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Master Thesis

Start-ups within the Industry 4.0, a Challenge for the Czech Republic

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3. Abstract

New and recent technologies have been rapidly changing the markets or economies across the world and even have been influencing daily life of practically all people around the world. Three Industrial Revolutions effected the humankind and the Fourth one is taking place right now. The core of this Revolution lies in the concept called the Industry 4.0.

The Czech Republic enjoys one of the longest industrial tradition not only in Europe but also worldwide but it is still visible, even after the dynamic transition from the centrally planned economy to market one, that it still has been partly catching up with its neighbours, mainly Germany and Austria.

Start-ups can be recognized as one of the leading forces of the innovation activities inside the countries as they can bring into a market (R)evolutionary solutions, products and services. However, start-ups in the Czech Republic have not been given almost any particular attention within the Industry 4.0 concept.

The main motivation of this thesis is to explore relatively small research area that combines 3 above-mentioned aspects and in the same time highlight the importance of the Czech start-ups leading to the Industry 4.0 principles. The existing supportive instruments, either financial or non-financial, should ensure that the Czech start-ups will able to boost their development, create new working places and unlock the potential of new technological findings and solutions.

Keywords: Start-up, the Czech Republic, the Industry 4.0, the Fourth Industrial Revolution

4. Introduction

New and recent technologies have been rapidly changing the markets or economies across the world and even have been influencing daily life of practically all people around the world. Four breakthrough technological stages can be identified and named as Industrial Revolutions. The last one, Fourth, is happening right now and it is not going to influence only industries or companies involved in the international trade but also aspects of everyday life. The core of this Revolution lies in the concept called the Industry 4.0, which covers the recent technological knowledge, trends and results. However, the Revolution itself is not only the Industry 4.0, but as mentioned above it can be for example Society 4.0, Labour 4.0 or Education 4.0, where an overlap of the new technological trends is seen and can be applied in different spheres.

The Czech Republic enjoys one of the longest industrial tradition not only in Europe but also worldwide. Despite the long-term influence of the former Soviet Union in the 2nd half of 20th century and general economic lagging behind compare to Western countries, the Czech Republic is one of the fastest growing countries in the European Union. It had to go through under the dynamic economic transformation from the centrally planned economy to market one. Industries and Czech companies have played one of the major roles in the process.

Start-ups are relatively a new form of the company in the Czech Republic and in the majority of the cases, it is still seen as a part of the small and medium sized companies. However, in contrast to SMEs, start-ups want to grow fast, they want to bring to market some (R)evolutionary solution or change the world. But they usually face many issues in the beginning of their life, such as financial problems, insufficient demand for their products and so on.

The main motivation of this thesis is to explore relatively small research area that combines 3 above mentioned aspects. The concept of the Industry 4.0, start-ups and place them into the specific environment of the Czech Republic. Author sees that features of the Industry 4.0 and start-ups are very close as both topics can be characterized by bringing dynamic changes, new technological solutions and fast movements.

On the other side, the Industry 4.0 and start-ups together have not received almost any wider attention neither from the Czech government or Czech public. This leads to formulating one of two research questions in this thesis:

How can the Czech government and its institutions support and strengthen the role of the Czech start-ups within the Industry 4.0 concept?

This question primarily aims to governmental bodies or institutions that are responsible for the observation, preparation and execution of programs and instruments connected not only to the Czech start-ups but more on the overall concept of the Industry 4.0. However, this question is also connected to other consequences that the Industry 4.0 can potentially have on the all society.

The second research question is formulated as follows:

How can the start-ups in the Czech Republic benefit from the available supportive instruments and initiatives within the Industry 4.0 concept?

At this case, the attention is given particularly to the Czech start-ups and the instruments, programs and initiatives that are available across the Czech Republic within the scope of the Industry 4.0. These, not necessarily financial, instruments should help start-ups during their business life-cycles and boost their activities towards even more advanced solutions and outcomes. The factual examples mentioned at this thesis should help the Czech start-ups to explore options that can be beneficial for them in the future growth.

As it will be visible during the thesis, the Czech government and its institutions have not made any rapid progress neither promoting the Industry 4.0 concept or start-ups themselves. But the Czech government is not the only subject that can directly influence the role and power of the Czech start-ups as the private companies, investors or business angels have been focusing on this area as well. All in all, the main objective of this thesis is to promote and contribute to a relatively small area of research, but at the same time, specific area, that can play important role in the nearest future based on the latest technologies and their outcomes.

4.1. Thesis Structure

The thesis begins with the introduction where the 3 main actors are introduced, followed by the formulation of 2 research questions that aim to promote the importance of the start-ups within the Industry 4.0 in the Czech Republic. Methodological chapter explains how the research is designed and what methods are found relevant for the answering the research questions. The way how the data and information are collected is also described, and at the end limitations of this thesis are set.

Chapter five is dedicated to the Literature Review. At this chapter, the main terms are introduced such as the Industrial Revolutions, their importance and consequences for the humankind, and start-ups, where the possible distribution of start-ups is showed, life-stages are described, financial and nonfinancial instruments are presented and lastly, the importance of the start-ups is highlighted.

The next chapter deals with the Industry 4.0 concept, where the challenges and opportunities brought by the Industry 4.0 are outlined, recent technological trends and tendencies are analysed as well as they should be the moving force of the overall concept. To increase variety and show differences across the world, author decided to also include existing initiatives towards the Industry 4.0. At the end of this chapter, the role of the start-ups within the Industry 4.0 is highlighted.

In order to provide reader with better visibility of the Czech Republic, short introduction about the overall economic situation serves as a starting point. The governmental document Initiative Industry 4.0 is the focal point at this chapter, followed by the dynamic SWOT analysis of the overall document and concept in the Czech Republic.

Start-ups and their role within the Industry 4.0 has dedicated chapter, which begins with the outlook of the current situation of SMEs and start-ups in the Czech Republic. Their preparedness towards the concept is also explored. Four successful examples are presented as they have shown variety in terms of product/service they offer, different instruments they have used for the growth. And lastly, the financial and nonfinancial instruments and initiatives that the Czech start-ups can benefit from are provided.

The chapter called The Evaluation of the Current Situation and Suggestion of the Future Steps is primarily dedicated to answering the two above mentioned research. The last chapter provides reader with the conclusion.

5. Methodology

This chapter has as a goal to clarify the methodological selection for the direction of the thesis. Here will be explained design of the research and method used during the thesis. Further, how the data were collected will be described, also limitations of this thesis will be set.

One of the focal points in the methodology is the correct selection, collection and usage of the right resources, in other words research philosophy. Author decides to select and follow principles of the ontology and furthermore pragmatism. Ontology deals with the nature of reality, at this case this can be understood as the environment of the Czech Republic and its existing start-ups within the Industry 4.0 frames.

Pragmatistic approach calls for the further action and stands “in the middle” between two extreme options, positivism and interpretivism. It can also combine qualitative and quantitative approaches. Author selects pragmatism as the appropriate way as the overall concept, the Industry 4.0, can be still seen as a topic which have many supporters and opponents in the same time, but none of them has a crystal ball to predict what is going to happen in the future. Pragmatism keeps the door open for any kind of result. (Dudovskiy, 2018)

5.1. Research Design and Method

Following the previous part, the research design serves as a bridge between the collected data and research question. Based on this, conclusion should be drawn. (Yin, 2009) The thesis research design is built on the exploratory single case study research practices.

Exploratory study field is a subset of the observational research, which can be characterized by quite broad research questions and usually answers open-ended questions. Edgar and Manz (2017) in their book about research methods in Cyber Security claim that: “*Exploratory studies consist of collecting, analyzing, and interpreting observations about known designs, systems, or models, or about abstract theories or subjects.*”

Exploratory research primarily aims to expand or promote deeper knowledge in particular business issue or opportunity, in other words: “*the term explanatory research implies that the research in question is intended to explain, rather than simply to describe, the phenomena studied.*” (Maxwell & Mittapalli, 2008) During this type of research, author wants to identify or uncover original/new ideas, patterns or areas for further research. It is beneficial to use it in remarkably innovative fields, which the Industry 4.0 and the Czech start-ups definitely are. Companies are able to identify possible ideas that can be turned

into practice from the exploratory research. For example, in German Siemens, exploratory research program focuses on exploring relevant technologies that can be used not during next few years but decades. But the exploratory research may be practical for more areas, such as identification of the best practices or innovative production. (Hair Jr., Celsi, Money, Samouel, & Page, 2015)

Explanatory research usually takes the form of qualitative research, as, according to Maxwell and Mittapalli (2008) and their summarization about the explanatory research, selection of quantitative approach can be under some conditions not the best choice to reach needed conclusions and results. However, the exploratory research can still be done in quantitative way.

The exploratory research uses, in the majority of the cases, secondary data. Secondary data, compare to primary data, have already been collected in other researches. They can take a form of various journal, internet resources and so on. This data must be examined and determined by the author(s) of the research in order to characterize the problem. (Sreejesh, Mohapatra, & Anusree, 2014)

The advantages of the exploratory research are that the overall research can lead to unexpected results or even open-ended outcomes, which should call for the further investigation. Furthermore, the research itself is quite flexible in terms of adopting to new and raised topics. On the other side, as mainly qualitative resources are used, they can lead to biased results. Moreover, findings of the research should not be generalized or applied to a broader public, so for example what can be beneficial for the Czech start-ups, does not need to be necessary truth for the Hungarian one. (Dudovskiy, 2018) (Erickson, 2017)

The Case Study Research as one of the potential research methods have been used in many areas including business or economic topics. The case study research tries to comprehend complex social phenomena, at this case the challenges for the Czech start-ups within the concept of the Industry 4.0. Furthermore, the single case study approach was selected as the most appropriate as the single case studies refer to unique or rare cases that should be described or analysed.

Multiple case study was not selected and found appropriate as this approach is based on the two main criteria's:

- 1) Generalization of the findings;
- 2) Internal validity.

Potential of generalization of the findings goes against the principles of the exploratory research because the research should be flexible despite the threat of biased results as mentioned above and supported by Dudovskiy (2018) and Erickson (2017). Furthermore, internal validity refers to usage of contrasting cases that allows rejection of alternative explanations. However, the exploratory research is based on open-ended questions at the end of the research. These two reasons led to selection of the single case study. (Yin, 2009) (Royer, 2012)

Close examination of the past and recent tendencies within the Industry 4.0 concept around the world and more specifically in the Czech Republic allowed author to target even more specific area, the Czech start-ups and their environment as they are undoubtedly one of the leading forces in terms of applying new technologies and knowledge of the Industry 4.0. The figure 1 illustrates the explicit area of the thesis, in other words the single case selection, which is bordered by the red colour. Author also primarily uses the qualitative method as he considers the approach more appropriate for the studied problematics. However, few features (such as graphs, statistics, etc.) of quantitative research are used in order to strengthen the importance of the thesis topic.

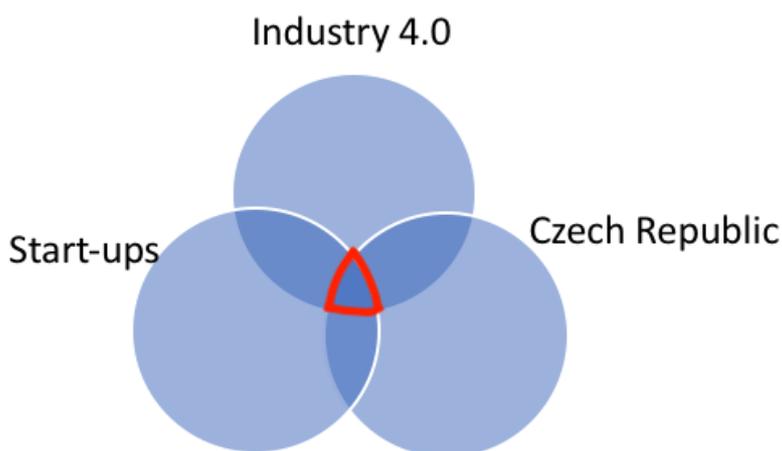


Figure 1- Borders of the Thesis Topic

Source: Author's elaboration

5.2. Data Collection

Developing a research question is one of the crucial aspects of the all research or thesis at this case. Question should encourage reader or provoke further actions. Alvesson and Sandberg (2003) claim that: *“Good research questions, however, do not just exist they also need to be created and formulated. As many scholars have pointed out it is particularly important to produce innovative questions which ‘will open up new research problems, might resolve long-standing controversies, could provide an integration of different approaches.’”*

However, speaking about the research question is much easier than doing. Research question should be a focal point, set the limitations and direct the research. Furthermore, the author should have previous knowledge about the topic itself from different resources. The author has to understand that the research may contribute to recent topics or issues. Theoretical background has to set the basics for formulating appropriate research question, which can be changed during the time of the research. (Race, 2010)

Theory has also two implications not only for author, but also for reader as:

- 1) Ideas are expanded and developed by using appropriate literature and sources;
- 2) Existing theory helps to confirm previously gained knowledge and even brings current improvements or data.

At this case, very few pieces of existing literature focus on the start-ups within the Industry 4.0 concept as it is relatively new and unexplored concept. Author tries to adopt existing researches and set them into the Czech start-ups specifics in combination with the Industry 4.0 literature. Furthermore, these researches can be used as a starting point for more precise examination in environment of the Czech Republic as it is recommended by Hair Jr. et al. (2015). Also, the existing literature should be the most recent one and should reflect actual situation within the research topic. Variety of resources, such as books or journals ensure this. (Kauda, 2012)

This thesis is not primarily based on existing theories but more on data and information available from the real-life practices. Theoretical parts are visible mainly in the literature review, where the Industrial Revolutions and their importance for humankind are characterized. Also, the theory dealing with effectuation and causation by Sarasvathy is used in order to strengthen rationality behind the opening new possibilities for newly created market subjects (start-ups). The Literature review predominantly uses information from the experts

that act on the start-up field, such as Steven Blank and his distribution of the start-ups. Majority of this information is supported by the background research, mainly in the part speaking about the importance of the start-ups.

The Industry 4.0 concept is backed up by the existing literature on this topic across the world. Many of existing materials deal with the same areas of interests, such as technologies, future development and so on, but use different naming for the overall concept like Smart Factory, Industry 4.0 and many others. The importance of the overall concept is also supported by variety of documents from the OECD and its authors or available analyses from for example Delloite.

Speaking about the Czech Republic in general, author decided to use, if possible, international resources rather than local one in order to decrease the potential bias created by misunderstanding of the resources. Data take source from the European Union Eurostat, the World bank, the OECD and others. However, the local resources are needed in the next parts, which focus on the Czech specifics of the Industry 4.0 or start-ups respectively. At these cases as a starting point serves primarily governmental documents, such as the Initiative Industry 4.0. This document can be considered as one of the crucial documents in this thesis and also identifies the main instruments that should support the Industry 4.0. However, additional research was needed in order to catch up with the latest news and initiatives. The corporate webpages and internet articles support selection of showed examples.

All in all, variety of resources is used in this thesis. Where it was possible, international literature and resources were used. On the other side to be more precise in highlighting the Czech specifics, local resources were also needed. Author tries to apply different resources, supported by the relevant graphs, statistics or information, which have source in the international organizations such as the OECD, the European Union and others. These institutions should “guarantee” the validity of the data provided.

5.3. Limitations of the Thesis

As every work, even this thesis has its own limitations. One of the biggest limitations, from the author’s point of view, is seen in the impossibility of adaptation of the results to another country or its reproduction. Each individual country has set different attitude towards the Industry 4.0 and created different supportive frames and instruments. Also, the general awareness about the start-up problematic is different across the countries, as for example in the Czech Republic start-up is still relatively new area or term, which

in the majority of the cases belongs to small and medium sized enterprises and it is not given any particular attention.

This fact can also create biased results as data available for start-ups are quite limited in the Czech Republic. Despite this, author use data that are relevant for start-ups and in the same time for the Industry 4.0 concept. Author tries to avoid selecting random examples of the successful Czech start-ups and supportive instruments, but more backed up the selection by available resources and emphasize the importance of selected information.

Another limitation is seen in relatively narrow and specific area of the research, showed in the figure 1, as it combines 3 main actors, the Czech Republic as a country, start-ups and the concept the Industry 4.0. Undoubtedly, different results can be gained by observation the start-ups in Germany or the attitude of the multinational companies in the Czech Republic towards the Industry 4.0 practices. However, the strict borders of the selected area should help to decrease the potential bias.

6. Literature Review

The Literature Review part examines the relevant literature on the two out of three main actors at this thesis, the Industrial Revolutions and the start-ups. It also sets the scene for the further research and other chapters are built from this part. It can be also understood as the first step towards answering the research questions.

The Literature Review examines the relevant literature on the topics of the Industrial Revolutions and their effects not only on the economies but more on the overall society. During these Revolutions new industries and companies are created, where effectuation and causation approaches introduced by Sarasvathy take place. After this, the general introduction to start-ups begin with their definition, types and life-stages they usually go through. One of the most important parts of this thesis are seen in parts dealing with financial and non-financial support that start-ups can use for their future growth. Finally, the importance of the start-ups is highlighted.

6.1. Industrial Revolutions Background

Industrial Revolution can be characterized as a period of swift changes from an agricultural to a modern or technical society, where lifeless energy, innovation founding, and improved productivity level take place. Until now, mankind has been facing 4 Industrial Revolutions. All these revolutions have been affecting (as the last, 4th, Revolution is happening these days) economy and natural surroundings as a whole and what is more - set basics for current working class. It cannot be forgotten that globalization has been influencing these Revolutions, which has led to wider cooperation across the world. (Matthews, 2014)

Supporting this, Snooks (2002) claims that what is unique about the Industrial Revolutions is fact that caused technological paradigm shift. These changes began in Britain in 18th century and caused shift from the agriculture-based economy to more industrial one. However, he also argues that without economic growth reached during centuries before, it would not be possible to reach these achievements and growth would not be that significant as it was.

It is not surprising that as one of the consequences of the Industrial Revolution, the outcome should grow. At this case, it can be spoken about outcomes from manufacturing, agriculture or services. Without any doubts, invention and innovation are considered as central factors in the Industrial Revolutions, but other factors, such as market size or labour cost, must be taken into consideration as well. (More, 2014)

Revolutions usually start from the radical innovations and followed, by certain time, by many incremental innovations. Changes appear moderately in the beginning of the process as feedback and interaction, from for example consumers or suppliers, is needed in order to reach a dominant design followed by a maturity. Incremental innovations play crucial role in the overall process. *“Each¹ can be seen as inaugurated by an important technological breakthrough acting as the big-bang that opens a new universe of opportunity for profitable innovation.”* (Perez, 2010)

These Revolutions have influenced not only economy or industries in practically all countries around the world but also other areas of society at all according to Dorothea Kleine and Tim Unwin (2009). Revolutions have consequence in “power layout”. *“Because of path dependency, those who ‘came late’ often stayed ‘behind’ while trying to ‘catch up’.”* (Kleine & Unwin, 2009).

