Journal of Business and Economics, ISSN 2155-7950, USA
October 2016, Volume 7, No. 10, pp. 1602-1612
DOI: 10.15341/jbe(2155-7950)/10.07.2016/003

http://www.academicstar.us

Industry 4.0: Machine-to-Machine (M2M) Communication

Wolfgang Sattler, Ralph Sonntag, Manuel Sitta, Carsten Frink
(Dresden University of Applied Sciences, Germany)

Abstract: This article shows the changing manufacturing industry including examples. It provides an overview of Industry 4.0, Machine-to-machine communication, the Internet of Things and their disruptive influence on currently established business models.

Key words: smart factory, digital transformation, business models, manufacturing, disruptive innovation
JEL codes: O330

1. Introduction

The high level of industrial production and the technical skills are important fundaments of the European wealth and success, especially in comparison to other continents. The industrial production, mainly the sector of mechanical and plant engineering, was a very traditional sector of the global economy. The industrial sector has not taken advantage of the variegated possibilities which the fast growth of digitalisation offered to it. Due to this the industrial production sector in (Western-) Europe lost significance compared to non-productive industries and in comparison to other continents like Asia. However, the fast development in the digital world will not stop forever in front of the industrial production. In the near future the so called “Industry 4.0” will be more and more important for organisations, and Europe will experience a re-industrialisation. Furthermore, factories will be smaller and more regional. That could bear many advantages for small and medium sized enterprises.

“Industry 4.0” is also how a high-tech strategy of the German government is called and has been created by the National Academy of Science and Engineering (acatech) in collaboration with the associations of VDMA, ZVEI and BITKOM, with participants from various research institutes, universities and well-known companies of the German industry. The target is to make sure that production sites will remain in Germany in the future. But also other European countries, the US or China have started projects in this way. This includes a fundamental change to the industry, their products, services and software solutions. Simultaneously, products will be linked over the internet and other networks. These procedures will inevitably lead to new products and services with new requirements for work, people and technology. Figure 1 illustrates the components of the new technologies which are part of that industrial revolution (Kaufmann, 2015, p. 4):

Wolfgang Sattler, Dr., Professor, Dresden University of Applied Sciences; research areas/interests: controlling, digital transformation, startups, business models. E-mail: sattler@htw-dresden.de.
Ralph Sonntag, Dr., Professor, Dresden University of Applied Sciences; research areas/interests: digital marketing, business models, entrepreneurship, word of mouth. E-mail: sonntag@htw-dresden.de.
Manuel Sitta, Bachelor of Arts, Dresden University of Applied Sciences; research areas/interests: product lifecycle management. E-mail: Manuel.Sitta@htw-dresden.de.
Carsten Frink, Bachelor of Arts, Dresden University of Applied Sciences; research areas/interests: economics, trade. E-mail: carsten_frink@web.de.

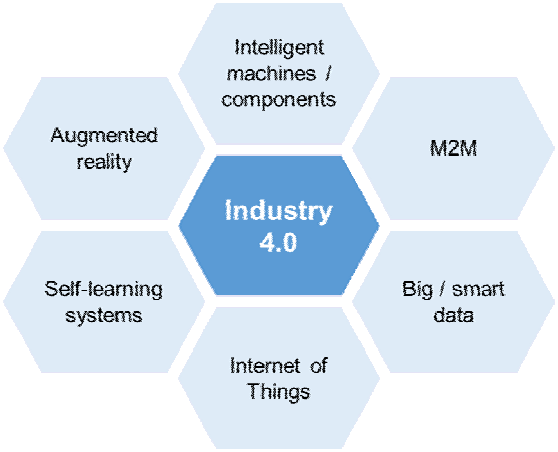

Figure 1 Parts of Industry 4.0

Source: Own representation based on Kaufmann 2015, p. 5.

This paper shows the change in industry from the past to now and explains some examples of the future perspective. In addition it provides an overview of Industry 4.0, Machine-to-machine communication (M2M), the Internet of Things (IoT) and their influence on the currently established business models, especially in the sector of the manufacturing industry. One aim of the paper is to illustrate the potential of the disruptive innovations which the digitalisation offers to the industry. Furthermore it presents how emerging economies can benefit from the disruptive innovations and how new business models can close the gap of economic output and standard of living between industrialised and emerging countries with the help of Information and Communication Technology (ICT).

