners and suppliers safely. A Creo AR Design Share is accessible in every workplace, the designers and the producers can iterate faster, they need less prototypes and in the design juries they can share the designs clear to all. A new important function of Creo 6.0 is the AR permission management. It can even be shared with 10 models and the designs can be displayed on smart phones, tablets or on HoloLens in a more spectacular way than ever before. The AR experiences can be accessed and started with the use of links, ThingMarks™ QR codes easily.

The new version provides all those design tools which are necessary to make use of the advantages of the additive production. The users can design, optimize, validate and control the printing without leaving Creo in order to decrease the production times and defects. Creo 6.0 provides even bigger designer flexibility to create stochastic foam or function-controlled lattice structure. The designers can analyze and optimize the production orientation, thus decreasing the printing time, minimizing the need of support materials and maximizing the tray utilization. Creo 6.0 provides an extended support to the 3MF standard.

Creo 6.0 can provide productivity enhancing development in several fields. The user interface has been further refined and optimized. The use of the mini toolbars has been extended to the establishment and modification of the building elements, work became faster with the modernized building element console, and the use of the model tree became even more flexible. Moreover, significant developments have taken place in the field of designing frame structures and screwed joints, 3D drawing, caballing and basic modelling.

6. The BOSCH SAP ERP

The BOSCH company enabled students educated in the Laboratory to access the sharp BOSCH SAP ERP that can provide a fantastic learning environment. The first step is to become acquainted with the R/3 interface to the use the MM, PP modules, and the preparation of reports.

Material Master

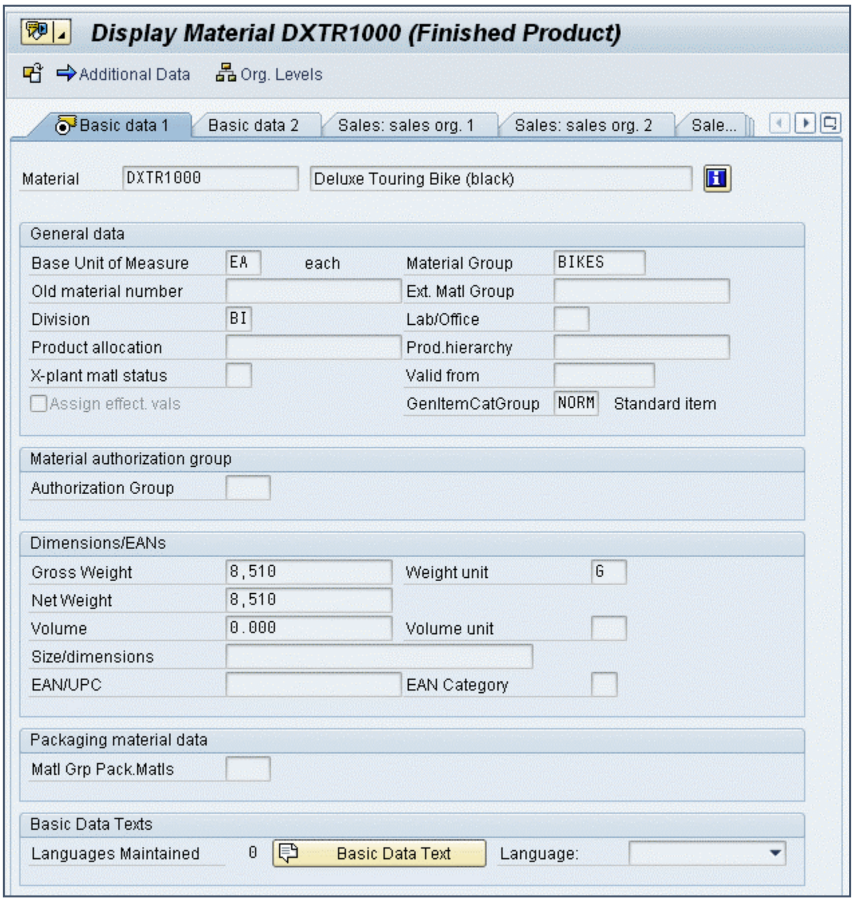
Contains all the information a company needs to manage about a material.

It is used by most components within the SAP system

- Sales and Distribution;
- Materials Management;
- Production;
- Plant Maintenance;
- Accounting/Controlling;
- Quality Management.

Material master data is stored in functional segments called Views.

Figure 16:
SAP material master record



Source: own illustration

The students work first in MM module: create, change and display raw material master records, which we will work with in the production line.

7. Production Line

By the time the students start to work on the work stations of the production line simulation, they have already learnt the above-mentioned application, adaptation of the methods, tools successfully including the operation concept of the industry 4.0 factories, technological implementations and the confident management of the SAP ERP relevant modules.