6.2. Effectuation and Causation Approaches and New Industries

It is evident that countries do not want to stay behind or catch up, they want to stay ahead. According to the OECD, country, which shows a large scale of entrepreneurial activities also generate new solutions, products or services. These activities are often connected to innovation as one of the main drivers of the growth. Furthermore, as it is going to be explained later on the case of the Czech Republic, entrepreneurs should be as a main actor in the transition process from the centrally-planned economy towards market economy. (OECD, 1998)

However, how can the government, public or anybody can start the transition process and create the market economy if there are not any entrepreneurs? Sarasvathy (2001) argues that there are two possible processes: causation and effectuation. Definitions are following: *“Causation processes take a particular effect as given and focus on selecting between means to create that effect. Effectuation processes take a set of means as given and focus on selecting between possible effects that can be created with that set of means.”*

She uses example of chef in a restaurant. Causation can be explained as a situation when customer is given a menu, select meal and chef already knows what ingredients are needed for a particular meal. On the other side effectuation speaks about the situation when customer asks chef to prepare something from ingredients that are available

¹ In the meaning of „Industrial Revolution“

in the moment and chef has to use imagination to create the menu. In the first case the goal was clear, finished meal for customer, the second case is based on the given set of means (existing ingredients or tools) and uncertain result, chef has to choose among different alternatives.

As mentioned in the previous subchapter, humankind has faced 4 Revolutions, which created new industries and companies. However, creating a new company in non-existing industry calls for different approach than in the traditional/existing one. *“These endeavours that opened up new markets and industries plugged into and exploited social and technological contingencies that could not have been anticipated or planned for. Also, they involved changing (not fulfilling), often on a revolutionary scale.”* It is evident that “pioneering” entrepreneurs would predominantly use the effectuation approach, rather than late comers, which would focus on the causation way. Entrepreneurs usually begin with the set of 3 means: who they are, what they know and whom they know. However, Sarasvathy claims that none of the approaches is the best one or more effective in the practise. (Sarasvathy, 2001)

6.3. Introduction to Start-ups

The word start-up was firstly used in the magazine Forbes back in 1976 (Start-Up, 2016) and since that time it became one of the most famous buzz words across the world. But what does start-up actually mean? Many definitions can be found across the Internet, for example:

- A start-up is a firm in the early stage of its activities. It is usually financed by its founder/entrepreneur, who tries to exploit developing product or service in the hope that satisfactory demand exists for this product or service. Majority of these small start-ups have problem in the long term as they face financial constraints due to initial high costs or small revenue; (Investopedia, 2018)
- BusinessDictionary (2018) sees start-up as an initial period in company, where can be seen the basic hierarchy and set-up. This period of time can be characterized as a time between initial idea and secure financial questions.

Slightly different view has Paul Graham (2012), who has financially supported more than 1000 start-ups.

- Start-up does not need to be necessary recently created company. Nor it is important to come up with new technological solution or be supported by various venture capitalists. The core of the start-up lies in the word *growth*. Graham mentions example

of thousands new companies across the United States in different fields, mainly in services such as restaurant, bakery etc. However, these companies are not set-up to grow quick. They need to have “different DNA” and need to be distinct since the beginning.

There is even a broad consensus about the “age” of the start-ups. Definitions above speak only about early or initial stage of business, but how long does this stage take? Some claims 5 years, other says 3 and other group argues for 10 years. Other tensions are seen in profitability and number of employees of the start-ups. The precise edge is missing again. Lastly, can be an acquisition of start-up considered as the end? Also, this question does not have a right answer. All in all, Natalie Robehmed (2013) from Forbes magazine concludes the start-up question with this: *“Likewise, if you’ve just set up a tiny for-profit enterprise and are intent on it becoming big enough to take over the world – even if you’re still working from your bedroom – you’re probably a startup founder.”* The more detailed view on Czech start-up characteristics are specified in the chapter 9.

6.4. Types of Start-ups

On the Internet or across the relevant literature to start-up topic can be found many different distributions of start-ups. At this work, author wants to mention 3 types of start-ups or their distribution.

6.4.1. Lean Start-up

The term lean, in connection to start-up, does not mean small or start-up without any financial resources but it has origins in lean manufacturing created in automotive brand Toyota. The core lies in cutting ineffective activities or activities, where is not seen any value. All activities should aim to customer and his/her needs. Founder of this approach, Eric Ries (2018), claims: *“Startup success can be engineered by following the process, which means it can be learned, which means it can be taught.”* Lean Start-up is set of tools and principles (build, measure and learn), which should to decrease potential risks by testing possible solutions.

One of the biggest initial obstacles, according to Reis, lies in the fact that many entrepreneurs think and shape their ideas for a very long time (months or even years) without speaking to potential clients and customers. When start-ups or companies launch their products, they do not meet customer needs as customers do not fully understand the product or service itself. (Cooper, Vlaskovits, & Ries, 2012)

6.4.2. Steve Blank Approach

Steve Blank (2018), whose model, Customer Development, serves as basics for above mentioned Lean Start-up approach, has discovered during his entrepreneurial career that start-ups can be divided into 6 different groups according to their strategies, funding and people within the company.

1) *Lifestyle Start-ups: Work to Live Their Passion*

- Usually start-ups, where the passion is combined with work, for example web designers;

2) *Small-Business Start-ups: Work to Feed the Family*

- According to Graham (2012) and his definition of start-up, this group should not be included in the list as here is spoken about small companies (such as groceries, plumbers, etc.), which usually do not growth very fast. However, these start-ups create the majority in the total number of entrepreneurs. Furthermore, they frequently create jobs for local people;

3) *Scalable Start-ups: Born to Be Big*

- Aspiration of these start-ups is through visions change the world. Their ambition here is to be traded on the stock market or be acquired. Start-ups at this group seek for risk capital, primarily from venture capitalists. As an example can be mentioned: Google or Facebook;

4) *Buyable Start-ups: Acquisition Targets*

- Compare to the previous group, buyable start-ups aim to be sold to large companies rather than looking for funds from venture capitalists. Typical case is creating website or mobile phone application, which are then sold;

5) *Social Start-ups: Drive to Make a Difference*

- Very close to scalable start-ups lies social start-ups. These companies target to “make the world a better place to live” rather than making millions of profits;

6) *Large-Company Start-ups: Innovate or Evaporate*

- As every company has its own lifecycle and during last decades this lifecycle has shorten, it is necessary for companies in order to survive to develop new business models. New structures and knowledge is needed to face this challenge.

6.4.3. Unicorn Start-ups

Special group of start-ups public calls Unicorns. Why unicorns? Significance here is on the scarcity of these start-ups as they have valuation higher than 1 billion USD. First list of Unicorn start-ups was created back in 2013, when Aileen Lee identified 39 unicorn companies. Nowadays two separate lists of Unicorn start-ups exist. (Pahwa, 2018)

The first one, published by the magazine Fortune included 174 companies, where the first 3 places take transportation platform Uber, followed by Chinese smartphone producer Xiaomi and accommodation platform Airbnb. (Fortune, 2018) The second list, created by CB Insights speaks about 237 Unicorns with Uber on the 1st place, followed by Didi Chuxing (“Chinese Uber”) and Xiaomi, where Uber reached valuation equals to 70 billion USD. (CBInsights, 2018)

What makes Unicorn start-ups unique? First of all, almost every Unicorn has made disruption within its industry or area. Airbnb highlights the feature of sharing economy, while Uber changed people habits how they call taxi. Secondly, their activities are ongoing, and they do not rely on one competitive advantage only. They understand that constant innovation and development is key to success.

Also, Unicorns’ activities are spread across different areas and it would be spotless to say that all of them are technological start-ups, although majority of them (87 %) are based on software application and the rest on hardware or other product and service. Lastly, more than 60 % of companies are focused on B2C market segment. The reason is quite simple: make the things uncomplicated and affordable for customers. (Pahwa, 2018)

However, the study made by the National Bureau of Economic Research claims that almost half of tested start-ups (base was 135 companies) should not be valued more than 1 billion USD. Being the Unicorn is perceived as prestige status, in order to reach this companies agreed on special conditions for new investors, such as new share classes with extended votes or veto rights. (Griffith, 2018)

6.5. Life Stages of Start-ups

Andrew Metrick and Ayako Yasuda (2011) at their book called *Venture Capital & the Finance of Innovation* define 4 stages of growth relevant to companies, which are supported by the venture capitalists. Although the book is mainly relevant for beginners at venture capital sphere, it still can be used as a framework for start-ups as they are in the focus of venture capitalists.

1) *Seed/Startup Stage*

- This stage usually includes activities such as product development, research of relevant markets or creation of business plan. This stage can be also called pre-marketing. In terms of financing, very little amount of support is provided to company;

2) *Early Stage*

- At this stage, authors speak about company, which exists for less than 3 years, however, it is not a necessary condition. Market research and product development are usually finished during this period and companies test their product or service. First rounds of financing offers can appear;

3) *Expansion (Mid) Stage*

- Company produces and sells its product or services, but it does not need to be profitable. Received financing can be used for further expansion, improving product or service;

4) *Later Stage*

- Last stage of company is called later stage, where it is quite common that growth is not that fast as in previous stages, but it is expected that profitability should increase. In terms of financing, IPO (Initial Public Offer) is one of the options.

Damodaran (2015), a professor of finance at the Stern School of Business at New York, stresses the importance between technological and non-technological start-ups. As a technological company he has in the mind company, which primarily creates value from various technologies. He arrives from the assumption that technological start-ups often act in areas where almost no entry barriers exist. Connected to this, technological start-ups usually have better access

to funding at the early stages, so it means, they can grow faster than non-technological companies.

However, technological companies cannot “enjoy” so called mature period for a long time as the environment is more competitive and turbulent. Also, they often lose their competitive advantage earlier than non-technological one. Another difference is during potential decline period as technological companies face rapid downturns due to appearance of newcomers or changing in customer needs. On the other side, it takes longer time for non-technological companies to grow up as more investments are needed. Furthermore, during the decline period they can cut some of the activities, but still act on the market. This is not usually way for non-technological one as they frequently close their businesses.

6.6. Financing of Start-ups

As the financial aspects were touched in previous chapter and as it was mentioned in previous chapters, finance plays one of the crucial roles for potential success of start-ups. Based on the book by Robin P. G. Tech, *Financing High-Tech Startups* (2018), 8 different options for financing start-ups exist and they will be shortly described.

Self-funding and FFF

Investing own money is often the first available option for entrepreneurs. After earning first profits, they can reinvest these profits back into the company. This process is called in start-up terminology bootstrap. Abbreviation FFF shelters words Friends, Family and Fools, as they, in the majority of the cases, also invest their own saving or money. They usually provide financing on better conditions than for example bank, so it means with low or none interest. Common motivation behind is not to earn profit from this investment but more about support of the entrepreneur. These first additional sources can give entrepreneur better flexibility and certainty in the beginnings.

Business Angels

Business Angels regularly appear in the first stages of start-up as well. In contrast to the FFF group, they usually bring higher amount of money (starting from 10 000 USD or euro) into business. Motivation of Business Angels differs from one to another. Some of them aims primarily to support new and fresh entrepreneurs, another expects high profitability on their investment. Generally speaking, relations between Business Angels and entrepreneurs are less

formal compare to other following groups, especially venture capitalists, and they demand less control rights.

Business Angels frequently create specialized portfolios, like around particular industry, area or technology, and their portfolios include dozens of start-ups. However, Fairchild (in Tech, 2018), claims that Business Angels does not bring any meaningful value into start-ups.

Banks

Traditional way of getting financial resources are banks. They provide clients with different options, namely: credit cards, mortgages or loans for various purposes. Nevertheless, banks are not typical subject for financing start-ups due to rigid terms and conditions. More common way for start-ups is seeking help in banks owned by individual states as these banks are in the majority of the cases created for providing public support for businesses.

Public Subsidies

Subsidies can have various forms and Tech divides subsidies into monetary initiatives and others. As an example of other than monetary subsidy can be mentioned: creation of spaces for work or offer of education. Monetary can include various grants, subsidies, tax reliefs or loans provided on low interest basics. In the global view, this category is one of the most crucial in terms of funding start-ups and SMEs.

Public subsidies should “fix” gaps between market imperfections caused by unequal spending on projects, which does not need to be necessary in direct interest of the public. However, until now many cases and researches do not proof any clear results about effects of these initiatives on start-ups or SMEs.

Crowdfunding

A new and unique option for start-ups represents crowdfunding financing. Crowdfunding can have different forms, such as reward-based, donation-based or P2P lending. Reward-based solution is considered to be the most used in the beginnings and it means that people, called backers, financially support start-up and in return receive reward in the form of the final company product or service in the future. Few platforms were created in order to support crowdfunding community, such as Indiegogo or Kickstarter.

Crowdfunding enable companies to make experiments with their product or service, whether it fits the market needs or not. Nowadays practice is that crowdfunding is used mainly in the seed stage, however, the wide potential is hidden even in the later stages of start-up. Crowdfunding itself can also serve as an indicator for spotting the unique product or service.

Family Offices

Family Offices are quite rare group among others as here is spoken about wealthy families, which are owners of already existing companies and they try to diversify their activities. This group usually do not invest into start-ups in the early stages as there is a high level of uncertainty and they rather look for lower level of risk. Because of this reason they cannot be considered as the Business Angels.

Corporate Venture Capital and Accelerators

Speaking about Venture Capital, specific group can be identified called Corporate Venture Capital. Settled companies create special units for running strategic investments as they want to gain intellectual property rights, get new skilled employees or simply extend their activities to new markets through start-up. Main motivation behind Corporate Venture Capital is not to receive high profits from their investment but rather secure or gain some unique feature of the start-up. However, not in all cases this knowledge and idea share is done in the “friendly” and legal borders.

Start-up accelerators focus on companies in their early stages as they can provide not only financial support to companies but combine more elements, such as education or mentorship. Companies participating in accelerators quite often go through intensive programs, which should boost their activities in the early stages. One of the specific features of accelerators is that they provide support only for fixed period of time. (Hathaway, 2016)

Venture Capital

Large investments are normally done through Venture Capital option. Here can be combined resources of one VC firm or more. VC firm collects financial resources from other entities, called limited partners, and invest their money commonly into start-ups with high potential and growth, but in the same time, these types of start-ups are one of the riskiest. VC companies have predefined strategy in terms of timing, when they enter start-ups or specific industry or area to invest on. VC investments are usually done through so called series.

Following the text above, the figure 2 summarizes common life stages of start-ups and types of investments, which are used during these stages. As it was described earlier, Business Angels, FFF and accelerators play the main role in the seed/start-up stage, so it means in the beginning of start-up activities. When start-up develops, crowdfunding and venture capital are the main resources for financing. If start-up is successful, it can be acquired by another company, merge with other entity or try to be listed on the stock market (IPO).

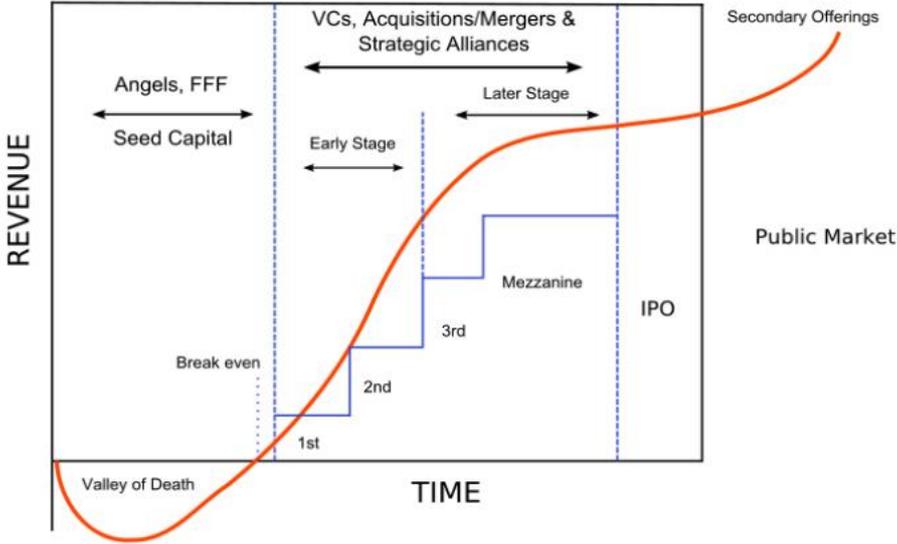


Figure 2- Start-up Financing Cycle

Source: (Novoa, 2017)

6.7. Non-financial Support of Start-ups

Previous subchapter speaks about financial support. Start-ups can be supported not only in terms of money but also by other ways. Author selected 2 other options to explain how they can help in start-up activities and development. One of the category, accelerators, was already mentioned above as it combines both aspects, financial and non-financial support.

Clusters

Clusters are usually created on regional level and puts together companies from the same business areas, such as suppliers, customers or even universities. Specific feature about clusters is that they cooperate and in the same time create competition. This create environment for boosting innovative activities, as none of the companies wants to stay behind the progress, increasing productivity, as companies can share information or collaborate with universities, and finally new companies can emerge. (Østergaard, 2016)

If it is assumed that majority of start-ups can be still considered as SME company in the same time, almost 40 % of the EU jobs are based on regional level. Nowadays, around 2000 clusters exist across the European Union. (European Commission, 2018)

Incubators, Technological Parks and Other Organizations

The main target of incubators is to encourage entrepreneurship and provide support to participating companies especially in the initial stages of their life. They usually provide variety of services:

- 1) Low rents in the incubator space;
- 2) Help with business plan development;
- 3) Managerial advices and access to incubator's network;
- 4) Administrative support;
- 5) And in some cases, financial instruments.

Each incubator offers different service and it creates space for creating new and competitive incubators. Also, incubators have different purposes and set-up. Some of them can be non-profitable (usually supported by local government or investors), another will to collaborate with universities and public institutions or they only target for companies in specific industries. (Rubin, Aas, & Stead, 2015)

Close to this group stands technological parks and science centres as they are based more or less on the same principles as incubators. They encourage entrepreneurship and support knowledge and information sharing across participants. Collaboration with the local universities is also very common. (Chleboun, 2012)

Last but not least, various agencies supporting start-ups can be mentioned. They are usually funded from the public resources, but also non-governmental organizations exist. However, each country has selected different approach and has created different organizations for this purpose. In general, they can provide variety of services, such as market research or analysis, they can help start-ups in terms of finance access or participation on different projects. Regarding to this category, more detailed view is given in the subchapter 9.4.

6.8. Importance of Start-ups

Across the literature and internet resources can be found many information and reasons, why start-ups are important not only for economy itself but for society as a whole. After reading and going through many academic and public articles, 2 main aspects and few “smaller” raised.

6.8.1. Market Gap Filling

In the majority of the cases, start-ups act in the fields with high turbulence and uncertain environment. They have to face many problems, especially during the initial period. According to Lim, Ken and Minshall (2015): *“The role of start-up companies as a source of innovation and an engine of economic growth is increasingly recognised by Western economies.”* Traditional companies can enjoy benefits of economies of scale, stable financial foundations or wide product portfolio, but this is not a case of start-ups. However, established companies carry the burden of fixed costs, such as equipment or facilities.