2. Industry 4.0

2.1 Industrial Change: From the Past to the Future

During the past centuries there have been various economic fluctuations in the world economy which were based on industrial inventions. The Austrian economist Joseph Alois Schumpeter recognised a pattern in these fluctuations and developed the so-called Kondratiev waves (see Figure 2).

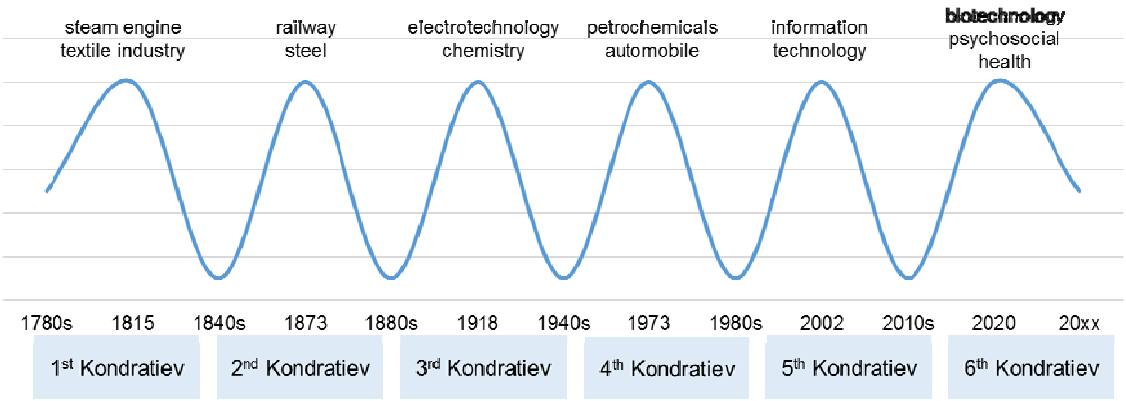

Figure 2 The Long Waves of the Economic Development (Kondratiev Waves)

Source: Own representation based on Nefiodow, 2014.

Innovative entrepreneurs who invented fundamentally new basic technology (e.g., railway, automobile), started

the so-called “long waves” that shaped the industry in the long term transition (Müller, 2010). Schumpeter called the periods between the innovations “Kondratievwave”. Mainly, he detected that short economic waves are overlaid by longer waves. Secondly, he recognized that the long economic waves are characterised by an upturn and a subsequent downturn (Grünewald, 2012). An innovation that was invented in this regard in the past was e.g. the steam engine, which completely revolutionised the industrial production. Later railways reduced transport times to a fraction (Müller, 2010). More innovations which ushered in new waves lie in the area of electrical technology, the automobile industry, information technology, or biotechnology. Similarly to the innovations in the past, Industry 4.0 and the associated digitising has the potential to launch a new wave. New waves are not only characterised by their novelty but are also distinguished by their widespread usage (Grünewald, 2012). As a vision of the future of production, a ubiquitous networking of people, things and machines in a completely new production environment takes place. Thereby, entrepreneurs, researchers and governments work hand in hand to implement this concept for the factories of tomorrow. Within Germany the Federal Government has introduced initiatives like the project “Industry 4.0” to implement this vision of production in future. Industry 4.0 aims at generating profit from production-related benefits through the creation of a networked, flexible and dynamic self-organising production process for high customisable products. In the next 15 to 20 years paradigm shift might be expected, which can be described as the fourth industrial revolution. The result seems to be revolutionary from the current perspective, but ultimately there will be a lot of steps of evolution in the overall networking. Figure 3 illustrates the four industrial revolutions.

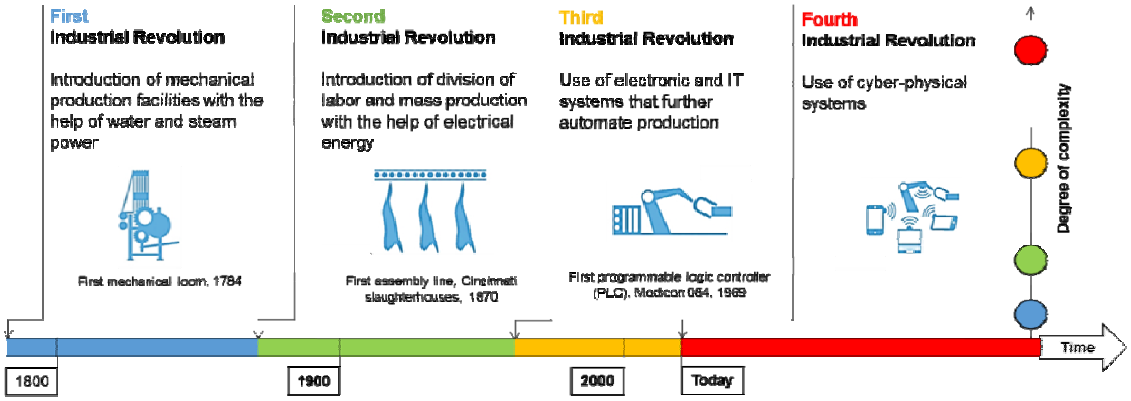

Figure 3 The Way from Industry 1.0 to Industry 4.0

Source: Own representation based on Siemens AG 2014.