The production line of the Laboratory consists of 7 workstations and supermarkets each. Each workstation has a work description, i.e., what to do with the semi-finished product and the raw materials they received.

From the removal storage supermarket, the raw materials get to the first workstation with RFID bracelet. From here, RFID and XDK sensors can be found among each work station which watch the activities, movements of the students and, in addition, automatically register the pieces of information into the SAP ERP the data they received they are suitable for the assessment, analysis of the students' production simulation works and drawing conclusions from them (e.g. controlling the cycle times, accomplishing KPI-s, data visualizations, etc.) From the last workstation, the finished products get into the storing supermarket which we also register in the

Prod'Action system, on the slot level. On the monitor of each workstation, the students can see the pieces of information in connection with the current production on the SAP interface and other data visualization interfaces. At the end of the production cycles there is an evaluation. Then the product-number undertaking the next production cycle will be displayed on the Board. The students can make optional modifications on the production line: they can stop, fuse workstations, regroup the labor force, etc. Their main duty is to optimize the production process. The initial task is to manufacture even more from a product within a given time, optimization in three production circles. A further development is the manufacturing of several products in parallel with the lean approach and optimal fulfilment of the acute customers' requirements. Afterwards, some industrial case studies will be discussed with the involvement of the production line.

Some words about the i4.0 technological implementation:

7.1. BraceID

With more and more UHF RFID applications in today's logistics processes, an increasing number of RFID tags have to be scanned. Using traditional handheld scanners is not always an optimal solution. Many devices are bulky and require at least one free hand for operation. With the BraceID RFID Bracelet from metraTec there is an alternative that doesn't stop the work process. With this wearable device you can scan UHF RFID transponders seamlessly during normal handling operations. With a weight of less than 120g you can carry this device on your arm without operator fatigue. The RFID scan is activated via an integrated touch sensor or can be completely controlled from the software side. The bracelet has an integrated UHF RFID module and an energy efficient wireless communication module that transmits all scan data to a nearby gateway station. This keeps your WiFi network free from IoT data and lets the battery run for more than 2.000 scanning events. Besides the pure scanning functionality, the bracelet can provide users with instant feedback after each action via three color LEDs, a vibration alarm or an integrated buzzer for acoustic feedback. The main module of the device can be separated from the base, so multiple users can share the same device. Applications:

- Identification of boxes in short time;
- Controlling picking steps;
- Optimization of warehouse processes.

7.2. RFID

The point of the RFID technology is the communication of the radio transceiver unit with the RFID labels on the observed object. The communication happens automatically, even without human intervention.

This way, it is unnecessary to read every single package, the system can read the labels of the products crossing the reading gate all at once and upload them into the data base. The labels can be used again which increases the economical character of the RFID identification system, too.

There are three versions of the RFID label, also known as RFID tag or RFID transponder:

The passive RFID label without own power supply unit receives the energy that is necessary to the operation from the electromagnetic space generated by the reading device. This is the smallest and easiest RFID label type.

The partially passive RFID label has the minimal power supply unit and is able to collect the data continuously and then to convey them to the identification points. For example, measurement of the environmental temperature.

The active RFID label operates with a battery, and its signaler is able to send and receive information even from a big distance. The battery can even keep its working ability for 5 years, depending on the reading frequency.

The RFID label can be placed on the product directly or on the package, although we can find this type of labels in the plastic cards of the entering control system, too. The RFID reading unit communicates with the labels through radio waves. The RFID reading unit is connected to the computer or in the IP network to the server that is responsible for the control of the system which filters and transmits the data received in the data base. The data can finally get into the company control or logistics system.

The application or server that controls the RFID system usually performs the following operations:

- Identifies the content of the consignment;
- Controls the number of pieces;
- Compares the pieces ordered and those that were read;
- Filters out the faulty items;
- Indicates, if any item ordered is missing from the package;
- Transmits the data for invoicing.

The number of uses is endless.

Owing to their complexity the RFID systems take important positions on many professional areas. Each professional area has its own requirements, solutions. The RFID systems can perfectly be adjusted to the operation processes.

7.3. XDK

With the new XDK sensor platform, Bosch can offer a complex hardware and software platform with different types of sensors and Bluetooth and WLAN connections. An acceleration and rotation sensor, a magneto meter and sensors that are suitable for the measurement of volume, humidity, air pressure, air temperature and light are all components. The companies can develop their own big or small IoT-solutions by using the data.

7.4. Active Cockpit

Processing and visualization of production data in real time

Efficient production processes require continuous improvement. It is essential for error prevention and improvements to provide quick access to consistent data. This allows rapid reaction with minimal effort on the production line at the company.