On the other side, start-ups usually dispose of fewer resources, but in the same time they have almost no liabilities. Inside the start-ups it is quite normal that strategic or long-term planning is missing. This can be caused by lack of managerial experience or financial constraints. The main point here lies in the freedom in terms of creating or adopting their own strategy or solutions. (Lim, Platts, & Minshall, 2015)

Uncertainty and disequilibrium² on the market create space for entrepreneurs and start-ups as they are able to fill these gaps by their new solutions. They see opportunity in this situation of imbalance. However, start-ups must have certain level of market knowledge in order to spot the gap and have sufficient resources available. They can also face problems in terms

² Based on Kirzner’s model, which assumes that entrepreneurship by filling the gaps makes equilibrium. On the other side, Schumpeterian definition speaks about equilibrium as a normal state and disequilibrium is created by entrepreneurs and innovators. (Andersen, 2016)

of insufficient production capacity or working power in order to satisfy relevant demand or adequate amount of financial resources to solve these problems. (Liyis, 2007)

Another point here is approach to risk. Without any doubts, start-ups are type of the company with one of the highest rates of failure or bankruptcy. Nevertheless, established companies prefer to invest into smaller scales project and technologies, where the risk is controllable, and returns can be predicted easily. These companies often have limits on budgets that can be spent on innovation and technologies. Opposite to this, start-ups stand. They will to invest into breakthrough technologies and are aware of risks and further potential failure of all company. Investments to innovation or technology can move them into the front of the market despite the high risk. (Cohan, 2011)

6.8.2. Creation of New Jobs

Stel and Suddle (2007) based their research around creation of new work places in connection to formation of new companies in the Netherlands. In the theoretical part they claim that creation of new businesses has direct and indirect effects. While, as an indirect positive effect can be mention introducing new technology or solution to market and reducing prices or increasing demand, which follows the logic of above mentioned point, indirect negativity can be seen the jobs lost in companies, which are affected by this new situation. The main direct, and in the same time positive one, is creation of new jobs.

The OECD (Criscuolo, Gal, & Menon, 2014) had collected employment data from 18 countries since 2001 until 2011. From the figure 3 below is evident that young companies (until 5 years since creation) showed disproportion in terms of newly created jobs and jobs that were lost in these companies. Young and small companies (less than 250 employees) contributed around 18 % to the total employment in selected countries of research. Despite the fact that “old” and small companies employ almost half of workforce they also created the biggest number of lost jobs so in other words negative gap. The same research showed that more jobs were created in service sphere rather than manufacturing, however, young companies still positively contribute to creation of the new jobs.

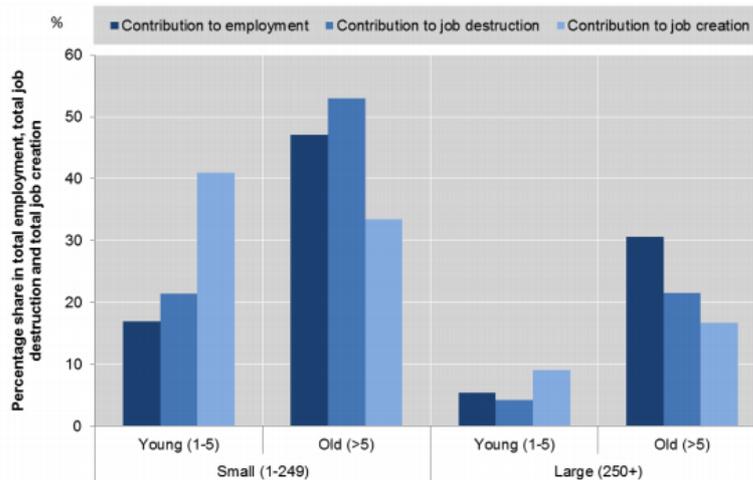


Figure 3- Employment, Job Creation and Job Destruction by Firm Age and Size

Source: (Criscuolo, Gal, & Menon, 2014)

Other report published by the Global Entrepreneurship Monitor (Kelley, Singer, & Herrington, 2016) collected data from 60 countries across the world around entrepreneurial activities. One of the parts of this research speaks about future job creations. It can be surprising that around 40 % of asked entrepreneurs do not want to create any new job in next 5 years. On the other side, the same share would like to employ up to 5 new employees and the rest (20 %) aims to 6 and more new jobs. The reasons behind unwillingness to create jobs were following: selected form of business, labour restrictions and regulations, lack of skilled workforce or economic situation.

6.8.3. Other Important Aspects

As mentioned in the beginning, start-ups influence not only economy itself but have influence on more spheres. Different governmental or (in the case of the Czech Republic) European Union initiatives or programs can enhance the firms' activities, such as innovation centres or science parks. As start-ups usually control certain knowledge to some degree and they want to grow in the future, there is high possibility that their knowledge will be diffused to other subjects. Geenhuiizen (2003) uses example of universities, which can collaborate with start-ups. In the most countries, universities are financed and controlled by government, which are responsible for innovation policies.

Setting the right conditions and environment for knowledge exchange or academic start-up can definitely improve future progress of start-ups in general as they can benefit from positive effects. Moreover, positive examples in Chile and the United Kingdom showed that the right set-up of the local environment can be beneficial for creation new companies, such as cutting

costs for registering new companies or bureaucracy. Entrepreneurship education should be part of school subject to increase awareness about start-ups or entrepreneurship itself. (Geenhuizen, 2003) (Kelley, Singer, & Herrington, 2016)

James Rosebush (Potente, 2015) claims that: *“The private sector economy has a life blood, and it is startups.”* In other words, it means that start-ups do not only create new jobs but move private sector ahead as they manifest creativity and innovativeness, and furthermore turn ideas into real life. Rosebush highlights that community should support local start-ups as they are integral part of the local system. He has in mind creating incubators or financial support from the local funds.

Following this, it is important to have in the mind that changes happens rapidly and impact many industries or countries in the same time. Products, services or technologies can be used almost everywhere in the world despite the country of the origin. Simply saying, market and customers are changing. Core of many start-ups lie in technologies and based on them products and services are designed. Final results of start-ups activities can be sold worldwide not only in the home country. This growth should help in creation new jobs, bringing profits and investments into the local country. Start-ups are flexible as they can be placed almost anywhere in the world if the founder(s) see favourable conditions, such as infrastructure, governmental initiatives and so on. (Gerard, 2016) (Shabangu, 2014)

7. The Concept of Industry 4.0

This chapter enlarges the more theoretical background of the Industrial Revolutions in the way of the practical implications that the Industry 4.0 can have. Furthermore, by deeper understanding of the Industry 4.0 concept reader should be able understood the common aspects of the start-ups and the Industry 4.0.

Following the beginning of the Literature Overview, this chapter speaks about the potentials of the Fourth Industrial Revolution, its various future technologies, current challenges and opportunities. Furthermore, few actual tendencies can be identified from the available resources, such as adaptation of new technologies or the question of automatization. Despite the fact that the Fourth Industrial Revolution has different naming around the world, author identifies the main frameworks dedicated to this area. Finally, the global role of start-ups within the Industry 4.0 is illustrated and supported by the latest researches at this area.

In the history of mankind, four Industrial Revolutions are known. By inventing steam engine and horde extraction of coal 1st Industrial Revolution started at the end of 18th century. This lead the move from an agricultural to an industrial society. Following, 2nd Industrial Revolution, was heavily influenced by two factors: mass production of electricity and large-scale production. Almost century later, in the second half of 20th century, 3rd Industrial Revolution took place and it has been continuing until these days. Nuclear energy appeared as a new and valuable resource of energy. Electronic devices, including telecommunication devices, computers or processors play the major role at this Revolution. The main goal is to achieve automation of manufacturing processes. (Bartodziej, 2017) (Sentryo, 2017)

The 4th Industrial Revolution has roots in Germany in 2011 based on the initiative called Industrie 4.0. Across Europe, the whole concept is named Industry 4.0, following the German term, in the US can be found frameworks called “Advanced Manufacturing” or “Smart Industry”. All these concepts and initiatives have common target in delivering: “*fundamental improvements to the industrial processes involved in manufacturing, engineering, material usage and supply chain and life cycle management.*” (Hermann, Pentek, & Otto, 2016)

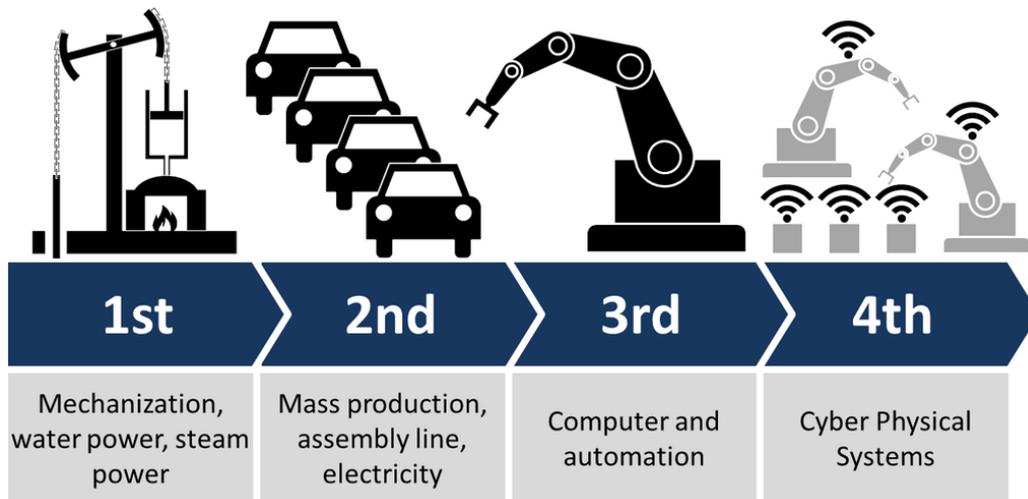


Figure 4- Industrial Revolutions

Source: (Roser, 2015)

The initial idea behind the Industry 4.0 was to strengthen the competitiveness of German manufacturing industry. It was not only governmental idea, but it was also supported from business and academic area. The Industry 4.0 became part of so called “High-Tech Strategy 2020 for Germany” and was founded by nearly 200 million euro from governmental resources. (Hermann, Pentek, & Otto, 2016)

The Industry 4.0 does not have any exact definition or explanation what is and what is not within the frame of the concept. However, Ustundag and Cevikcan (2018) claim that: “Industry 4.0 is comprised of the integration of production facilities, supply chains and service systems to enable the establishment of value added networks.” The Industry 4.0 also takes into account new and emerging technologies, which play crucial in the current days. They describe three centre features and nine supportive technologies, which should be part for successful adaptation to the Industry 4.0.

- a) *Vertical Integration and Networking of Manufacturing or Service Systems*- provides production with flexibility and ability to produce small lot sizes via different cross-linking across organizational levels;
- b) *Horizontal Integration via Value Chains*- by observing production in different companies, horizontal integration can improve product life cycle;
- c) *End-to-End Engineering of the Overall Value Chain*- usage of supportive technologies, which will be named below, and digital integration can help in development of new products.

- 1) *Adaptive Robots*- these robots are result of microprocessors and Artificial Intelligence combination, which gives robots not only to be part of production but also be autonomous and they are able to divide tasks into subtasks, which are filled by different modules;
- 2) *Embedded Systems*- in the reality, embedded systems are usually created by sensors, controllers and other features, which help to integrate physical reality with digital tools;
- 3) *Additive Manufacturing*- “*is an appropriate name to describe the technologies that build 3D objects by adding layer-upon-layer of material, whether the material is plastic, metal, concrete.*” (Additive Manufacturing, 2017);
- 4) *Cloud Technologies*- having data and information available in real time help to coordinate production and enable to utilize available resources;
- 5) *Virtualization technologies*- virtual and augmented reality provide user with visual presentation of different features within created environment by using properties like smart glasses or smart lenses;
- 6) *Simulation*- very close to the previous point is simulation, which support decision making before implementing solution. Simulation can take form of visualisation or different scenarios can be simulated;
- 7) *Data Analytics and Artificial Intelligence*- information and data (nowadays called Big Data) flow inside the companies from different sources (R&D, manufacturing, etc.) and they can be used in terms of adaptation to new challenges. This flow can happen by using the right technologies, such as readers, sensors or RFID tags;
- 8) *Communication and Networking*- mainly can be seen as an intermediate between physical tools or machines and its connectivity among each other, in other words Industrial Internet of Things;
- 9) *RTLS and RFID Technologies*- these technologies assist in traceability, transportation or logistics activities as they can easily locate or detect objects. (Ustundag & Cevikcan, 2018)

7.1. Challenges and Opportunities of Industry 4.0

“We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before,” says Klaus Schwab, founder and executive chairman in World Economic Forum Geneva. It is evident that the Industry 4.0 or the 4th Industrial Revolution is not only about manufacturing or industries themselves,

but it has been affecting many areas of daily life. Many of people routines and activities can be done remotely, such as listening to favourite music, ordering air tickets and so on. (Schwab, 2016)

According to survey made by Business Development Bank of Canada (2018), 60 % of asked entrepreneurs claimed that digital technologies boosted their businesses as it helped them in more efficient prediction, optimization and maintenance. One of the biggest advantages was seen in sensors, which can easily control the quality and time for production and in the same time they reduced the operational costs, mainly in terms of real time control.

However, Abdulmughnee (Business Development Bank of Canada, 2018) claims that every integration needs considerable amount of time and effort to be fully implemented into the current structure.

Another point is that by collecting data inside or outside the company (mainly from customers, suppliers, etc.), company can gain valuable source of information, which can help in real-time planning and scheduling not only in production. Also, as company has customer's information and data available, company can more easily adopt to its needs because company can use recent technologies, machines and modules for individual or batch tasks. On the other stands the issue of potential abusing these gained data, mainly concerning data security and high level of reliability or stability of the overall IT system. (Comerford, 2016) (Marr, 2016)

Brynjolfsson and McAfee (in Schwab, 2016) raised the concern that this Revolution can cause even greater inequality, specifically in terms of labour market. It can lead to labour market, which would have only low skilled and in the same time low paid workers, or on the other side high skilled and highly paid jobs. Furthermore, gap can be even wider when taking into account dependency on capital or labour. Those, who provide capital or technologies, such as investors, innovators and others, would benefit more from the Industry 4.0 and its features, however, those, who depend on labour, would possibly earn less. Erwin Telöken, General Manager of German company TEKA, argues that manpower will be needed in any case and it will be still the crucial aspect of boosting the innovation across the industries. Also, *“with the Industry 4.0 it is possible to deploy a lot of employees according to their competences and training. New industrial branches will arise, service and flexibility will increase.”* (LaserTeknik Journal, 2017)

Recent trend visible from the figure 5 is that dominant focus on employee’s training lies on high and medium skilled positions. On the other side, minority of training possibilities goes to low skilled workers.

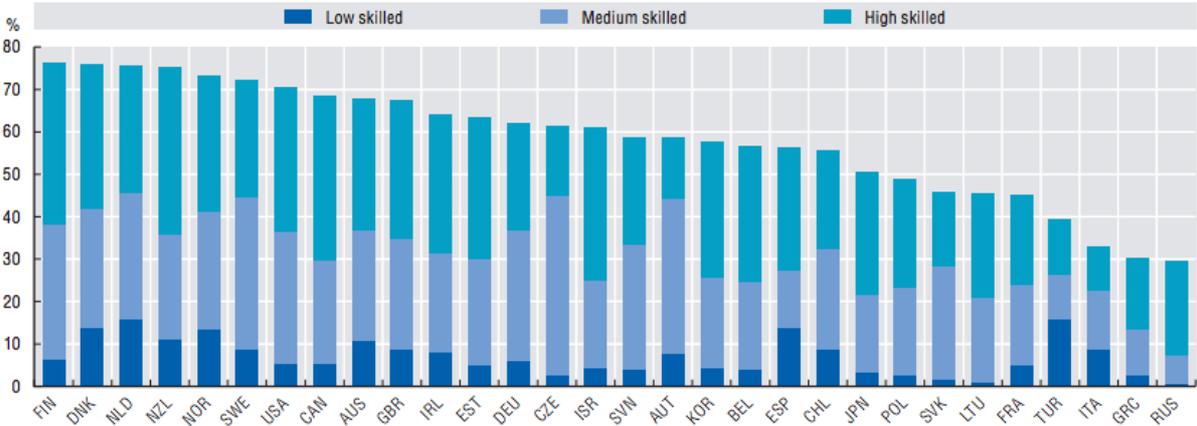


Figure 5- Workers Receiving Training According to Their Skill Level

Source: (OECD, 2017)

7.2. Recent Tendencies in Industry 4.0

Business world has been facing many challenges during last few years, at this place can be mentioned increase in trade across national borders, in other words growth in international trade, sold products are usually “packed” with extra services and lastly these products can be delivered digitally by using different technologies.

7.2.1. Adaption of the Technologies and Changes

These challenges have been affecting global value chain as companies use different locations for different tasks and also favourable local trade conditions. Another point is how companies work with knowledge and information. Nolan and Pilat (2016) claim that OECD countries have been focusing on activities, which are connected to production of the goods (such as software, design, R&D, etc.) rather than production as such. They also claim that The Next Production Revolution should create new and unexplored combination of recent technologies. They mention possibility of using Big Data and its analysis, autonomous robots or nanotechnologies. However, on the other side consequences of these technologies and their feature are obscure. Most businesses have not been able to adopt latest technologies and unleash their potential into practice. These technologies should affect organizations as a whole, such as management, workplace and so on. (Nolan & Pilat, 2016) Also, the knowledge and skills needed in the future

can rapidly change regardless the economic status of the country. Latest technologies can replace some of the skills needed in production, mainly cognitive one, nevertheless, social skills and creativity are probably one of the most valuable ones.

Countries, which lose momentum for adopting to these changes, can experience decrease in competitiveness in general. Companies have to think about their innovation model as the “old and traditional” (typically represented by high investment into internal research and development) which is not that effective anymore. On the other hand, being open to new ideas and collaboration from the sphere of entrepreneurs, especially start-ups, takes the leading role in innovation models. Technological start-ups emerged all around the world and they helped to begin with disruption of “traditional” businesses and creating new one. As a result, local innovation and businesses appeared and new work places were created. (Mulas, 2016)

As an example, there can be mentioned South Korean government with its promotional activities toward the Industry 4.0 concept. One of the governmental points is to create committee dedicated only to the Industry 4.0 topics and issues. This committee should consist of experts not only from governmental sphere but also from businesses under supervision of the Ministry of Science. Another point focuses on small ventures and their support in terms of R&D. Lastly, governmental investments should flow into projects, where the connection to the Industry 4.0 is seen, such as motorways for autonomous cars. South Korean government proactively steps into education and skills development of its citizens by issuing state programs aiming to spheres influenced by the Industry 4.0. (Choi, 2017)

7.2.2. Automatization in the Industry 4.0

Another “hot” topic within the Industry 4.0 or the Fourth Industrial Revolution is automation. Even though that automation was the core of previous Revolution, it still has consequences and influence on the current revolution. Manyika et al. (2017) claim that: *“Automation will change the daily work activities of everyone, from miners and landscapers to commercial bankers, fashion designers, welders, and CEOs.”* Automation should ensure that businesses can improve quality and momentum of production and in some cases, results can overcome human work. Manyika et al. forecasted that automation itself should boost productivity around the world from 0,8 to 1,4 percent. However, in each sector of economy results should vary but almost every work place can be affected by automation in the same time. Their estimates speak about 15 trillion USD saved by potential automation benefits. On the other side,

automation is not a short-term goal and possibly faster on micro-economic level, rather than on macro level. (Manyika, et al., 2017)

Supporting this, McKinsey Global Institute (2017) analysed 54 countries, which count from more than ¾ of global work power. All in all, more than half of labour power have potential to be replaced by automation technologies and machines. The figure 6 illustrates the percentage of potential jobs affected by automation in different countries. Size of the frame shows the part of each individual country on the global total. The most disturbed areas of economy can be seen in agriculture (jointly with forestry, fishing and hunting), where almost 700 million people work nowadays, manufacturing and retail trade. In all these areas potential of automation is above 50 %.