The first industrial revolution was triggered by the invention of the steam engine and the mechanisation of manual labour in the 18th century. The second revolution was accomplished by the introduction of electricity and was fundamental for the creation of mass production techniques in the early 20th century. With the third revolution in recent decades, enabled by the use of electronic systems and information technology, the automation of production processes continued. And now the beginning of the fourth industrial revolution results to changes in the value chain.

The National Academy of Science and Engineering (acatech) believes that in the wake of Industry 4.0 manufacturing processes will lead to an increase in industrial productivity by 30% in the future. Moreover the academy suggests that not only the production but also mobility and health care will be revolutionised. This development will ultimately lead to a huge increase in the automation and intelligence of production. In this

context the market researchers of the IHS Technology expect a worldwide sales increase of USD 170 billion in 2013 and USD 209 billion in the year 2016. At the present time it is uncertain how the intelligent factory of the future will look like in detail. But one fact is certain: components, tools, transport containers, machinery and conveyor systems can be already linked with sensors and communication systems (Siemens, 2014).

The challenges in this context are varied. An increasing networking of industrial equipment used over the internet or other networks is indispensable. The willingness to surrender of sensitive corporate data across the entire value chain is unavoidable. Furthermore, it is important to develop appropriate networking software to adapt the entire process in a company. Additionally, it is important to define a new life-cycle of products. Furthermore, high investments in the field of industrial solutions will be necessary. Moreover there will be an even bigger intensification of international competition (Baum et al., 2013, p. 4; PWC, 2014, p. 7). The industrial revolution offers many opportunities for the German industry and especially its SME sector. The restructuring and adaptation of the business models will allow the contractor to improve its existing business models and optimise or create entirely new business models in various fields. Based on the products sold an expanded range of complementary services can be offered. It also provides the opportunity to create the image of an innovative, pioneering company that will be attractive for workers and jobseekers. Other benefits that may develop in the context of the fourth industrial revolution are improvements in efficiency, increased customer loyalty through customised products and services and a reduction in logistical costs due to optimised supply chains (Huber, Kaiser 2015, p. 4). A central role in this case is played by the communication between the machines which are used.

2.2 Machine-to-machine Communication (M2M)

The M2M communication is an important component of Industry 4.0 and proposes new opportunities in the way of production and disposition. The digitisation of the value chain offers the opportunity to produce individual products at lower costs and with fewer resources for companies. The predicted effects are an annual efficiency gain of 3.3% and a cost reduction of around 2.6% per year (PWC, 2014, p. 22). M2M is a broad term that can be used to describe any technology that enables the devices to communicate and perform actions without manual support of human information. Direct communication between two or more machines is based on data networks such as the local area network (LAN), a wide area network, the Internet of Things (IOT) or wireless Internet of Things (WIOT), Wi-Fi or mobile networks. Devices which are connected in this conclusion are computers, controllers, field devices or phones, security remote service or telematics devices (IT-Wissen, 2015).