With ActiveCockpit for production you have all the relevant data directly on the line

As an interactive communication platform ActiveCockpit processed and visualized production data in real time. ActiveCockpit networked IT applications such as production planning, quality data management and e-mailing with the software functionality of machines and plants. The information is the basis for decisions and process improvements.

Advantages resulting from special product features:

- All relevant information available to everyone in real time directly on the production line;
- Intelligent networking saves information processing time;
- More efficient improvement processes through clear analysis and conclusive task definition with ActiveCockpit.

Industry 4.0:

- Real-time collection, processing and visualization of all relevant data of a manufacturing facility for the exchange of information between people, machines and production process on the shop floor;
- Interactive software for the diagnosis and optimization of machines and processes, and disorder management;
- Browser-based Internet standards and openness to third-party applications;
- Easy connection to back-end systems (MES / ERP).

Customer benefits and advantages

Higher productivity through continuous, digital supported process improvement, integrated disorder management and a higher resource efficiency through improved planning.

By current and consistent key figures, decisions can be made quickly and efficiently on the shop floor.

- Saving time and failure prevention by direct connection to any back-end systems (ERP, MES);
- Customer specific apps can be integrated as a widget;
- Communication and information tool for employees at all levels;
- Structured and recorded team meetings;
- Customer-oriented configuration thanks to an intuitive web application;
- Save time by automatic login function;
- Space-saving.

Basic functions

PUBLIC AREA

- All relevant data available digitally on site;
- Information from different file formats can be displayed (e.g. As Excel, PowerPoint, video);
- Available for all employees.

VIEWS

- Fast compilation of data and documents, for example for improving rounds;
- Individual user management, for example read, modify, delete;
- Information can be displayed and used across departments. Documents are updated by Desklink;
- Filtering and presentation of relevant information, without changing the original file.

MEETINGS

- Operators can assign own names for each plant;
- Meeting documentation with freely selectable elements and customizable structure;
- Automatic report generation with all relevant information and annexes to the discussed topics.

NOTE PAD, WHITEBOARD FUNCTIONALITY

- Note function for communicating with colleagues or for escalation in the round;
- Annotation function via touch screen to highlight, annotate directly to ActiveCockpit;
- Show and transmit relevant information. (In disorders e.g. a photo can be taken by tablet and forwarded directly to ActiveCockpit).

Q- AND S-WIDGET

- Register and manage quality and safety deviations;
- Displaying the current status with a large Q (for quality) or S (for safety);
- Overview Quality or Safety Status per year;
- Values can be transmitted via Industry 4.0 interface back in ERP MES.

Additional functions – Industry 4.0 interface

INDUSTY 4.0 INTERFACE

- networked in real-time with ERP and MES-backend-systems through standardized connection to your existing systems;
- Customer specific definition of relevant data and connection possibility for easy and safe access.

FUTURE-PROOF THROUGH APPS

Bosch Rexroth offers numerous additional functions apps such as:

- Deviation Management: Registration and processing of deviations. These measures are defined in the ActiveCockpit and passed on the industry 4.0 interface MES and ERP;
- Table: presents your data clearly and intuitive to track processes optimally and detect deviations at an early stage;
- Personal deviation: for interactive creation of employee capacity schedules on the assembly lines;
- Process Quality Manager: Detect and avoid deviations in the production process as soon as possible.

WEBFRAME

Fast integration of apps, even third-party apps.

CUSTOMER SPECIFIC SERVICE

Bosch Rexroth offers its customers project specific services, such as the creation of a value stream designs.

Data Security

- All data incl. E-mails are encrypted and transmitted via SSL;
- Application uses methods of "defensive programming", which checks all entries in advance;
- A defined role and authorization concept regulates the access to the system and prevents errors during data entry;
- All passwords are encrypted stored in the data base to prevent spying in the case of a compromised database. All user entries are checked for correctness and malicious code;
- Indirect database queries avoid possible attacks ("SQL injection").

8. AR Supported Workplace Environment

Not only simulation and finish-product design are realized with the AR technology in the Laboratory, but the university lecture notes belonging to the Laboratory are AR supported, too. This means that in case of the pages of the printed lecture notes the relevant pieces of information are underlined and clicking on the pictures the relevant videos can be played. If you look for certain expressions you can directly go to websites, diagrams, and numerous other objects are also available in AR environment in real-time.

Moreover, if you enter the Laboratory, numerous AR elements can also be found: the teaching posters on the wall come to life, arrows and superscriptions help the orientation in the Laboratory and the function of the device and the course of education can also be determined, so that the orientation in time and space takes place in AR, as in a Smart Warehouse, too.

All this shows the wide range of possibilities, which the AR technology can provide and, last but not least, it gives a strong motivation for the participating students.

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