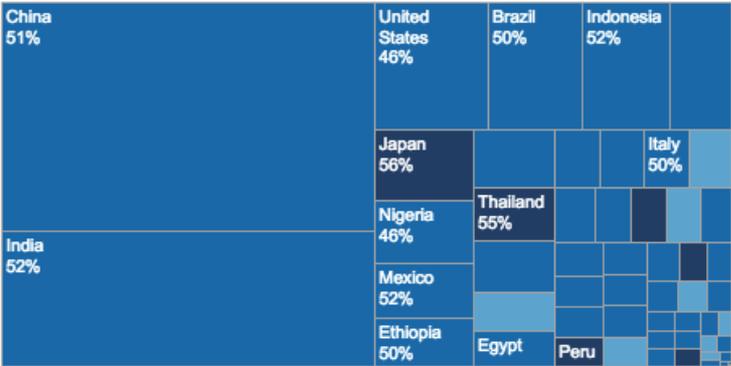


Figure 6- Global Potential for Automation

Source: (McKinsey Global Institute, 2017)

7.2.3. Industry 4.0 and Anticipated Skills

Even Organisation for Economic Co-operation and Development (OECD, 2017) admits that current technological progress will unavoidably influence today’s industries and these technologies will determine the success or competitive advantages of companies. *“But resilience and prosperity will be more likely in countries with more forward-looking policies, better functioning institutions, better educated and informed citizens, and critical technological capabilities in a number of sectors.”*

Furthermore, OECD recognize few aspects, which should lead to benefits from the Industry 4.0. Companies should invest not only into hardware (such as robots or machines) but also into complementary assets and know-how. This can lead to work power moving and creating new firms. Connected to this, governmental institutions should provide support in this technological dispersion, namely across small and medium sized enterprises.

Also, education system should be closer to current industries and their needs as newly promoted technologies seek for educated and skilled employees. Numerical, problem-solving or IT skills can play the major role at this topic as the data and information gained are expected to be central aspect in 21st century. Lastly, not only government, but also businesses and leaders should set long-term goals on top of shorter targets and these goals have to be evolved over the time.

The figure 7 illustrates the gap already created in terms of needed skills in digital-intensive and less digital-intensive industries. As mentioned above, numerical or problem-solving skills should be critical for future success of employees. However, combination of different skills is needed in order to achieve the success.

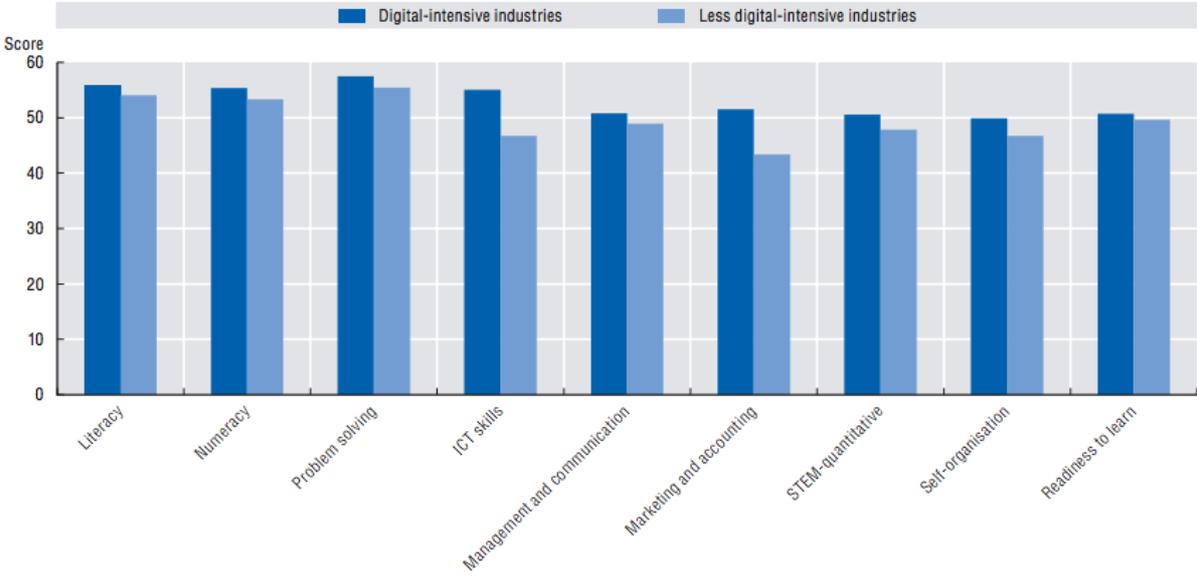


Figure 7- Skill Levels in Digital and Less Digital-Intensive Industries

Source: (OECD, 2017)

7.2.4. Industry 4.0 and Potential Future Leaders

OECD (2017) also publishes every two years handbook called OECD Science, Technology and Industry Scoreboard. Last edition from 2017 focused on Digital Transformation topic and its influences across the OECD countries and few other. In global, majority of new ICT (Information and Communication Technologies), including Artificial Intelligence, come from China, Taiwan, Japan, Korea and the United States of America. These countries also play major role in patenting and serve as a base for the top R&D companies in the world, which leads to unequal distribution of research and development activities.

The figure 8 shows that highest investments (according to the size of bubble) into R&D come from the USA, China and Japan. If the European Union is counted together, it almost reaches the value of Chinese R&D investments. However, Nordic countries (in this case Finland, Denmark and Sweden), Israel and Korea have the topmost number of researchers per 1000 employees.



Figure 8- R&D Investments and Researches per 1000 Employees

Source: (OECD, 2017)

7.2.5. Concerns about the Industry 4.0

To conclude this subchapter, PricewaterhouseCoopers (2014) made research across more than 230 German companies from 5 different industries. One of the questions targeted challenges of the overall Industry 4.0 concept (the figure 9). The most frequent answer was that companies cannot precisely forecast potential economic benefits brought by the Industry 4.0 practices, and in the same time, these practices require large amount of investments. However, the root of the issue here can lay in non-existing strategies towards the Industry 4.0 and none or small investments made. As the concept is relatively new and asks

for serious changes, companies would appreciate sharing experiences across the industries. Other challenges seen by companies are lack of qualified workforce, which was already mentioned above, and agreed standards which can be used.

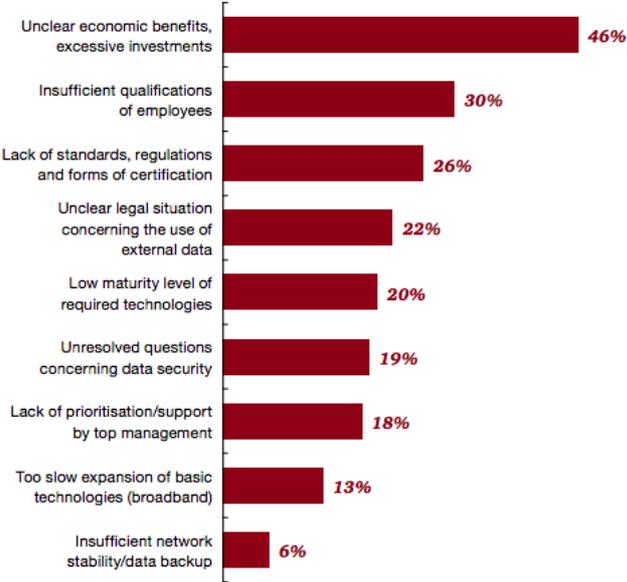


Figure 9- Challenges for the Industry 4.0

Source: (PricewaterhouseCoopers, 2014)

On the other side, the same survey showed that fulfilling customers’ needs should be improved by the Industry 4.0 practices. Furthermore, when companies have the right, in terms of skills, employees they should be also more efficient, and products or services would be delivered in faster time. Also, companies, by implementing the new technologies and approaches, should gain more flexibility and innovation process may be faster. (PricewaterhouseCoopers, 2014)

7.3. Initiatives Towards Industry 4.0

As it was mentioned in the beginning of this chapter, many initiatives with different naming exist across the world towards the concept Industry 4.0. Even though that overall concept was born in Germany it has spread around the world from the USA to China and Japan. Industry 4.0 is not in scope only for governments, but industrial companies and consulting firms have been taking part as well. Accenture, McKinsey or PricewaterhouseCoopers can be mentioned here. (i-SCOOP, 2018) Below, few examples of different initiatives and approaches will be presented in order to give reader quick overview about various point of views on the Industry 4.0.

7.3.1. The Industry 4.0 in ASEAN

Association of Southeast Asian Nations (ASEAN, 2018), which groups 10 Southeast Asian countries from Vietnam to Indonesia, aims to boost economic, social and cultural integration and development through partnership and joint projects. ASEAN sees the biggest opportunities brought by the Industry 4.0 in deeper regional cooperation, which should help to reach diverse markets. As the Industry 4.0 does not acknowledge any national borders, ASEAN wants to take advantage of data sharing across participating countries and knowledge diffusion. By deeper integration, harmonized environment for business should be created and in the same time it can serve as an opportunity for potential investors to Asia as ASEAN will be presented as one complex unit. However, one of the obstacles for accelerating integration is insufficient budget for implementing. Latest estimation speaks about need of 220 million USD in 2030 compare to 20 million USD in the current days. (World Economic Forum and Asian Development Bank, 2017)

7.3.2. Made in China 2025

Chinese adaptation of the Industry 4.0, Made in China 2025, primarily aims to narrowing, and in the same time, improving quality and efficiency of Chinese manufactures as they have been facing new and low-cost producers mainly from Asian countries. Made in China 2025 focuses on 10 priority areas, such as automatization and usage of robots, application of new IT technologies or aerospace development, which were identified by the Ministry of Industry and Information Technology.

One of the main goals to achieve is growth in share of used Chinese components and material in products to 40 % by 2020 and 70 % by 2025, in other words more value-added activities should take place in China rather than in other countries. Chinese government has supported this initiative with more than 1,5 billion USD in the form of loans, subsidies or by creating 5 national and 48 provincial manufacturing innovation centres. Local institutions are expected to support this plan by the same value until 2020. (Yang, 2018) (Kennedy, 2015)

7.3.3. The Industry 4.0 in the USA

Two main initiatives can be identified in the USA in terms of the Industry 4.0:

- a) Advanced Manufacturing Partnership announced by Barack Obama in 2011, which nowadays has been updated into 2.0 version;
- b) Industrial Internet Consortium formed by AT&T, General Electrics, IBM, Intel and Cisco in 2014.

Advanced Manufacturing Partnership (AMP) should connect businesses, universities and governmental sphere and jointly invest into developing technologies, which should create new working places and increase American competitiveness. One of the cores of this plan is creation of so called the National Network for Manufacturing Innovation, which should have roots in regional hubs. It is planned that total investment in 45 hubs reaches 1 billion USD. (Kurfuss, 2014)

Industrial Internet Consortium (IIC) was created in 2014 upon initiative of 5 American companies mentioned above and its main target *“is to bring together “operational systems”, which mean machines and industrial plants in the widest sense of the term, and information technology.”*, in other words the keys here are mobility or logistics topics. Nowadays, this initiative concentrates around 250 companies across the world. (Itasse, 2016)

7.3.4. The Industry 4.0 in the EU

In the European Union already 15 countries (the figure 10) have launched their own initiatives towards Industry 4.0 concept (some of them even presents more than one main stream of the Industry 4.0 strategy) and 7 more countries have been preparing for launch. However, all countries (excluding Malta) have released national initiatives in terms of Digitalization of Industry. At this case, across the EU, there is no coherent or common strategy in terms of the Industry 4.0 and even the EU have not created one single strategy or approach and rely more on the local (in the meaning of country) steps. However, the EU efforts streams to “unification” towards to be more comprehensive across the Union countries.

Each country has also selected different approach in terms of financing innovation and R&D activities, such as innovation vouchers, tax reliefs or creating the National Innovation Funds. Furthermore, countries can reach financial resources available from the European Union and combine them with national resources as well. The EU estimates that investments

into the Industry 4.0 and all relevant programs can exceed 50 billion euro. (European Commission, 2017) (European Commission, 2018)

European Commission (2017) took a stance and claims that countries should build on already existing industries rather than creating new as emerging technologies can be applied there. Nevertheless, existing strategies in many ways overlaps each other, but exchange of the best practices is missing.



Figure 10- Governmental Initiatives in the European Union

Source: (Tasigiorgou, 2016)

As the step forward for better exchange of knowledge and information the EU created the European Platform of national initiatives in March 2017, where “the Platform plays an essential role in the roll-out of digitalisation of industry across Europe, where:

- a) experiences can be shared;
- b) collaboration and joint investments can be triggered;
- c) common approaches to regulatory problems be explored, and;
- d) means for re-skilling of the workforce be further exchanged.” (European Commission, 2018)

7.4. Global view on start-ups within the Industry 4.0

Industries have been facing many technological changes during last several years. Firms are getting more and more inter-connected and moving to be more digital. Due to applying these processes and innovations within the companies, they can reach higher level of being autonomous and in the same time more efficient. These innovations frequently come from start-ups, which operate in different fields of the Industry 4.0, such as automatization, analysis of Big Data or application of sensors and many others. Start-ups can be seen as one of the most dynamic powers within the Industry 4.0. (Sentryo, 2017)

Another crucial point to mention is that companies which are open to the Industry 4.0 concept usually do not have sufficient capabilities and skills for applying the concept. They need to set up new partnerships or collaborations in order to overcome these obstacles. One of the possible ways is going along with the start-up companies. Based on interviews made by Deloitte Israel (Tidhar, Siegman, Keynan, & Paikowsky, 2018), where companies were asked about their experience with start-ups collaboration in terms of the Industry 4.0 concept application, 80 % claimed that: *“Aside from access to their unique skills and know-how, collaborating with startups creates value in other various ways.”*

They also mentioned 5 reasons, why it has been beneficial to begin cooperation especially with the start-ups:

- 1) Price for provided services is often lower than by “traditional and established companies”;
- 2) More flexibility and possibility of customization of solutions;
- 3) Willingness to go the extra mile in order to satisfy customers;
- 4) Start-ups usually provide complete solutions (end-to-end) thanks to their interdisciplinary teams and various of knowledge, so in other words from the development until implementation of solution;
- 5) Start-ups tend to have long-term relations with their customers as they can get broad insights.

To support the importance of the start-ups within the Industry 4.0, latest data from the end of 2017 showed that investments from venture capital subjects to start-ups raised from 600 million USD in 2013 to 2.3 billion USD in 2016 and 1.7 billion USD for first 10 months in 2017, which are presented in the figure 11 below. The trend is clear that investors have spotted potential in start-up companies and their technologies, solutions, know-how across the world.

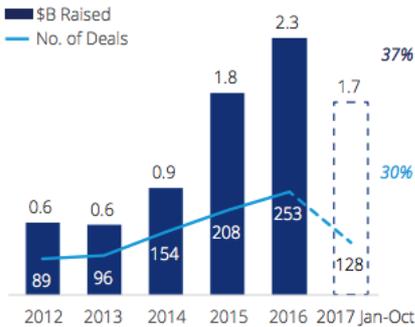
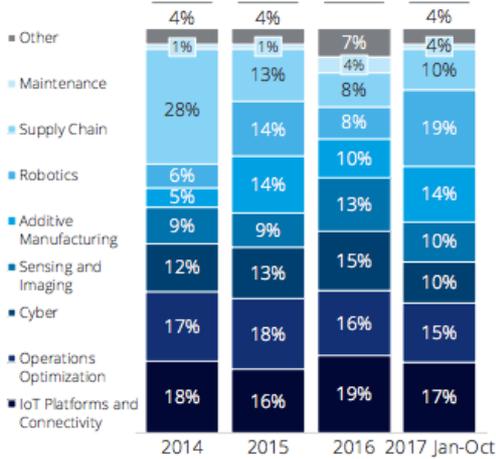
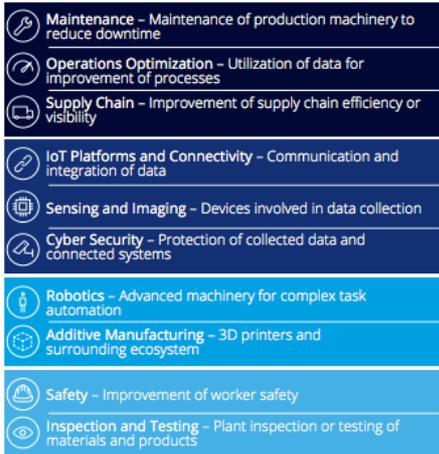


Figure 11- Venture Capital Investments into the Industry 4.0 Start-ups

Source: (Tidhar, Siegman, Keynan, & Paikowsky, 2018)

Tidhar et al. (2018) distributes possible solutions for the Industry 4.0 into 10 different categories variates from maintenance, Internet of Things and cyber security to robotics and additive manufacturing (the figure 12). It is visible from the figure 13 that the biggest share of the global investments went to Internet of Things platforms and connectivity. Robotics and additive manufacturing increased their shares during the last year, 2017. Another trend, which can be seen, is that there is not a dominant category, but it can be more spoken about diversification of the investments into different technological areas.



Figures 12 and 13 - Main Areas of Investments and Their Shares in Industry 4.0

Source: (Tidhar, Siegman, Keynan, & Paikowsky, 2018)

Looking from the geographical perspective and focusing mainly on Europe, there is a strong positive view on the future of European technological ecosystem based on data published in *The State of European Tech* (Atomico, 2017). This mood can be supported by numbers as employment in the technological area grew 3 times faster than the overall EU employment rate compare to the previous year. There is also a robust belief, across all various occupations that European technological entrepreneurs can better direct social challenges than local governments during the next few years. Here can be mentioned food shortage, healthcare access or change of the climate.

Petetin (2018) mentions at his article that European start-up environment has been improved mainly thanks to variety of governmental initiatives like financial support from public investments banks (BPIfrance or Business Finland), establishing hubs and accelerators (for example Techstars or Eit Digital) or organizing events dedicated to start-ups. These activities have led to easier access to potential investors or building new connections.

According to the OECD (2017), start-ups³ count, in the majority of the OECD countries, from 20 to around 30 % of all existing companies. However, their share on the total employment is less significant, where this number correlates around 10 %. Majority of these start-ups employed from 5 to 9 employees.



Figure 14- Share of Start-ups and Their Employment

Source: (OECD, 2017)

³ In the terminology of the OECD, start-up equals to a company, which does not exist for more than 2 years

Despite the fact that the Fourth Industrial Revolution is relatively new concept, it has received attention worldwide. It is also connected with variety of technologies that should be in the core of the future human development and should affect practically all aspects of daily life. However, as each coin has two sides, even the Industry 4.0 is connected with the negative impacts on the labour market and jobs losses or lack of standardization across the concept. Each country or group of countries have different view on the Industry 4.0 and its potential benefits. The role of the start-ups is relatively clear as they should be in the foreground of the technological development and be pioneers in the same time. Investments into start-ups have been steadily growing and it is not expected that any radical downturn should come. Furthermore, there are not almost any obstacles in terms of the market enter, which give start-ups opportunity to act in different fields of the Industry 4.0.