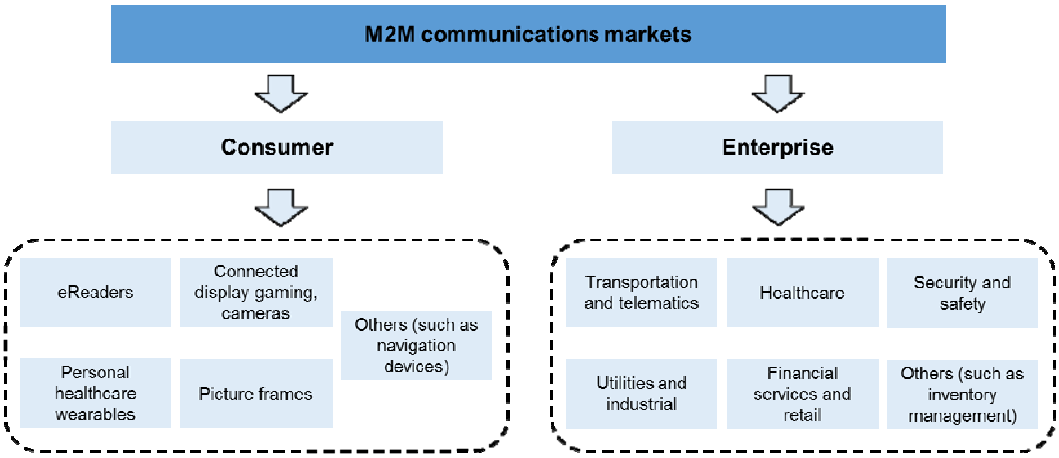

Figure 4 M2M-Markets

Source: Own representation based on Frost & Sullivan, 2013, pp. I-3.

The range of M2M communication has a variety of uses in the private and the commercial sector (see Figure 4). Private consumers can currently link their eReader with online libraries, check their calory consumption or control their sleep rhythm with the help of their smartphone. Companies and non-profit organisations currently use the M2M communication for example in the field of logistics and transportation. Moreover, complex production facilities can be linked to reduce the processing time and the scrap rates within the industrial sector dramatically. Also patients in hospitals may be directly connected to a monitoring computer by the means of sensors (Frost & Sullivan, 2013, pp. I-3f).

2.3 Internet of Things (IoT)

The Internet of Things is one of the main parts which provide the evolution of Industry 4.0. In this case the link between the different types of machines is done by the above-named kinds of networks. Only through this crosslinking the basic idea of a fourth industrial revolution is possible. Currently there are consumer-oriented products offered at the market such as smart watches or energy efficiency home applications for smartphones. The goal in this context is to generate networked knowledge across all areas of life to cross ordinary structures and industry boundaries and to define a new value cosmos (McKinsey Global Institute, 2015, p. 4; Andelfinger, Hänisch, 2015, p. 2).

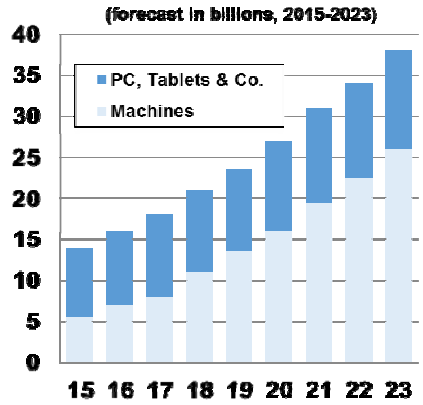

Figure 5 Number of Connected Devices Worldwide

Source: Own representation based on Machina Research 2015.

Currently there are roughly 14 billion devices, machines and computers across the globes which are networked together. Predicted for the year 2023 there will be approximately 38 billion networked devices. The growth of networked machines increases disproportionately compared to networked “smart home” applications (PC, Tablets & Co.) as Figure 5 illustrates. This fact shows the strong potential for the industrial sector in the near future (McKinsey Global Institute, 2015, p. 7).

3. Benefits for Emerging Economies

3.1 Development of Manufacturing Worldwide

The technical development of Industry 4.0 will alter the process of the manufacturing industry around the world. This change of the processing industry towards a higher extent of digitalisation and more usage of supporting IT accessories offers the chance that a lot of companies develop completely new business models. For this purpose it is not necessary that the country is still completely industrialised. More important is that the country and its enterprises recognise the importance of the new development, and invest in the infrastructure and

digitalisation of the industrial production. This would provide the country and its enterprises the chance to be a part of Industry 4.0 from the beginning. Therefore it is important to point out the potential of the new market to the emerging countries and companies. If this happens, Industry 4.0 will not just be an opportunity for already industrialised countries increase the extent of industrialisation, but also and primarily, emerging countries can benefit from the new development. Many of these countries already meet the requirements (e.g., digital infrastructure, industrial establishments) to use Industry 4.0 and be more than a typical component supplier for companies of industrialised countries. This fact provides the possibility to those countries and companies to enter new markets from the beginning and to be an important part in the development of new business models through an increase of digitalisation. Furthermore, Industry 4.0 offers a chance to close the gap between industrialised and emerging countries with regard to the unequal distribution of prosperity between different regions on the world. That this is not just a wishful thinking depicts the increasing importance of emerging countries in the manufacturing sectors. In the last centuries a change of manufacturing evolution took place worldwide. Thus illustrates the growing importance of still non-industrialised countries. Since 1991 the global industrial footprint changed fundamentally. The absolute worldwide manufacturing value added has almost doubled, from EUR 3,451 billion in 1991 to EUR 6,577 billion until 2011 (Roland Berger, 2014, p. 3). In 1991 over 60% of that amount could be attributed to six major industrial nations — the United States of America, Japan, Germany, Italy, the United Kingdom and France. But as of now, as Figure 6 illustrates, just the emerging economies hold a share of around 40% of the output of the worldwide industrial manufacturing. Those economies have doubled their share in the last two decades, whereas Western Europe lost over 10% of its portion of manufacturing value added (it currently a share of 25% (Roland Berger, 2014, p. 4). Over the period from 1991 to 2011, the traditionally industrialised countries increased their manufacturing value added by an average of 17%, whereas in the emerging industrial countries the value added has risen by 179% (Roland Berger, 2014, p. 4). The increasing share of the emerging economies worldwide is very closely linked to the strengthening of Asian countries, mainly China. Additionally the other members of the BRICS (Brazil, Russia, India, China and South Africa) countries experienced an industrial boom. And this trend will also soon reach Eastern European countries such as Poland, Romania and the Czech Republic (Roland Berger, 2014, p. 4). The manufacturing industry's role in the economy of these countries has been traditionally very strong (over 20% of the national value added). And currently those countries have the main advantage of low-cost manufacturing and the value added per job is still lower than in traditional industrialised countries. Furthermore there are companies which have been recently established and which are highly automated. Those facts will support the fast development of high value-added activities in the manufacturing industry (Roland Berger, 2014, p. 4).

Moreover, the alteration of the manufacturing industry results in different numbers of industrial jobs: The number of manufacturing jobs in China and Brazil increased by 39% and 23% respectively, whereas this figure decreased by 8% in Germany, by 20% in France and by 29% in the UK (Roland Berger, 2014, p. 3). There are three main criteria why the traditionally industrialised countries experienced a decline in industrial manufacturing. The first one is that these economies had already achieved very high production profits over the last few decades i.e., that those countries have reached a very high technological level. On this level the companies use more robots, machines or fully automated production lines instead of a high number of manpower. The second aspect is a loss of market shares towards newly emerging competitors. And last but not least, another reason is the outsourcing of activities such as logistics, facility management, maintenance and different types of professional services to the service industry (Roland Berger, 2014, p. 4).

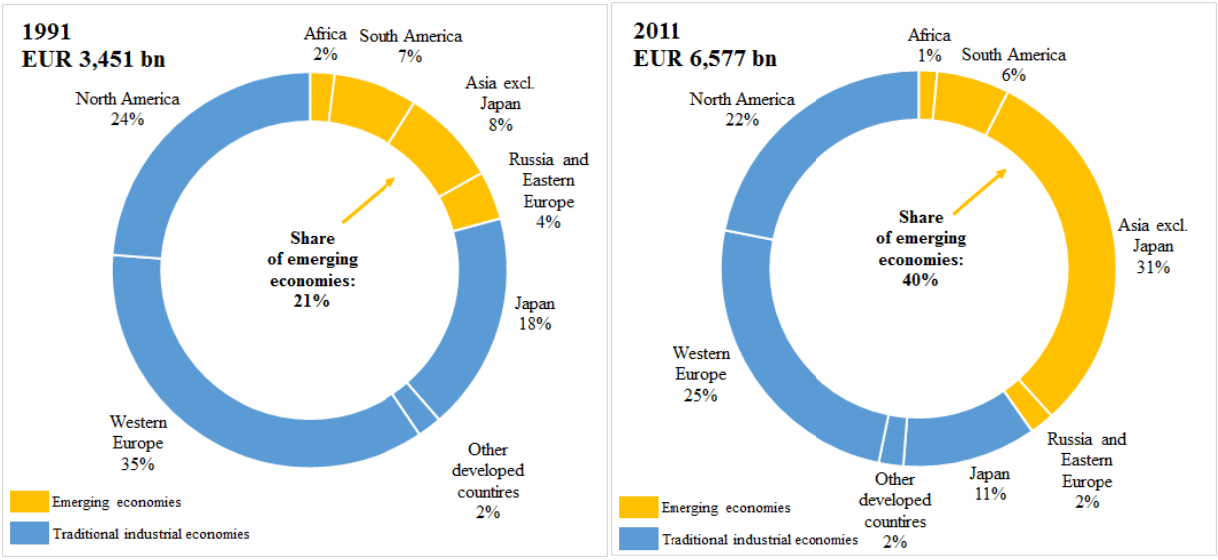

Figure 6 Share of Manufacturing Value Added Worldwide in the Year 2011 and 1991

Source: Own representation based on Roland Berger, 2014, p. 4.