8. Economic Overview of the Czech Republic

At this chapter author would like to introduce shortly the history of the Czech Republic, the specifics of the Czech business environment and statistics that should explain the author's rationality behind the selection of the Czech Republic as a place, where the Industry 4.0 has a potential for expansion. Innovative activities as one of the leading forces of the growth will be assessed.

By presenting and analysing the main document about the Industry 4.0 in the Czech Republic, the Initiative Industry 4.0, basics of the Czech environment will be set and should help in easier understanding of the local environment where start-ups act. The whole chapter is finalised with the dynamic SWOT analysis assessing the overall concept of the Industry 4.0. All in all, this chapter primarily aims to shed the light on the governmental approach to the Industry 4.0 concept, which partly corresponds to the 1st research question.

In the Central Europe, sometimes called in the heart of Europe, the Czech Republic is located. After more than 40 years of Communist influence and 70 years of common state with Slovakia, the Czech Republic became independent after so called Velvet Divorce in 1993. Nowadays, country has around 10,6 million inhabitants, it is member of international organizations, mainly the European Union (since 2004) or NATO (since 1999) and many others. (BBC, 2018)

Whole country had to go through the process of liberalization as its direction was primarily ruled by the Soviet Union before 1989. It was necessary to introduce new programs, rules or policies towards wider openness mainly to "Western World". Economic restructuring was essential. As the first step, privatization was selected in order to attract foreign investors. However, in the beginning of the whole process it became clear that the Czech economy is not that "healthy" as it was expected before, mainly due to poor and unskilled management or high level of corruption. Despite these facts, the Czech Republic has reached on average higher living standards than other countries, where Communists were leading force. On the other side, wide, not only economical, gaps can be seen across the country. (Osborne, et al., 2018)

The Czech Republic has shown during the last years one of the fastest growth among the EU countries. In the figure 15 below, it is visible that in majority of the years the Czech Republic overcame the EU average in terms of the annual growth of GDP in %. Also, as was mentioned above, the consequences of the initial issues connected to the privatization are distinct

from the figure 15. The Czech economy demonstrated last year, 2017, the second fastest (after 2015) growth during last 10 years, as it reached 4,5 %. However, according to previous assumptions and forecasts by financial analysts and the Central bank of the Czech Republic, growth did not achieve their targets. (Aliapulios, 2018) According to the Czech branch of Deloitte (2017), rise of GDP should slow down to around 3 %, but this growth can be still concerned as one of the highest in the European Union. The main drivers are seen in domestic consumption and companies' investments.



Figure 15- Annual Growth of GDP in % in the Czech Republic and the European Union

Source: (The World Bank, 2018)

8.1. The Czech Republic as an International Trade Partner

Taking the point of view how the overall GDP of the Czech Republic and its composition, it is evident that share of industrial sector is one of the highest across the European Union, almost 38 %. Only Ireland and Poland reached higher shares, and even Germany with long history of different industries has around 30 % share, the rest belongs to services and negligible part to agriculture. (Central Intelligence Agency, 2018)

Furthermore, based on the OECD data (2018) and World Integrated Trade Solution (2018), the Czech Republic belongs to countries, which are tightly depending on export (80 % of GDP in 2016) and import (72 % of GDP in 2016) of goods and services. This share, visible in the figure 16, has steadily increased over the years, as the share was on half percentage back in 1993. However, comparing the Czech Republic to other EU countries in terms of value (in million USD), both export and import are comparable to the value of Denmark (188 million USD, 173 million USD respectively).

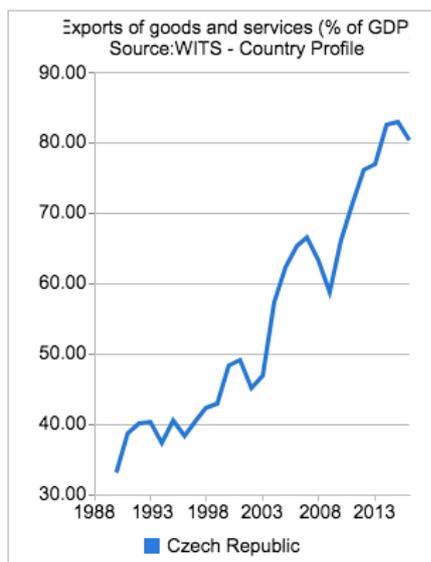


Figure 16- Development of Export Share in GDP in the Czech Republic

Source: (World Integrated Trade Solution, 2018)

International trade of the Czech Republic is primarily driven by trade in goods, which counts for around 80 % of the total trade. Both, trade in goods and services, have not demonstrated any rapid accretion or downturn in the last recent years. Current structure of the export and import is not that dissimilar either. Around 20 % of total export (based on Harmonized Commodity Description and Coding Systems⁴) takes cars and vehicle parts. All in all, machines and transportation groups count for more than half of the export. Slightly different situation can be seen in import, where one third creates metals, chemicals, plastics and mineral products.

It is not surprising that the top trade partners of the Czech Republic come from the Central Europe, mainly from its neighbouring countries, Germany, Slovakia, Austria and Poland. As it is clear from the table below, the Czech Republic highly depends on the trade with Germany (33 % of total export, 27 % of total import), following by Slovakia and Poland. Only more significant exception is Chinese import to the Czech Republic, which reached 13 % of total in 2016. This fact also impacts the share of European countries in terms of import as it jointly counts for around 2/3 of the total, but in terms of export to these countries, it is above 80 %. (OECD, 2018) (The Observatory of Economic Complexity, 2018)

⁴ “The Harmonized System is an international nomenclature for the classification of products. It allows participating countries to classify traded goods on a common basis for customs purposes.” (United Nations, 2017)

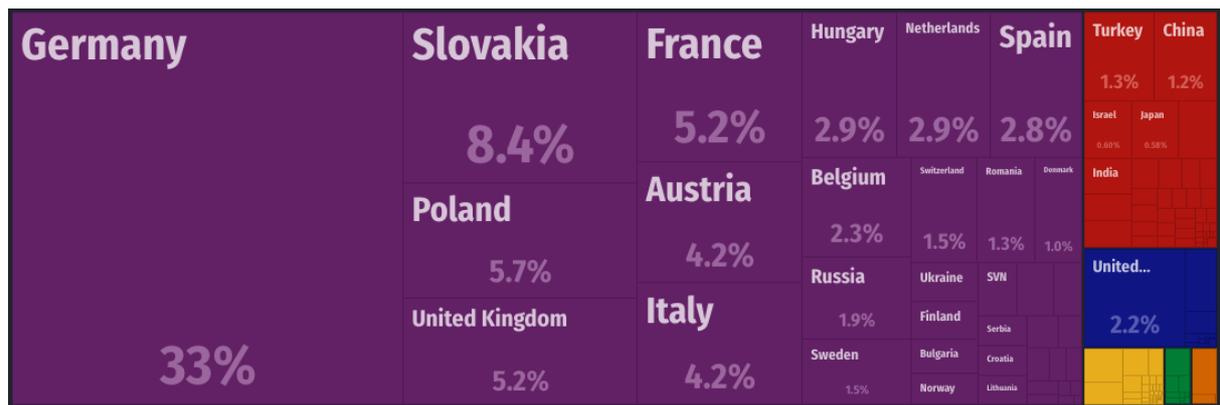


Figure 17- Share of Countries in Export of the Czech Republic

Source: (The Observatory of Economic Complexity, 2018)

8.2. Labour Market in the Czech Republic

Another important fact to mention is that the Czech Republic has been leading in unemployment statistics since 2015 until these days. Latest data from February 2018, published by the Czech Statistical Office (2018), indicates unemployment rate at 2,4 %. The reasons behind are also connected and influenced by the data presented above.

First of all, hourly labour cost reaches approximately 50 % of the EU average (26,8 euro), however, this is not sufficient explanation for quite low unemployment rate as in the countries, such as Bulgaria, Romania or Hungary, rates are even lower (starting at 4,9 euro). (Eurostat, 2018) Secondly, large share of the whole economy, belongs to manufacturing, where 1/3 of all available workforce is employed. The main factor here is the car production, which is driven by the Czech traditional brand Škoda, and Hyundai or Peugeot having their manufacturing plants based in the Czech Republic. Last but not least, environment created by the Czech government back in 90's is based on several initiatives. This helped to attract investors from the Western Europe and created new jobs. Another significant break point can be considered joining to the European Union in 2004.

As each coin has two sides, low percentage of unemployment has led to shortages in available workforce on the labour market and started to affect salary increases. This can lead to setting barriers for potential economic growth as there will not be many appropriate human resources available. Another fact, which is not issue only in the Czech Republic, is an aging of the population. Marek (Nelson, 2017), chief economist at Deloitte Czech Republic, said: *"The Czech Republic is the assembly center of Europe, not the knowledge center,"* as the overall economy contains high number of low paid, and in the same time low skilled

jobs. Those jobs showed little progress in terms of skills and knowledge. Also, he mentioned that government should take responsibility at this point and change “old fashioned” education system, and on the other side support system, which should strengthen creation of high skilled jobs.

8.3. The Czech Republic as an Innovative Country

According to the European Commission (2018) and its Innovation Scoreboard from 2017 (the figure 18), the Czech Republic belongs to so called Moderate Innovators based on 27 various indicators like attractiveness of research systems, firm investments, intellectual assets or employment impacts and many others. The Czech Republic reached 2nd place among countries affected by the Soviet Union influence. However, the overall index (86) is still below the average of the EU (100) and it is also visible that the performance has been falling since 2010. Compare to the EU statistics, smaller percentage of total employees work in agriculture and mining, but on the other side higher percentage in manufacturing.

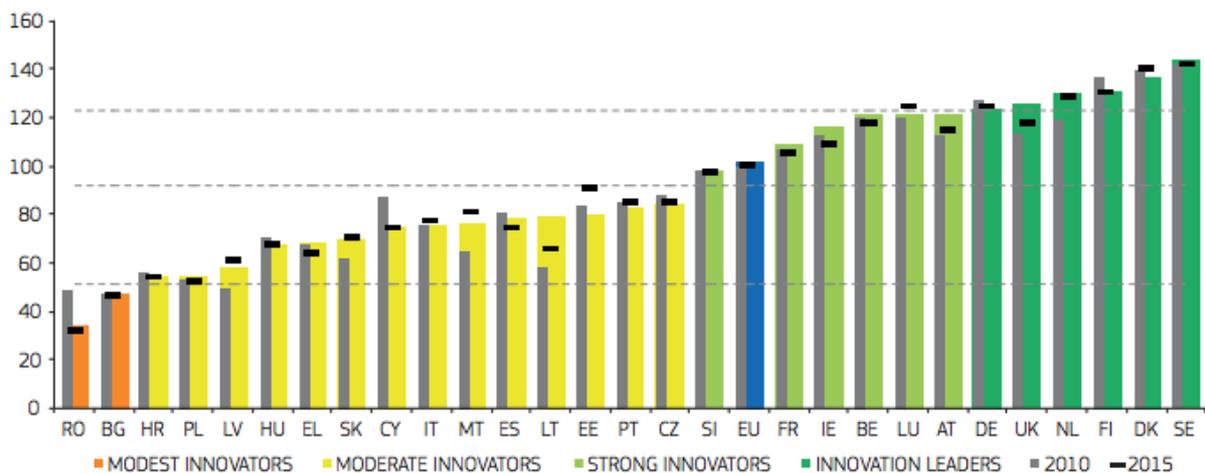


Figure 18- European Innovation Scoreboard

Source: (European Commission, 2018)

Speaking about research and development activities in the Czech Republic, R&D investments have been growing since 2003 and reached around 2 % of GDP. The main share, 60 %, comes from businesses and the rest from the Czech government. Compare to other European countries (the figure 19) it is clear that governmental spending has higher share in the Czech Republic. It is important to say that more than half of companies’ investments have source in companies, which have a foreign owner or are affiliated to it. These investments are usually located in manufacturing with low value-added activities. (OECD, 2016) Furthermore, governmental spending aims primarily to basic research and higher education organizations.

However, significant part goes to SMEs. On the other side, large companies usually run R&D activities on their own without any governmental support.

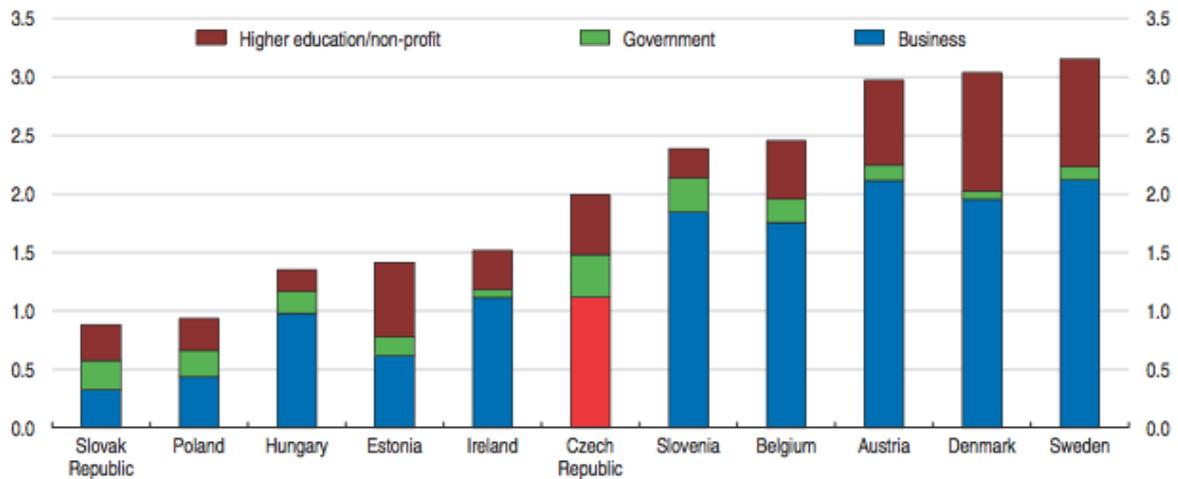


Figure 19- R&D Expenditures by Sector as % of GDP

Source: (OECD, 2016)

8.4. The Industry 4.0 in the Czech Republic

The Industry 4.0 concept in the Czech Republic has touched many official governmental documents and has been influenced not only by needs of Czech subjects, but also by European initiatives and frames.

The main initiative that the Industry 4.0 should be given more attention comes from the National Research, Development and Innovation Policy of the Czech Republic 2016-2020, which was approved by the Czech government in the beginning of the 2016 year. This document builds on the previously submitted strategy for 2009-2015 year and focuses on 5 areas, where the closest area for the Industry 4.0 is part called Innovation in Enterprises. It also follows some of the European Union initiatives and programs such as Europe 2020 strategy, Horizon 2020 or ERA Roadmap. All these documents are closely connected to topics of innovation and R&D. (Section for the Science, Research and Innovation, 2016)

In August 2015, the Czech government approved so called Action Plan for Digital Market Development, however, that time the Industry 4.0 was not included in the Plan, but preparations had already begun. The Plan identifies 9 steps towards to development of digital market, like strong and stable digital infrastructure, digitalization of manufacturing and its consequences on employment or creation favourable environment for digital companies (start-ups). (BusinessInfo.cz, 2015)

The Industry 4.0 was included in the 2nd half year 2016, when the Action Plan was updated. It arrives from the term “Society 4.0”, which should be understood as an extensive and gradual change of all Czech society towards to usage of Internet of Things, digitalization and the Internet network in many areas of daily life. The Society 4.0 in the Czech Republic is not only Industry 4.0, but also other initiatives called:

- a) Labour 4.0;
- b) Education 4.0;
- c) Research Project in the area of the Society 4.0.

Work and Education 4.0 Initiatives are closely connected to the current education system in the Czech Republic and its relation to labour market. On-going learning should be the milestone at both Initiatives as it could quickly react to labour market needs. Digital skills and learning are in focus as well. Research projects, which are linked to the Society 4.0, are supported from the Technology Agency of the Czech Republic and its programs Beta and Beta 2. As a supervising subject was created the Alliance of Society 4.0, which should coordinate all 3 concepts towards common goals. (Government of the Czech Republic, 2016)

The main document (The Ministry of Industry and Trade, 2016), the Initiative Industry 4.0, published by the Ministry of Industry and Trade in 2016 summarizes in 10 chapters the current situation, potential ways of future development and key challenges in various areas in the Czech Republic. As the whole document has more than 200 pages not all parts are included or mentioned at this master thesis.

One of the main targets of the Industry 4.0 concept in the Czech Republic is to reach the responsible support in the way of thinking across the Czech society, rather than mentioning particular technologies. The document counts with the fact that this Industrial Revolution should have impact not only on the specific industries but more on the society as a whole, so this mean that the Czech society should be aware of the Industry 4.0 concept and try to understand potential benefits and consequences of this concept.

Speaking about governmental support of the whole concept in the Czech Republic, the Czech government wants to build on already existing programs and initiatives. However, current programs are fragmented due to fact that different ministries are responsible for various programs. This fact calls for further consolidation and better visibility of available options. As one of the cornerstones can be considered OP PIK, which can be freely translated into English as Operational Program: Entrepreneurship and Innovation for Improving

Competitiveness. This program has currently 4 priorities: development of R&D, support of SMEs, more effective energy consumption and development of ICT. Overall budget is approximately 5 billion euro and the program has been available since 2014 until 2020. (OPPIK, 2018)

Another important program is called Research and Innovation Strategy for Smart Specialisation, which should lead to more effective usage of the European Union funds in member countries in the terms of increasing each individual regional competitiveness. In the case of the Czech Republic, all regions (excluding capital city Prague) are relevant applicants for support from this fund. Each country is responsible for creation its own strategy, which must be aligned with the EU one. (The Ministry of Education Youth and Sports, 2018) However, many other programs, initiatives and organization exist in the Czech Republic, such as program Proof of Concept, OP VVV (Operational Program: Research, Development and Education) or the Technology Agency of the Czech Republic and its programs. (The Ministry of Industry and Trade, 2016),

8.5. Dynamic SWOT Analysis of the Industry 4.0 in the Czech Republic

In the following lines, the dynamic SWOT analysis will be presented according to its separate parts and followed by recommendations based on the Initiative Industry 4.0 and National Initiative Industry 4.0 documents. (The Ministry of Industry and Trade, 2016) (The Ministry of Industry and Trade, 2015)

Strengths

- Long tradition and history of industrial manufacturing;
- Presence of multinational corporations in the Czech Republic;
- Flexibility of small and medium sized enterprises in terms of strategic decision making and flexible adoption of best practices;
- Governmental interest in further investments into research and development activities.

One of the biggest advantages of the Czech Republic is that it does not need to build its industry “from the scratch” but it can build on existing infrastructure, solutions and companies. Furthermore, the Czech Republic has relatively strong starting position in terms of innovative activities compare to other countries influenced by the former Soviet Union.

What is more, the Czech Republic has developed close international relations with other, namely European Union, countries after 1993 year and became export-oriented country. Many Czech companies have connections in various foreign companies and set-up collaboration in different areas. This should help them in knowledge or technology transfer from abroad and its further development in the local conditions.

Beside this, the Czech government tries to make investments and offer support in order to create favourable conditions for the Industry 4.0 and diffusion of its benefits. Also, the Czech technical education is comparable in many ways to the standards of foreign universities and R&D of the Czech universities can be applied in the Industry 4.0 practices.