According to the study "the Internet of Things: mapping the value beyond the hype" of the McKinsey Global Institute about the potential of Industry 4.0 and the Internet of Things (IoT), the worldwide economic added value of IoT in 2025 will amount up to USD 11.1 trillion. This value will be almost equivalent to more than one tenth of the global economic output (USD 99.5 trillion), according to the forecast of the World Bank for the year 2025 (Dürand, 2015). This amount includes different areas of applications with regard to human health, retail environments, factories, cities, vehicles, etc. In that regard, factories will have the highest potential (up to USD 3.7 trillion). This context includes improvements in operation optimisation, predictive maintenance, inventory optimisation, health and safety (McKinsey Global Institute, 2015, p. 7). There will be a gap between advanced and developing countries, with regard to the apportionment of the total amount. The advanced economies will possibly generate bigger shares of the potential of annual output by the whole amount (62%), in contrast the number of deployments will probably be higher in the developing world (McKinsey Global Institute, 2015, p. 5). In one of the most important and valuable areas, the gap will be not that big: In the area of factories emerging countries will be likely to generate 43% of the total amount (McKinsey Global Institute, 2015, p. 5). That percentage will be higher than the share which emerging countries currently hold. This is another argument for the strengthening of emerging markets in the future.

3.2 Area of Application and New Business Models

Thus, emerging economies can profit from the previous positive development in the sector of industrial manufacturing and generate a higher value. However, it is also important to evolve new business models for Industry 4.0. Preferably, enterprises in emerging countries should be an innovator from the beginning, before the industrialised countries generate most of the profit by their own. Otherwise the aim to close the gap of economic output and standard of living between the industrialised and emerging countries will be endangered.

One important part of Industry 4.0 for manufacturing companies in the sector of mechanical and plant engineering is the described M2M communication. It provides new chances in the way of production and disposition. The digitalisation of the value added chain offers enterprises the possibility to produce specific, individual products at lower costs and with less input of resources. That also supports a sustainable economy. The

predicted effects are an annual increase in efficiency of 3.3% and a cost reduction of around 2.6% per year (PWC 2014, p. 12). Furthermore, factories will be smaller and more regional. This could bear many advantages for small and medium sized businesses (VDMA, 2015, p. 2). More and more customers prefer a customer-oriented and flexible production. In the future the companies have to react faster and more accommodative for customer demands and regional needs (VDMA, 2015, p. 3). These requirements can be best satisfied by small and medium sized businesses if the organisations dispose of intelligent networked factories.

In the future the existing business models will change due to Industry 4.0. The goal is the increase of the customer value through more digital services and enhanced networking products (PWC, 2014, p. 31). To satisfy the customer demand the enterprises have different possibilities to generate new business models. Figure 7 illustrates these three typical ways that are possible to create a new business model in a company.

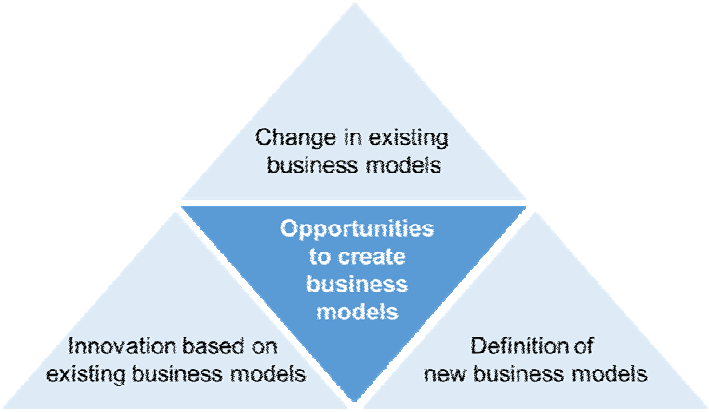

Figure 7 Opportunities to Create Business Models

Source: Own representation based on Kaufmann 2015, p. 12.

In general, there are three kinds of opportunities to create a new business model. The first one is a business model which is based on already existing business models, i.e., they have been implemented in other industries and companies before. The novelty in this case is that the company transfers this model to its own production. For example a company could offer personalised clothing, chocolate or laptops.