Weaknesses

- Unawareness or little knowledge about the Industry 4.0 concept, mainly across the top management in the companies due to very few existing cases, where the principles of the Industry 4.0 were applied and tested;
- Inability of the Czech government for setting the priorities in connections to digitalization of the whole Czech economy and insufficient development of infrastructure needed for introducing the Industry 4.0 practices;
- Non-existent conception of economic effectiveness of the whole Industry 4.0 concept in the Czech Republic;
- Current educational system lags behind the needs of the Industry 4.0.

One of the possible solutions for rising awareness about the Industry 4.0 is creation so called testbeds, which mean testing platforms for experiments and science purposes. At these testbeds, companies should be able to observe how they can potentially benefit from implementing solutions brought by the Industry 4.0 into the real cases. Another option is to clearly define (in terms of technologies) what it is still within frames of the Industry 4.0 and what is not.

The Czech government should create precise conditions for corporate R&D support and companies' collaboration with public research offices in terms of not only in the form of subsidized projects but also possibly by tax reliefs. This point is mainly relevant for small and medium sized enterprises, and start-ups respectively, as they usually face financial barriers connected to R&D.

Lastly, the Czech educational system needs to adapt to a fast changing environment as the current situation seems to miss more inter-connectivity across all educational systems. Also, education should have links to companies, which can provide students with crucial practical information and knowledge. Furthermore, on-going education does not have a long tradition in the Czech Republic, but this aspect is one of the major for the future success of the Industry 4.0 as employees should react quickly for continuous changes and disruptions.

Opportunities

- Early catch-up with the Industry 4.0 concept;
- Participating on small-scale projects;
- Creation of new jobs.

As the whole concept was introduced only a few years ago in Germany, the Czech Republic can benefit from the fact that it has close geographical and trade connections to Germany and also knowledge sharing and diffusion should be much more easier in this case. Despite this, the Czech economy underwent large changes and challenges during the last 30 years, so it still shows features of on-going adaptation to new trends.

As the Czech Republic is a relatively small country even within the EU, it can still participate in various projects and be a credible partner for foreign companies. This fact should help to increase the country's competitiveness as companies will gain new knowledge and apply new technologies. Furthermore, SMEs should benefit from this participation as they usually face financial constraints, but by joint collaboration, they can be a part of the whole unit.

By applying practices of the Industry 4.0 many jobs should be created in newly raised areas across all sectors of the Czech economy. These places will probably ask for high skilled workforce.

Threats

- Political misunderstanding of the whole concept;
- Dependence on particular country or industry;
- Negative impact on the labour market;
- Insufficient and not well-connected public institutions.

The Initiative Industry 4.0 should be understood as a united program in order to reach its targets. Each individual step towards the Industry 4.0 should not be created independently but rather jointly. Also, the topic of Industry 4.0 can be misused only for marketing or political purposes. Government must have long-term vision and plans how to deal with various topics of the Industry 4.0.

Behind the whole Industry 4.0 does not lie one particular technology that should be the milestone for the humankind, but more as a set of available and developing technologies. In the case of the Czech Republic, the potential issue lies in the close connections to Germany. Germany has been the number 1 in terms of export and import for many years and it is not expected that this position should be changed over next years. The main focus here should be in diversification.

Fast changes on the labour market may be overseen by prepared governmental instruments, mainly in terms of social and unemployment policies. Another point here can be mentioned that job lost should force government to improve current education system and possibilities for on-going education especially for people negatively affected by the Industry 4.0 consequences. However, majority of these steps government should foresee and not just react to sudden situations and issues.

9. Start-ups in Connection to the Industry 4.0 in the Czech Republic

This chapter aims to illustrate the specific environment for the start-ups in the Czech Republic and is based on variety surveys and governmental documents. Short overview about the current situation of the Czech SMEs and start-ups is showed as the start-ups are often placed into the group of SMEs. Author decided to include the successful examples of the Czech start-ups in order to emphasize that there is not a universal way that the Czech start-ups can go but they can act in different fields, can use variety of available support and finally reach the global audience.

The last subchapter of this part deals with the potential financial and non-financial instruments available for the Czech start-ups, their focus and application in the practice. This part is strongly dedicated to the second research question as it gives robust overview of the existing options.

Any official statistics about the precise number of start-ups in the Czech does not exist as the term “start-up” does not have any precise limitations even across different organizations (such as Czech Statistical Office, various ministries or supportive organizations, etc.). (eDotace, 2016) Based on data from Startupjobs.cz (StartupJobs, 2018), which is internet portal advertising vacant position in the Czech start-ups, number of the Czech start-ups is estimated around 3000, excluding bio and nanotechnological start-ups.

According to founder of Startupjobs.cz, Filip Mikschik, 450 start-ups were registered in 2017 year, compare to almost 600 start-up the year before. However, he claims that newly created start-ups have robust structure and better financial support as they are, in the majority of the cases, led by already experienced start-up founders. Majority of start-ups were established in technological sphere (more than 40 %) and more than 10 % have connections e-commerce and service categories. Start-ups primarily look for people with previous developer (related to IT) experience, and, by the time and development of the start-up, they are interested in employees with marketing and sales skills. (StartupJobs, 2018)

9.1. Start-ups and Small and Medium Sized Enterprises in the Czech Republic

As start-ups are considered, from the governmental point of view, as a part of Small and Medium Sized Enterprises (SMEs) it is necessary to look for current situation across this group. All in all, SMEs⁵ share in the total number of companies takes 99,8 % in the Czech Republic, so it means that very little part belongs to large and multinational companies. But if all value-added activities are summed, the share of SMEs is only slightly above 50 % and employment reaches almost 60 %. (The Ministry of Industry and Trade, 2017)

According to the World Bank report (2017), Doing Business 2018, conditions for setting new business in general are one of the most difficult across the European Union. In countries, such as Slovakia, Hungary or even Moldavia or Ukraine are more favourable conditions than in the Czech Republic. The Czech Republic should put emphasis on e-governance topic as the current situation heavily relies on bureaucracy and paperwork. Situation has improved during last several years as it became easier to start “společnost s ručením omezeným”, which equals to English limited liability company. However, uneasy process can be illustrated on many existing agencies that for particular fee help to register and create new enterprise. If the overall process is easier and almost without any barriers, these companies would not exist and would not be needed. (Dostál, 2018)

9.1.1. Preparedness of Start-ups and SMEs Towards the Industry 4.0

The Ministry of Industry and Trade initiated preparation of two documents regarding to topic SMEs and the Industry 4.0. First one was handled by the Electrotechnical Association of the Czech Republic (2016) and second one by the University of Business and Law (Veber & Krajčík, 2016).

One of the results took into account insufficient data availability around the Industry 4.0 topic despite the fact that it is one of the main initiatives for the Ministry of Industry and Trade. The Czech Statistical Office provide user with variety of data in terms of innovation, R&D or other economical topics. However, as the Industry 4.0 has been taking more and more attention, at least on high governmental level, separate section for this topic should be dedicated. Even nowadays, when user tries to search term “Průmysl 4.0” (equivalent

⁵ Companies with less than 250 employees and turnover below 50 million euro/year

of the Industry 4.0), the system does not give back any particular answer in terms of data or statistics.

By combining both documents, it is useful to conclude current situation of SMEs, where start-ups are inherent part, and considering the Czech specifics to following SWOT analysis.

Strengths

As Czech SME manufacturing showed relatively wide flexibility in their production lines, they are also able to be more flexible towards new concepts and solutions as the Industry 4.0 definitely is. Furthermore, they will to be more risk taking rather than larger companies. Large and multinationals companies see potential in SMEs in terms of supply of special services that SMEs and start-ups can create for them.

Moreover, SMEs and start-ups showed interest in innovation and technologies as they can help them in bridging with the issue of insufficient number of workers. They can more or less precisely identify their needs and tasks that need to be solved by available technologies. Companies are aware that current situation on the Czech labour market calls for improving working conditions and benefits in order to retain skilled workers.

The Czech SMEs and start-ups seek for feedback as it serves as a tool for further improvements and development. Reached milestones, such as certificates, are usually presented and used for marketing purposes.

Weaknesses

The Czech SMEs still have relatively small amount of information about the overall concept Industry 4.0 and based on this, they cannot even start creating their own plans towards the Industry 4.0. Data showed that 94 % of interviewed companies have not made any strategic decisions yet and only minority (around 15 %) has realised few little steps, such as workshops. Companies claim, literally saying, that the Industry 4.0 is not something that they can simply buy.

Personal interest in the Industry 4.0 and digital technologies were mentioned as a first answer, how top-managers are aware of the concept, however 40 % mentioned that the Industry 4.0 is not in the major focus due to different priorities such as unavailability of skilled workforce on the labour market or retention of competitiveness in terms of pricing or quality.

Companies also see the Industry 4.0 as a political or marketing tool, which can be misused, and even some respondents mentioned that overall implementation would take extremely amount of time, which they considered as a “wasting”.

Lastly, SMEs and start-ups face obstacles in supplies to large and multinational companies as they have to comply with standards set up by these companies, mainly in terms of the volume of production and timing. SMEs and start-ups do not want to be dependent only on few companies but be more open to other options.

Opportunities

The Czech Government has been supporting SMEs and start-ups through variety of programs and initiatives, however, any particular strategy towards SMEs and start-ups in connection to the Industry 4.0 is currently missing. The government can create opportunities particular for SMEs and start-ups building on already existing solutions and initiatives.

Universities and other public institutions should be supported in terms of cooperation with SMEs and start-ups as it can lead to win-win situation on both sides. The government has influence to change education system based on company needs and technological trends. Companies can provide necessary insights into daily practices and create demand for particular graduates.

Lastly, overall Czech Initiative Industry 4.0 is resulted as a joint work of the government and companies, including SMEs. They should prolong this cooperation in terms of setting the needed standards and try to reach consensus in raised questions.

Threats

Majority of interviewed companies is not prepared to run business compliant to the Industry 4.0 principles as the biggest threat for companies is lack of skilled employees and financial resources. Connected to this, there is also threat from the bigger companies such as Siemens, General Electrics or Foxconn as they are stronger in terms of R&D, financial situation and so on.

It is possible that customers of SMEs and start-up will not need any implications of the Industry 4.0 from their suppliers or partners, so in other words, investments to the Industry 4.0 principles can be useless.

Mainly government and its institutions should be responsible for rising awareness across the companies, explain reasons for implementing the Industry 4.0 features and emphasis inter-connectivity across the industries. Current connections and links between industries are not sufficient for the Industry 4.0 as it is not well understood.

Government is also criticised for wide spectre programs and initiatives which are missing focus on the Industry 4.0 problematics. SMEs and start-up have not been presented almost any visible results of the Industry 4.0 benefits or do not have access to reliable information. Lastly, the Ministry of Education, Youth and Sports have not done necessary steps to modification of the current system as it is visible that present situation calls for more educated and skilled workers and furthermore, research capacities are not sufficient at universities.

9.2. Current Start-up Situation

After the extinction of the Soviet Union and before joining the European Union, countries in the Central Europe were fragmented. However, the Visegrad Group is one of the leading initiatives, which tries to increase integration and cooperation between participating countries (Poland, Hungary, Slovakia and the Czech Republic) as they have been sharing part of their history, traditions and so on. The Visegrad Group collaborate in various areas, such as economical questions, culture or security issues. (The Visegrad Group, 2018)

The first initiative towards common approach to start-ups was set-up in the beginning of 2017 as countries signed the memorandum creating the Regional Start-up Platform, which should primarily help start-ups in terms of sharing IP rights and services around this topic. (The Visegrad Group, 2017) Nowadays, the Regional Start-up Platform creates ecosystem of 7 participating countries, the Visegrad Group, Germany, Austria and last member Slovenia. (PODIM, 2017)

Maria Staszkievicz and Daniela Havlíková (2016) made quite intensive research across the Czech start-up companies and collected questionnaire answers from almost 150 start-ups. Author sees a valuable practicability in terms of industries where start-ups act. Only little part of the selected start-ups has their business in areas, which are not closely connected to the Industry 4.0 sphere and its technologies. On the first places were mentioned areas such as, software as a service, analytical and other research tools, cloud technologies or Big Data.

9.2.1. The “typical” Czech Start-up

How “the typical” Czech start-up looks like from the point of view of this research? The CEO or founders are, in the majority of the cases (80 %), between 20 and 40 years old with university degree, where is not a dominant trend in a specific education profile. Less than half of the founders have previous experience with start-ups, but more than half have previously worked in corporations. Only in every fifth start-up woman can be found among founders and only 2 % are the only founder.

Unsurprisingly, the majority of start-ups are located around the capital city, Prague, with around 60 % of the overall start-ups, followed by Brno and Ostrava. More or less the same situation is within the Visegrad Group as Bratislava in Slovakia and Budapest, Hungary, are the core cities for start-ups, only in Poland start-ups are fragmented around 4 bigger cities. Based on the research called Startup Heatmap Europe (Thannhuber, et al., 2016), Prague was selected as 16th favourable place for start-ups from 30 different European cities as the local “competitors” such as Warsaw, Vienna and Munich beaten Prague at this ranking. However, Prague and Warsaw are still considered as one of the strongest hubs in the Central and Eastern Europe, mainly for the post-Soviet countries.

The Czech start-ups showed wide range of the target customers as it is visible from the figure 20. They focus primarily on individuals and medium sized companies (51 to 250 employees) followed by large firms and public institutions.

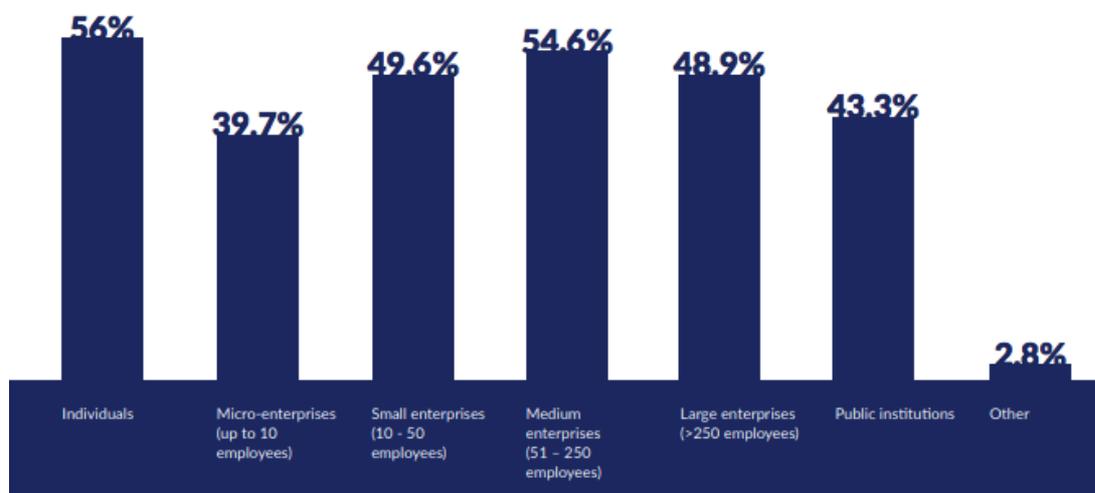


Figure 20- Target Customers of the Czech Start-ups

Source: (Staszkievicz & Havlíková, 2016)

9.2.2. Start-up Collaboration with Government

Speaking about public institutions and governmental initiatives, around 1/3 of respondents have been collaborating with the universities or other public research institutions, on the other side only 14 % of the selected start-ups are university or research spin-off, which stresses the fact that start-ups from academia sphere are quite rare in the Czech Republic. However, as an example can be mentioned cooperation between companies and academia in Artificial Intelligence sphere as especially two technical universities in Prague and Brno can offer highly skilled employees with efficient knowledge. This cooperation has created international projects, which are coordinated by well-known companies such as Facebook or IBM and also highlights the prestige of the Czech research centres. (Beauchamp & Skala, 2017)

Interesting situation originated around receiving public subsidies as 57 % of respondents mentioned that they are interested at this option, mainly because this financial support can strengthen their cash-flow, boost growth or help in education of employees. On the other side, 43 % of start-ups claims that governmental sources cripple market, bureaucracy connected to application is overwhelming and governmental targets and priorities are wrongly set.

Petr Víték, the Co-Founder of Impact Hub said to this topic: *“The state should help to develop the innovative business culture, rather than thinking about the specific support for the individual forms of the business. This includes keeping the law and taxation system simple, decreasing the administrative burden, lowering the corruption, opening the data to be an example in transparency...”* He also suggested that immigration policy should be changed as the current situation on the labour market calls for more than 200 thousand employees. As an example, he mentioned Austria and its start-up visa or “digital one stop shop”.

Juraj Atlas, the founder and CEO of Liftago (Czech competitor of Uber) has seen development in the overall Czech start-up ecosystem. Four or five year ago, start-ups primarily targeted to governmental support in the form of financing, while many hubs, incubators or accelerators were created. He is glad that this form of support did not succeed at all as he thinks that government should aim to indirect support of the overall start-up environment in the form of previously mentioned incubators or co-working centres.

9.2.3. The Czech Start-up (Non)Financial Support

The Czech start-ups are mostly (almost 80 % of surveyed companies) financed by founders saving or reinvested profit, followed by FFF group and local business angels. Only less than 9 % of the start-ups have used any public support and crowdfunding did not attract almost any popularity as it is visible from the figure 21. Compare to other Visegrad countries, venture capital is on the lowest level in the Czech Republic (6,5 %) as for example in Hungary (25 %) or Poland (22 %). However, different view is gained when the Czech companies were asked about the future resources of financing. Unsurprisingly, own capital was on the 1st place with almost 60 % across the companies. The 2nd most frequented answer was selection of strategic investor, followed by local business angels and venture capital funds. Public support was in focus for 18 % of the selected companies.

Renata Nemkyová from TechSquare Scout (one of the first co-working places in the Czech Republic) claimed that the Czech start-ups have started to understand that external financial support is not a target but should be taken as a tool. They have to understand market and if their product or service fits into it. Jan Dejl, the Director of the Department for Support of Financial Instruments at the Ministry of Industry and Trade said that the market with venture capital has not developed as in the other countries in Europe. One of the potential reasons for this can be non-existing governmental tools for promoting this type of financing. Nevertheless, the European Investment Fund has planned to invest around 40 million euro into venture capital funds, which should spot the Czech start-ups for the potential investment. Furthermore, National Investment Fund should be first governmental initiative allocating around 12 million euro. However, the last news speaks about cancelling this initiative despite the 3 years of preparation and future steps should be aligning overall strategy towards the European Investment Fund as the main tool. (Stuchlík, 2018)

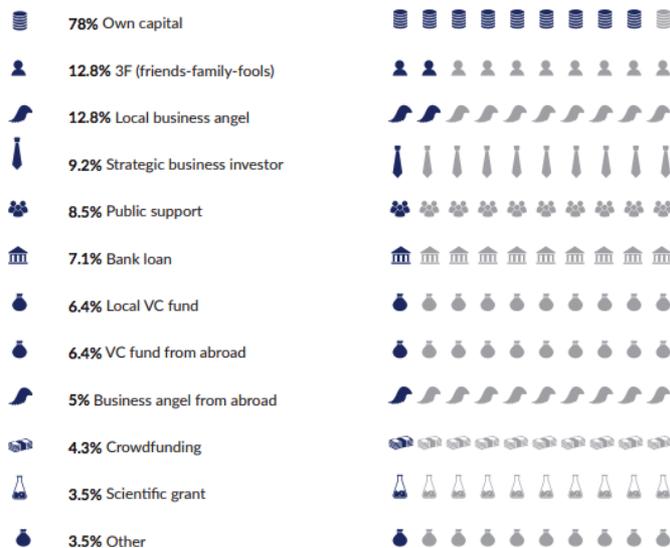


Figure 21- Most Used Financial Support in the Czech Start-ups

Source: (Staszkievicz & Havlíková, 2016)

The Czech start-ups are also interested in non-financial support and possibilities, however, precise number of start-ups which used non-financial support is missing. As it is visible from the figure 22 below, the most frequent answer was selected mentoring, followed by participation at the local competition and attending local community events. These options are seen as a short-term option compare to longer one, such as acceleration programs or incubators. Local possibilities were preferred compare to international one as start-ups see the possibility of more intensive cooperation and knowledge sharing due to geographical closeness.