Newly defined business models are models that have not been invented up until now. That offers completely new business opportunities, which can be used to generate new target groups and markets (Kaufmann, 2015).

Another opportunity could be a change in existing business models by using Industry 4.0 technologies. This means to change one dimension in an existing business model. The dimensions that are considered here are shown in Figure 8.

A general recommendation for a company depends on different premises, aims and costs of the project and needs a thorough research of that specific enterprise. Figure 9 illustrates some different kinds of new business models. Exemplarily a new business model can contain a special attention to personalised products (i.e., serve individual demand of a customer with a huge variety of standardised product components) or develop a new product by using the open source concept (i.e., support by a free and open community).

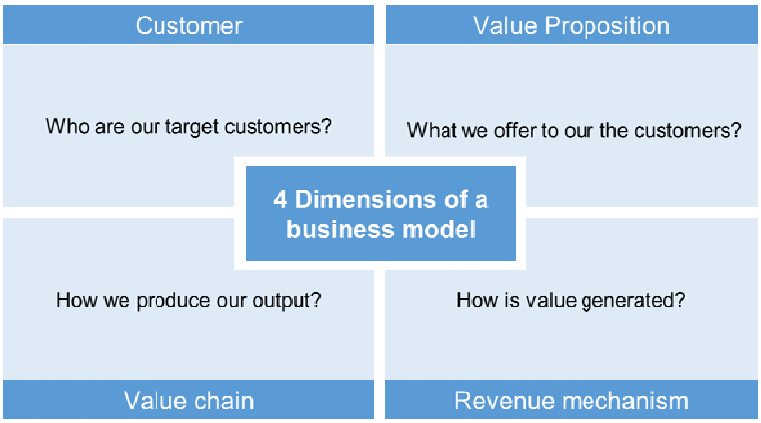

Figure 8 Four Dimensions of a Business Model

Source: Own representation based on Kaufmann 2015, p. 11.

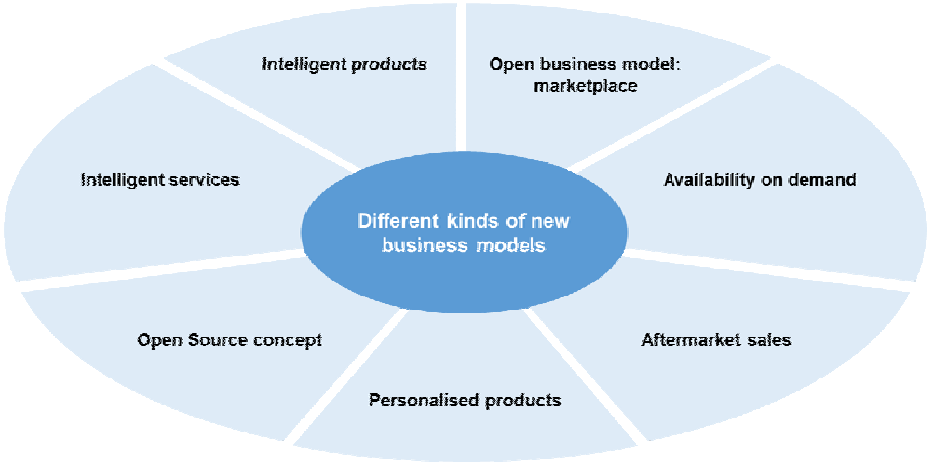

Figure 9 Different Kinds of New Business Models

Source: Own representation based on Kaufmann 2015, p. 12.

To apply those new business models to the sector of mechanical and plant engineering, a change from classical selling of physical products towards more solution-oriented business models, (accompanied of intelligent services) is involved. One example is the flexible accounting of printing machines: Instead of selling a whole printing machine to a customer the company only sells the printed pages. The idea behind is selling machine hours instead of the machines themselves to the customers (PWC, 2014, p. 32).

Another example is the German machine tools manufacturer Trumpf. The company has produced the first “social machines”. Each component is “smart” and knows what work has already been carried out on it because the production facility already knows its capacity utilisation and communicates with other facilities. So production options are automatically optimised. Customers can receive pictures of the machines in real-time during the production process. So there is the chance to provide feedback very early in the production process. That can help to build even better machines (Roland Berger, 2014, p. 18).