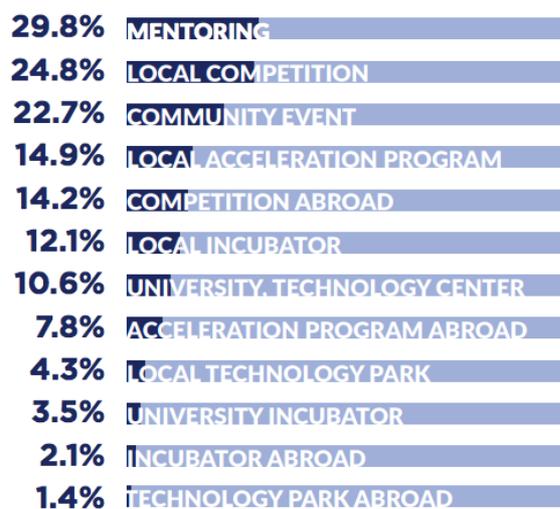


Figure 22- Most Used Non-Financial Support in the Czech Start-ups

Source: (Staszkievicz & Havlíková, 2016)

“Entering international markets is not an easy task for any company, let alone a startup. Given the size of the Czech market, for some startups, nevertheless, there is almost not another option than growing internationally if they want to provide for their future growth”, said Markéta Havlová, the Director of Startup Department in CzechInvest. This trend is also illustrated in the Czech dependence on the country export mentioned in the chapter dealing with Economic Overview. As the first option for the Czech start-ups are the EU countries (mainly Germany and the United Kingdom) and the USA. The share of export-oriented start-ups is relatively high in comparison to other Visegrad countries. In the Czech Republic the share of exports reached 75 %, in Slovakia 79 % but in Poland nearly 50 %. (Staszkievicz & Havlíková, 2016) (Beauchamp & Skala, 2017)

9.3. Examples of the Successful Start-ups in the Czech Republic within the Industry 4.0

Even though that the Czech Republic has only nearly around 10,6 million inhabitants, few Czech start-ups have reached global scene and they are one of the leaders in their fields. As it was mentioned above, due to size of the Czech market, many Czech start-ups already started with the global ambitions and targets, where globalization can play in their favour.

Author decided to select 4 examples, which have been trying to change the world, got attention internationally and their activities and solutions are close to the Industry 4.0 practices. Author used as a starting point 3 different ranking. Czech Forbes (Mareš, 2017) and its list of TOP 10 start-ups in the Czech republic for 2017, Startup Ranking (2018) for the Czech Republic, and finally the list published by EU-Startups (Curda, 2018) webpage. Another reason for selecting these particular examples is that each of them has different background, history, product or service and in particular used different instruments for growth. These start-up examples should show the variety of ways that other start-ups can go and also emphasize that there is not a one golden path that suits all the Czech start-ups. Addition to this, each mentioned start-up and its products/services have real implications to business practices and some of them even have reached “common users” (mainly Prusa Research).

Without any doubts, many other Czech start-ups can be found on the internet as they offer or created solutions that have global influence. However, author sees that selected examples have gained global attention, some of them were acquired by the international companies or got awarded by international rankings.

One of the most famous Czech companies and start-ups, which can be mentioned here, are without any doubts Kiwi.com (former Skypicker), AVG AntiVirus or Avast Software. Despite the fact that Kiwi.com can be still, from some point of views, considered as a start-up as it is only 5 years old, it reached 800 million euro revenue during the last year, 2017, but Kiwi.com deals with selling the airline tickets, which is not relevant for the Industry 4.0 topic. Closer to the concept are two antivirus companies, AVG and Avast. They are leaders on the field of the cyber security on the global level, however, they cannot be in the start-up scope anymore as both of them were created more than 20 years ago.

9.3.1. Prusa Research

3D Printing area reached more than 13 billion USD globally in 2016 and it is expected that it will growth 30 % annually and it can exceed 30 billion USD in 2022. Large multinational companies, such as Hewlett-Packard, lead this industry but the Czech start-up Prusa Research are one of the fastest growing according to Delloite (2017) Technology Fast 500 EMEA, where Prusa Research gained 9th place with growth 6910 % between 2013 and 2016. Josef Průša, the founder of the Prusa Research, started with 3D printing under open-source project RepRap, which is based on 3D printers that allow to replicate themselves by printing parts for new printers.

Just to support the extremely fast growth, the total revenue was 3,5 million CZK in 2014, the year after almost 25 million CZK, the company increased revenue 10 times to roughly 250 million CZK in 2016, and last year, 2017, reached almost 1 billion CZK, which equals to 40 million euro. Prusa Research was pushed to hire 100 new employees in order to satisfy boosting demand for its production. Nowadays, company produces around 6000 3D printers every month compare to 1000 pieces last year. (Stingl, 2017)

Prusa Research printers can be found all around the world starting from Canada and Brazil, through Saudi Arabia and South Africa to Mongolia and Malaysia. Around 70 % of the overall production is exported, mainly to European market followed by North America. (Prusa Research, 2016)

Nowadays the company sells only two versions of 3D printers, Original Prusa i3 MK3S and Original Prusa i3 MK2, and despite the narrow offer, it has already gained attention from prestige magazines and web portals focusing on 3D printing. As the break point event can be considered award received by magazine MAKE. Original Prusa i3 MK2 got 3 prices, Best Value, Outstanding Open Source and finally Best Overall across 38 competing printers.

The magazine tester, Ryan Priore (2016), said about this printer: “*Prusa Research has raised the bar for consumer 3D printing platforms while not breaking the bank. And with its total score of 36 points — more than any machine we’ve ever tested — the Prusa i3 MK2 became the machine all the testers wanted, and more than one of us went home and immediately placed an order.*” Josef Průša said that by only winning at MIKE magazine, orders grew up by 50 %, which just underlined the prestige across the 3D printing community. (Průša, 2016)

Moreover, web page 3Dhubs.com, which is based on users’ reviews, awarded i3 MK2 as the best 3D printer with the overall score 9.3 from 10. Users appraise mainly the quality of the printing, easiness of using and price, which starts from 725 USD depending on configuration. (3D Hubs, 2018)

How can Průša’s printers change the world? Here are two short stories. At Charles University at the Faculty of Science 3D printers are used for printing biological material as this material is relatively expensive, such as 40 euro for one model, which can be print in hour for a few euro cents and customized for the actual need. Non-profitable organization Team UnLimbited helps families and their disabled people by publishing models for medical aids. One of the parents bought i3 MK2 and printed arm for his son. (Průša, 2018)

Prusa Research can also attract skilled and experienced workers as it hired former Warehouse Specialist, Martin Rezler, from Foxconn, which has one of its factories placed in the Czech Republic. Martin Rezler works as an Operations Director mainly focusing on the overall economic situation and manufacturing. Moreover, PrusaLab, a creative maker and hacker space, should be open this year, where the general public should be able to explore 3D printing even in bigger detail. (Prusa Research, 2018) (Průša, 2016)



Figure 23- Original Prusa i3 MK3 3D Printer

Source: (Prusa Research, 2018)

9.3.2. Apiary.io

The Czech start-ups can attract even well-known technological companies as it was showed during acquisition of the Czech company Apiary by American Oracle in the beginning of 2017. Overall acquisition is evaluated around 100 million USD and the cooperation between Apiary and Oracle begun many months before.

What Apiary actually does? *“Apiary's pioneering APIFlow solution provides the framework and tools for developing application programming interfaces (APIs) that share enterprise services and data and help create modern, cloud-based applications and experiences. APIFlow spans the API creation lifecycle, including design, governance, testing, and documentation, while supporting API Blueprint and OpenAPI industry standards.”* (Apiari, 2017) In other words, Apiary created standard which is used for creating and writing programs. Its products are used not only in Oracle, but also in Microsoft or Google. What is even more curious is that company employees less than 40 employees based in Prague and San Francisco compare 130 thousand people working for Oracle.

Before the acquisition, Apiary attracted few venture capitalist funds, investors and business angels. According to CrunchBase (2018) database, Apiary was financed by the amount exceeding 15 million USD, so it is obvious that all investors made profit on the acquisition. Among investors can be found not only famous Czech venture capital funds such as Credo Venture or RSJ Private Equity, but also Apiary attracted the famous business angel, Esther Dyson, specializing in technological companies or according to Forbes one of the best start-up investors Steve Anderson and his Baseline Venture. (Kreč, 2017)

9.3.3. Pocket Virtuality

Jan Hovora was one of the founders of the Czech gaming company Bohemia Interactive, mainly famous for the computer game Operation Flashpoint and ArmA, which are partly used during the simulations and training of the US army. However, after almost 15 years working and being responsible for graphical side of projects, Jan Hovora decided to set-up Pocket Virtuality. Pocket Virtuality specializes in Virtual and Augmented Reality by using already developed properties like Microsoft HoloLens, HTC Vive or Samsung Gear VR.

One of two current projects, HoloObserver, serves for showing augmented 3D models on the real objects. These models can be viewed by more participants in the same time and participants can follow instructions created by a guide. Newer project, Fata Morgana,

focuses on 3D environment and its streaming to virtual reality system remotely. In other words, real objects can be converted into augmented reality and work with it further. Pocket Virtuality cooperates with the Czech automotive company Škoda or the Czech plane producer Aero Vodochody. As an example here, how the Pocket Virtuality technology can be used, is the situation when plane repairman wearing Hololens glasses sees the real plane engine and in the same time streams his view to technician. Technician can lead the repairman in the service by using the 3D model. Moreover, the Pocket Virtuality solutions can be used in medical sphere especially for students that can observe various situations simulated on real figurines.

Pocket Virtuality attracted the Czech investment group TOUZIMSKY and sold ¼ of the company. TOUZIMSKY has already acquired few companies from the same area, so it is not the first step towards unexplored environment and what is more, TOUZIMSKY recognizes the importance of the Industry 4.0 concept and try to align its acquisitions to the concept. Following this, Pocket Virtuality moved its headquarters to the Czech Institute of Informatics, Robotics, and Cybernetics, which is under supervision of the Czech Technical University in Prague. By joint forces they can build new laboratory focusing on augmented reality and academia sphere can contribute to further knowledge diffusion. (Sedlák, 2017) (Pocket Virtuality, 2018)

9.3.4. Neuron Soundware

Neuron Soundware is a great example how the variety of support including incubators, participating in the accelerators and winning competitions can be beneficial for reaching needed additional investments. All in all, relatively new start-up was founded in 2016 and in the same year won the competition Vodafone Idea of the Year, where it beaten more than 170 other projects. Furthermore, the Neuron Soundware participated in the prestige Czech accelerator, StartupYard, where it gained the initial investments. All these activities and rewards led to 600 thousand euro investment from the Czech J&T Venture. This investment should be primarily used for hiring new employees and their education, improving existing technologies and extending distribution to larger groups of customers, where can be count companies from automotive, aviation and railroad. (Ptacek, 2017) (Waldo, 2016)

Neuron Soundware is based on the artificial intelligence and its ability to learn via “listening” to variety of sounds produced by different machines used in the industries. As human being is not able listen to more than one sound in the time, Neuron Soundware created technology that is able to listen to thousands of voices in the same time and use “sound base” for identifying potential problems. Pavel Konečný, one of the founders, mentioned situation when technology can listen to hundreds of aviation engines for thousands of hours and collecting data needed for further analysis. (EMD Consultants, 2017)

It will not be surprising that Neuron Soundware activities attracted many companies interested to cooperate, such as German Siemens or Deutsche Bahn (potential faults on escalators). The start-up is also negotiation collaboration with Škoda Auto and its R&D lab called DigiLab, German automotive company Daimler and finally aviation company Airbus. (Novotný, 2017)

9.4. Possibilities of the Support and Existing Initiatives

Building on the subchapter dealing with the Industry 4.0 in the Czech Republic, many initiatives and incentives towards the Industry 4.0 exist. At this point, author combines mainly governmental resources and documents, as they have created frames and strategies for providing public support and also created organizations which primarily aim to start-up scene in the Czech Republic. Based on the available information, author selected the main relevant programs, options and instruments that the Czech start-ups can reach within the frame of the Industry 4.0. However, without any doubts, many other initiatives exist in the Czech Republic connected to this topic and area.

9.4.1. OP PIK

OP PIK can be considered as one the of pillars for the Industry 4.0 implementation. The Ministry of Industry and Trade (2016), sees OP PIK (2018) as a main tool or platform for boost activities in the next few years, mainly due to its transparency towards the Industry 4.0 concept. OP PIK has 4 different parts, where each of them focuses on different areas: development of R&D, support of SMEs, more effective energy consumption and development of ICT. In total, OP PIK programs have overall budget around 5 billion euro that can be spent until 2020.

Author identified that 11 different programs aim to financial support of small and medium sized enterprises (start-ups belong to this group of companies) and 2 programs promote non-financial aspects of business. The total amount dedicated to these programs exceed 50 billion CZK, which equals to around 2 billion euro.

Initiatives called Technology, Innovation – Innovation Project and Potential primarily aims for providing subsidies to SMEs in terms of investments to purchase of the new technologies, tools, machines, equipment and so on. Depending on the program, companies can get compensate up to 50 % of dedicated project costs, but what is interesting is fact that the Technology and Innovation programs cover higher part of costs in small companies (up to 49 employees) than in medium (from 50 up to 249) and large one, so it is clear that small (partly medium) sized companies are more preferred in terms of providing the support. The Technology and Potential projects are dedicated only to SMEs. Part of the Technology program focuses on starting entrepreneurs, in other words start-ups, as they can use subsidy for purchase of the initial technological equipment and manufacturing machines.

Following previous initiatives, Application program aims to research and development activities across the participating companies. Companies can reach up to 80 % cost cover from this program. Furthermore, companies are motivated to exchange and transfer gained knowledge and results as they can gain higher percentage of the support (vary from 10 or 15 % more than independent R&D). When results are reached, results can be patented by using the program Innovation – Patent, which cover up to 50 % of expenditures connected to patents, trademarks or industrial designs. Also, public institutions, such as universities, can participate at this program.

Relatively close to two above mentioned programs stay the Cooperation and Knowledge Transfer Partnership as they want to promote deeper collaboration and diffusion between companies and public institutions. The Cooperation focuses on creating new and developing already existing clusters, technological platforms and innovation networks and 3 or 4 SMEs are needed to apply at this program. Beside the cooperation, companies can attract foreign companies to partnerships and what is more, even more financial support can be gained from the EU funds. Participating subjects can use support for buying necessary assets, consulting services or salaries of employees. The Knowledge Transfer Partnership help public institution to set up connections with SMEs and boost their R&D activities as public institutions send academic employees and students to different companies.

Three programs (ICT – data centres, ICT – data sharing centres and High-speed Internet) encourage companies to invest into recent information and communication technologies. ICT programs aim to creation and maintenance of data centres or data sharing centres as these centres can improve overall effectivity by using various software, sharing data on-line and so on. The High-speed Internet initiative tries to increase the Internet coverage and speed in the Czech Republic, because the Internet is considered as one of the most important aspects in the Industry 4.0. This program has also the biggest budget across the selected programs with almost 12 billion CZK (0,5 billion euro).

SMEs can use external services, such as counselling or expertise in the form of so called innovative vouchers. These vouchers should boost innovation activities inside the companies like optimization, research, design and so on. Very close to the innovative vouchers is initiative Counselling 1 for newly created SMEs. It is obvious that this support is dedicated to starting companies, because the main goal is to increase the number of entrepreneurs in the society, especially in the regions which lag behind. As a part of this program, incubators, technological parks and innovation centres are support in order to attract SMEs. Following program, Counselling 2, builds on the previous program mainly focusing on the technological parks and organizations created by the government. These subjects should provide support to SMEs in the form of various analyses, advices and mediation of contacts.

One of the newest initiatives from the OP PIK programs is called Technology – Industry 4.0. It is visible from the name of the program that this program focuses on investments into new technologies, automatization and digital transformation. Program is available only for SMEs, which can cover up to 45 % of the overall costs and this support can be used either for non-manufacturing technologies (these technologies can be considered as a supportive one) or manufacturing, which are directly related to production. Companies cannot include any labour costs into this program as it only allows to buy tangible and intangible assets, from machines to software and licences. (Navrátil, 2018)

9.4.2. Epsilon

The Technological Agency of the Czech Republic (TACR) is governmentally financed organization which should promote the reforms in the terms of research and development activities and furthermore redistribute public budget dedicated to these activities. TACR is also responsible for creation its own programs and initiatives, it cooperates its strategy not only with the Czech government, but it is also aligned with the European Union institutions.

Currently, it provides 10 different programs, which follow naming of Greece alphabet (excluding program national Competence Centres), such as Beta, Epsilon, Gama. (The Technology Agency of the Czech Republic, 2018)

All programs try to support activities towards innovation, research but each of them from the different angle. For example, Eta initiative is very close to the topic of the Industry 4.0 but primarily aims more to social and human aspects of the concept through strengthening the role of social and human sciences across the society or Zeta program focuses on young students (master or doctorate) and developing their skills and knowledge based on cooperation with companies or public research institutions. Delta program wants to support tighter links with international organizations similar to TACR and jointly cooperate in different projects with participation of the local companies. Unfortunately, very few projects in the Delta program succeed to gain the needed support. However, the main program which combine features of the Industry 4.0 and start-ups is called Epsilon.

“The EPSILON programme is mainly focused on improving the standing of the Czech Republic, as well as European industry in a global context, through the support of applied research and experimental development, whose results have a high potential for rapid application in new products, production processes and services...” (The Technology Agency of the Czech Republic, 2018) Program is one of the longest in the history of the TACR as it started in 2015 and lasts until 2025. Overall budget is set for more than 16 billion CZK (slightly more than 0,6 billion euro) and has priorities in 3 different areas, namely:

- 1) Knowledge-based Economy- focuses on the transmission and application of the knowledge and results of R&D into companies’ practices;
- 2) Energy and Materials- tries to ensure that the Czech Republic will have sustainable mix of energies in the nearest future;
- 3) Environment- target of this program is to decrease the impacts that different actions have on the environment by using the latest technologies and so on.

The major focus of the start-ups should be on the first group, Knowledge-based Economy as it aims to sustainability of the future economic development across the industries and encourage companies to innovation activities rather than continuing in the current set-up, which may lead to lock-in or survival. All these activities can increase the overall competitiveness of the Czech Republic.