Another area of operations involve maintenance of machines. Due to digitalisation it is possible to reduce the maintenance costs of machinery and equipment by 10% to 40%. Furthermore, the periods between maintenance actions can be optimised or stretched. This is possible due to the help of sensors that send signals if it is necessary to change parts of the machinery to avoid permanent damage. In that way damage to machinery and equipment

can be minimised by detecting wear or material failure very early (McKinsey Global Institute, 2015, p. 60).

4. Conclusion

Industry 4.0 is a collective term of different new technical possibilities, which interact between each other. Industry 4.0 has the potential to be a real revolution for the entire industry. It provides opportunities to almost every country or company, irrespective of whether it is an industrialised or emerging country. Companies and countries have to create new business models based on Industry 4.0 to enter new and until now unknown markets. Otherwise the enterprises will be more and more likely to lose the connection to the customers and competitors.

For the companies of emerging countries it is important to take the opportunities of new business models as early as possible. That requires entrepreneurial courage and the volition to generate innovations without doing things for the sake of doing things. It is important to take corporate responsibility as well as to consider the opportunities and risks which arise for a company (Wieselhuber & Partner GmbH, 2015, p. 51).

Whether it will be a real industrial revolution like the three before (e.g., the first one with the introduction of mechanical production facilities with the help of water and steam power) is to be evaluated in retrospect, i.e., after the final result.

References

Andelfinger A. and Hänisch T. (2015). *Internet der Dinge. Technik, Trends und Geschäftsmodelle*, Wiesbaden, Germany: Springer Gabler.

Baum G. et al. (2013). *Industrie 4.0 — Beherrschung der industriellen Komplexität mit SysLM*, Heidelberg/Berlin, Germany: Springer.

Wieselhuber & Partner GmbH (2015). *Geschäftsmodell-Innovation durch Industrie 4.0*, Chancen und Risiken für den Maschinen- und Anlagenbau, Munich, Germany.

Frost and Sullivan (2015). "The future of nondestructive testing", accessed on 10/09/2015, available online at: http://de.slideshare.net/FrostandSullivan/ the-future-of-nondestructive-testing.

Frost and Sullivan (2013). "US machine-to-machine (M2M) communications", accessed on 10/02/2015, available online at: http://www.frost.com/sublib/ display-report.do.

Gassmann O. et al. (2013). *Geschäftsmodelle entwickeln*, Munich, Germany: Hanser.

Grünewald S. (2012). "Was sind die Kontratieff-Zyklen?", accessed on 11/26/2015, available online at: http://www.gevestor.de/details/was-sind-die- kondratieff-zyklen-568051.html.

Huber D. and Kaiser T. (2015). *Wie das Internet der Dinge neue Geschäftsmodelle ermöglicht*, Wiesbaden, Germany: Springer Fachmedien.

IT-Wissen (2015). "Maschine-zu-Maschine-Kommunikation", accessed on 08/26/2015, available online at: http://www.itwissen.info/ definition/lexikon/machine-to-machine-M2M.html.

Kaufmann T. (2015). *Geschäftsmodelle in Industrie 4.0 und dem Internet der Dinge*, Wiesbaden, Germany: Springer Vieweg.

Machina Research (2015). "M2M Forecasts", accessed on 10/05/2015, available online at: https://machinaresearch.com/forecasts/.

McKinsey Global Institute (2015). *The Internet of Things: Mapping the Value beyond the Hype*, New York, USA.

Müller A. (2010). "Das Comeback von Kondratieff", accessed on 11/26/2015, available online at: http://www.handelsblatt.com/: politik/konjunktur/oekonomie/nachrichten/theorie-der-langen-wellen-das-comeback-von-kondratieff/3414216.html.

Nefiodow L. (2014). "The sixth Kondratieff: The new long wave in the global economy", accessed on 10/09/2015, available online at: http://www.kondratieff.net/#!the-sixth-kondratieff/c1rxx.

Pricewaterhouse Coopers A. G. (pub.) (2014). *Industrie 4.0 — Chancen und Herausforderungen der vierten industriellen Revolution*, Frankfurt, Germany.

Roland Berger Strategy Consultants GmbH (pub.) (2014). *Think Act. Industry 4.0: The New Industrial Revolution: How Europe will Succeed*, Munich, Germany.

Siemens A. G. (2014). “Digital factory — Manufacturing: Self-Organizing Factories”, accessed on 10/09/2015, available online at: http://www.siemens.com/innovation/en/home/pictures-of-the-future/industry-and-automation/digtial-factory-trends-industry-4-0.html.

VDMA European Office (pub.) (2015). *Industrie 4.0: Chance für Europa*, Brussels, Belgium.