All cooperation is based on public tenders, which are proposed and on average the program should take up to 4 years. Companies can cover up to 80 % of their expenditures depending on the size of the company, again the small enterprises are favoured compare to medium or large one. If companies collaborate with the research organization, they can reach higher percentage in terms of cost cover. Financial support can be used for salaries, purchase of needed patents or licences or material needed for R&D.

However, based on the available data for the first round of applications during 2014, only 12 % of applications succeeded and was granted the support from more than 700 received applications. Unsurprisingly, only half of the available financial support was used during this round. Majority of the support went to industries, followed by sciences, such as math or physics, and agriculture. Any international participant did not receive financial support. (The Technology Agency of the Czech Republic, 2016)

9.4.3. TRIO

The Ministry of Industry and Trade announced new program to promote R&D activities called TRIO in 2015, which should be funded by amount 3,7 billion CZK (almost 150 million euro). Companies can get support via public tenders, similar principle to the Epsilon program, and few key technologies and areas are identified (based on the European Key Enabling Technologies (European Commission, 2018)), such as nanotechnologies, micro and nanoelectronics, biotechnologies or advanced manufacturing technologies. All of these technologies can be considered in the scope of the Industry 4.0 and in the same time relevant for start-ups.

One of the obstacles for participants is that they have to be placed in the Czech Republic so foreign applications are not possible. Another limitation is set by the rule that participants must collaborate with research institution in order to exchange technologies or results gained during the project. The Ministry aims here to promote links to public institutions as it sees gaps in cooperation between companies and these institutions. Furthermore, SMEs can reach up to 80 % of the financial support cover for the project as one of the targets of the program is to increase innovation activities among SMEs. During the last round of the public tenders, more than 20 % of applications were approved from the Ministry side and can gain the financial support. However, the Ministry has not published any report or overall statistics about the current or historical status of the program. (The Ministry of Industry and Trade, 2018)

9.4.4. CzechInvest

The Investment and Business Development Agency (shortly CzechInvest) is an organization founded by the Ministry of Industry and Trade in 1993 and represents the Czech Republic abroad as a country favourable for foreign investments. The CzechInvest has exclusive rights for investment initiatives in the Czech Republic, support Czech companies, which want to reach global markets and try to improve overall business environment in the Czech Republic.

All services, such as help with investments schemes, consultations (especially for foreign partners investing in the Czech Republic) or negotiations with the public offices and many others, are provided without any charges. The CzechInvest aims to provide help and support to SMEs, start-ups and also leverage investments into manufacturing or technologies either from the local companies or international one. Activities towards start-ups will be explored in next lines. (Czech Invest, 2018)

The CzechStarter is program offered to start-ups which have already existing product or service (not only idea), have less than 50 employees, are not older than 3 years and have potential to reach global markets. Applying to CzechStarter can ensure to start-ups up to 7 months of mentoring and consulting services that are mainly (85 %) financed by the CzechInvest. The most successful start-ups can participate on two weeks camp in Silicon Valley, where many of the high-tech companies are based. Up to now, 111 start-ups were selected to the CzechStarter and 6 of them received financial support from investors.

Participants of the CzechDemo program can attend international start-up events around the world. More than 25 start-ups used this option and visited 9 different events, such as CES in Las Vegas, Slush Tokyo or TechDay in New York. If start-up is selected (at this case can be up to 5 years old), it receives financial support in terms of entrance fee for the event, mentoring before the event and support with the presentation, marketing materials and so on. By participating at these events, start-ups can attract potential investors, extend its network or increase awareness of their product or service.

One of the most attractive programs for start-ups with existing innovative product or service is the CzechAccelerator. This program offers its participants possibility to spend 3 months abroad in the local business incubator. Silicon Valley, New York, Singapore and London were selected as appropriate places for this program. Start-ups can benefit from the fully paid offices, partly paid mentoring programs from international experts or participation on the local events. Almost 40 start-ups participated during the 3 years (2011-2014).

The CzechMatch partly copies the CzechAccelerator as it aims to promote investments into start-ups by supporting them through dedicated seminars outside the Czech Republic and meeting potential investors and partners from abroad. Start-ups have to go through mentoring program before participating at the seminars. It is expected that almost 100 Czech start-ups will attend 12 different seminars in New York, San Francisco or London. (Czech Invest, 2018)

As the latest initiative by joint forces of the CzechInvest, Rockaway Capital, IBM Czech Republic, Czech ICT Alliance and Association of Small and Medium Sized Enterprises is webpage Czechstartups.org (2018) which serves as an interactive portal in terms of up-coming events, latest news from the Czech start-up environment and finally basic information about existing programs that are offered for the Czech start-ups. However, the list of available programs does not primarily aim to the Industry 4.0 and should be understood more as an overview.

9.4.5. European Investment Fund

One of the newest actions regarding to the support of the Czech start-ups is the European Investment Fund, which uses resources of the European Structural and Investment Fund. It was created in the beginning of 2017 year and it was expected that dedicated resources (around 40 million euro) would go directly to the new forming National Innovation Fund. However, as it was written this Fund is not probably going to exist, so the next steps should be aligned with the Ministry of Industry and Trade. (European Investment Fund, 2017)

The main goal of the EIF is to help SMEs, including start-ups, in accessing relevant financial resources provided by the local partners, such as banks or venture capital funds. In the case of the Czech Republic, after selecting only start-ups, 40 relevant options are available in the form of loans, guarantees or venture capital. Each option has different focus, some of the focus on particular areas of business (creative sector, cleantech, etc.) or in the amount of financial support offered. (European Union, 2018)

This is the first governmental fund investing directly into start-ups or companies in the early stages. The Czech government saw that the EIF gained attention in different European countries and share the know-how with the government as the project like this did not exist before. Furthermore, the Czech government invest its own resources and combine them with financial support provided by the European Union in order to attract even private investors for cooperation. All in all, the overall ecosystem of the Czech start-ups should be strengthened

and awareness about the so-called risk capital as one of the form of the financing should be increased as well. (The Ministry of Industry and Trade, 2017)

9.4.6. Venture Capital Funds and Private Investors

Based on the available data from Havlíková and Staszkievicz (2016) and the figure 21, it is clear that financing via venture capital is not that popular in the Czech Republic. Supporting this, the total investment from the venture capital in the Czech Republic is one the lowest across the European union according to the data from Eurostat (the figure 24). The figure below shows the percentage of venture capital compare to the total GPD of the country. Lighter the colour is, smaller share venture capital has. The leaders in venture capital are Denmark, followed by Finland and Ireland with Luxembourg.

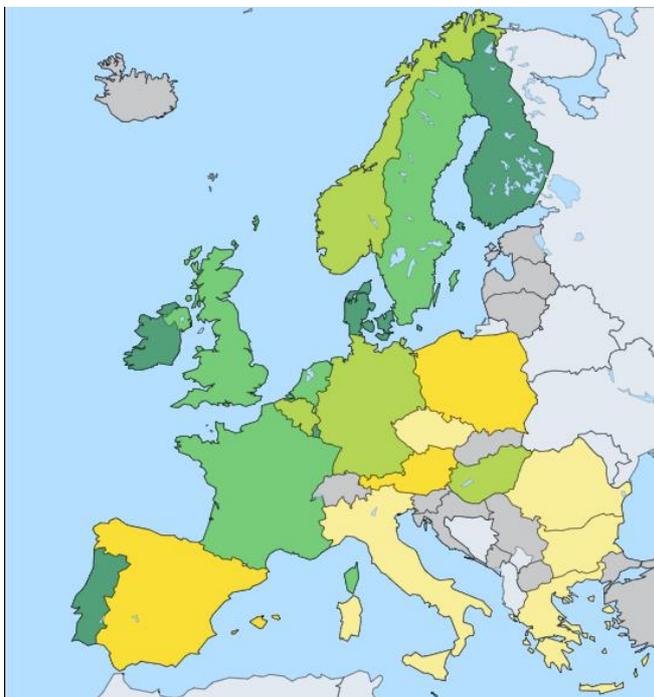


Figure 24- The Total Venture Capital as a Percentage of GDP

Source: (Eurostat, 2018)

However, it is expected that the Czech start-ups will to use this option in the nearest future according to survey, mainly due to limited own resources for the further growth. In the Czech Republic specifics, venture capital, private investors and business angels are relatively new option for start-ups to use. Furthermore, the structure of venture capital funds is often unclear as they are owned by different subjects. For this reason, the Czech Private Equity and Venture Capital Association (CVCA) was created. (eDotace, 2016)

As one of the successful examples of the venture capital firm can be mentioned Credo Ventures, which was co-founded by one of the pioneers of the venture capital in the Czech Republic, Ondřej Bartoš. This year, 2018, Credo Venture plans to launch 3rd fund, which has already attracted different investors from the Czech business sphere. As one of the investors from the past is also EIF mentioned above. This fact just highlights the cooperation between EIF and the local partners. (Filipová, 2018)

Credo Venture (2018) has supported many, not only Czech, start-ups. Some start-ups from the portfolio already exited and was acquired by other company, such as previously mentioned Apiary or Futurelytics, the start-up founded in 2012, supported by 3 different venture companies and business angels and providing its customers with the complex services in customers analytics, Big Data or personalization mainly in e-commerce sphere. (Futurelytics, 2018)

From the current portfolio can be mentioned start-up Teskalabs, which offers mobile and Internet of Things services, such as security solutions or easier access to applications. Teskalabs has partnership with the Czech O2 and Cisco, it is also member of Microsoft BizPark Plus. (Teskalabs, 2018) Another example close to the Industry 4.0 is Sensoneo, focusing on Internet of Things sensors that collect data about waste management. Its solutions can be used in separate businesses or even across the cities around the world. (Sensoneo, 2018) While searching across the Credo portfolio, the dominant technological stream is evident as the majority of start-ups focus on software application, Big Data, Internet of Things or analytics.

Part of the J&T Finance Group (one of the leading Czech financial entities) is J&T Ventures which supports innovative companies and start-ups. They do not only invest financial resources but offers consulting services for setting the strategy or provide relevant contacts for the potential business partners. In the current portfolio can be found NeuronSoundware, which was mentioned as one of the successful examples at this thesis, or ICE Gateway that has developed solution for public lights in the cities and together it creates digital infrastructure for the city of the future. Moreover, Locco project was created to support co-working activities in the Czech Republic. (J&T Ventures, 2018)

Building the Internet Economy in Emerging Markets is the slogan of Rockaway Capital (private equity fund) which invests and builds companies based on the Internet technologies. They have already created community of businesses and supported more than 35 projects in Europe

and worldwide. The core of Rockaway Capital is Mall Group and its e-commerce companies that are the leaders in the Central and East Europe. They also play important role in traveling via companies Invia or flug.de or Reisen.de. Last part is dedicated to start-ups, such as SQLdep that focuses on creating data warehouses, which can be accessed online, or Yottly, which aims to development of analytical tool for immediate data analysis. (Rockaway Capital, 2018) Majority of the start-ups in Rockaway Capital can be considered as a useful “supplements” in the overall portfolio, which is heavily based on e-commerce and travel area, where Big Data flows and further work with them is needed.

Without any doubts, many other companies focusing on start-ups can be found in the Czech Republic and they do not have necessary only Czech origins. However, it is obvious that Czech businessmen have deeper knowledge on the local environment and can use this in the investments. This is also supported by Havlíková and Staszkievicz (2016) where the Czech start-ups prefer local partnerships (venture capitalists, private investors or business angels) rather than from abroad.

9.4.7. Science and Technology Parks and Incubators

The Science and Technology Parks Association of the Czech Republic (STPA CR) has been active since 1990 and encourages creation of the Science and Technology Parks that creates space for development of the SMEs, transfer knowledge between the companies and parks or provide other services. These parks create a base for further technological and innovation activities, which are usually located around places, where is a large potential of human resources, financial support or material and equipment. Majority of the parks have been created as a result of a transformation from already existing research institutes.

Parks are usually provided with building, offices or laboratories for their activities and can be either non-profit or commercial one. *“The STP⁶ is an internationally recognised way to the fastest overcome of technological backwardness and lack of market competitiveness and to creation of new perspective work opportunities in an active employment policy.”*

In the case of the Czech Republic, STP has two functions:

- 1) *Innovation* – in the meaning of development of products or services;
- 2) *Incubation* – in the meaning of start-up support.

⁶ The Science and Technological Park

Subjects operating under STPA CR can have 3 forms:

- 1) *Science Park;*
- 2) *Technology Park;*
- 3) *Business and Innovation Centre.*

Current location of STP in the Czech Republic is visible from the figure below. Almost every region has at least one park, but it is visible that more parks are placed in one region. This create space for start-ups as they can find the relevant park or incubator in a reasonable distance. Nowadays, the Czech Republic has 15 accredited parks, 34 have been waiting for needed accreditation. It will not be surprising that Parks cooperate mainly with other governmental institution and organizations as the majority of resources come from the public support. However, STPA CR have made partnership even with international subjects, mainly with other Technological Parks and Incubators, from for example Russia, Poland or China. (The Science and Technology Parks Association CR, 2018)

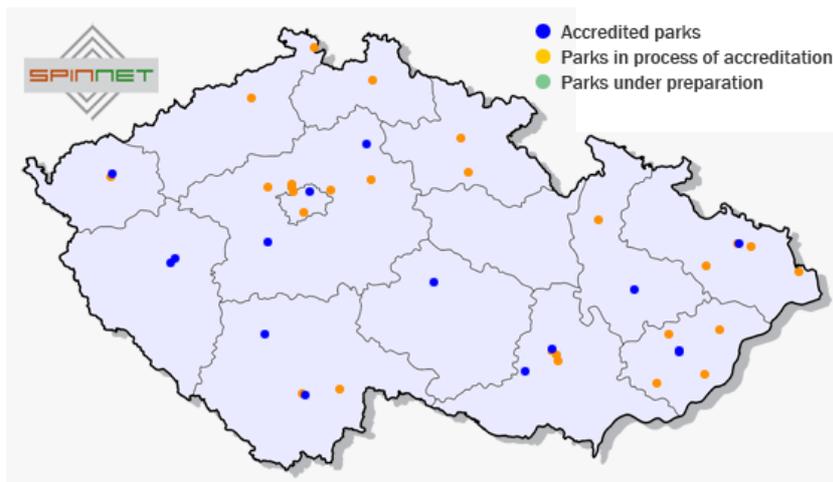


Figure 25- Science and Technology Parks in the Czech Republic

Source: (The Science and Technology Parks Association CR, 2018)

Majority of the Parks and Incubators are organized under the structure of the Czech universities, which helps to promote even closer collaboration between start-ups, Parks/Incubators and academia sphere. Also, the scope of each individual Park differs from one to another. It is evident that for example Biology Park Brno focuses on biotechnologies and biomedicine and its further application in companies or research organizations. (Biology Park, 2018)

Nevertheless, the majority of start-ups, based on data by Havlíková and Staszkievicz (2016), prefer to use and participate Incubators rather than Parks, 12,1 % for local incubator compare to 4,3 % in favour for the Technological Parks. From wide range of incubators in the Czech Republic author decided to select two examples, Point One based in Prague and JIC, which stands for abbreviation Jihomoravské Inovační Centrum (Southmoravian Innovation Centre).

The successful example of the Technology Park can be mentioned The Science and Technology Park and Business Incubator TITC in Brno. Preparation of the project started in 2009 and the first activities became 5 years later also with the support of the EU funds and the local technical university. The Park offers to its clients' immediate contact with other research institutions and universities placed in Brno, participating on available projects or get contacts to the potential investors. The business incubator is also part of this Park as it should even more promote start-ups activities. From the existing projects under the TITC can be mentioned companies such as Lematec focusing on automatization and its application in different areas, or Software Solutions Global specializing on development of mobile phone applications for energy, manufacturing or transport areas. (The Technology Innovation Transfer Chamber, 2018)

Regional Innovation Strategy of the South Moravian region set the basics of the Jihomoravské Inovační Centrum (JIC) in 2003. Nowadays JIC cooperates with the local Masaryk University, developed its own Innovative vouchers and also created the first start-up accelerator in the Czech Republic in 2010. JIC's activities were spotted even abroad as it received the 3rd place in the Best Incubator Award in 2011. Nowadays, JIC provides start-ups with 4 different programs based on the growth stage and furthermore, created independent venture capital firm. JIC has supported more than 220 start-ups since 2014 and these start-ups have created 2000 new working places. Moreover, majority of start-ups focus on the foreign markets as turnover abroad reached 2,7 billion CZK compare to the total value of 3,2 billion CZK in 2015. Local start-ups have also attracted investors that spent more than 200 million CZK. (JIC, 2018)

9.4.8. Accelerators

Compare to incubators, which are in the majority cases founded and supported primarily from/by public institutions or government, private companies or wealthy individuals take this role in the case of accelerators and situation in the Czech Republic is not different. Accelerators are relatively new possibility for start-ups as the first accelerator was launched in 2010 in previously mentioned JIC.

One year later, 2011, probably the most known Czech accelerator, StartupYard was created. Until now, it helped more than 55 companies, which shows very competitive environment and in the same time demanding requirements for being accepted into the program, 5 start-ups were acquired, almost 25 received financial support and only 15 companies do not exist in the current days. At StartupYard, mentors and consultants help to shape companies' product or service, companies can use direct investment from the fund, but in return for 5 % of its share. However, on the other side, added-value here is in extreme professionalism as mentors come from the TOP management sphere from international companies, or they have already created successful companies.

StartupYard is a 3 months program, which helped Neuron Soundware mentioned previously at this thesis, or start-up Rossum (Artificial Intelligence that can analyse large amount of data and process this data further inside the company). It is clear while observing alumni start-ups that participated at StartupYard that it mainly focuses on the start-ups based on the recent technologies such as Internet of Things, Artificial Intelligence or Cyber Security. This focus just highlights the importance of these technologies in the nearest future. (StartupYard, 2018)

Another accelerator, UP21, is one of the newest in the Czech Republic as it was established only two years ago in 2016 by well-known billionaire Karel Janeček. UP21 slightly differs from StartupYard mainly due to fact that emphasis personal development of the individuals inside the start-up. It is also visible from the slogan of UP21, which says that: *“Investment is not enough. Ask for a great co-pilot.”* Beside the personal development UP21 targets 3 more areas, financial aspects of the start-up, mentoring and developing important skills relevant to each individual start-up.

Up to now, more than 800 start-ups have applied to UP21 but only less 20 have succeeded in the application process. However, these start-ups have already attracted 4,5 million USD in investments. Cross Network Intelligence, which helps to run telecommunication networks more efficiently, or Spaceflow, focusing on digitalization inside the various of buildings, are just few examples of start-ups placed in UP21.

Compare to StartupYard, UP21 has wider variety of the start-ups in the portfolio as some of them focus on learning platforms, sharing economy or food production. However, all these companies had to go through very intensive application process and investors see the potential not only for rapid growth, but also social impact of created products or services. (UP21, 2018)

9.4.9. Other Options

Start-ups within the Industry 4.0 can also use services and support provided by other organizations and institutions in the Czech Republic. Shortly named companies and their initiatives are not definitely the full list of options available for start-ups but should serve more as an extension for previously mentioned support.

The only legal entity that represents interests of the Czech entrepreneurs is the Czech Chamber of Commerce, where more than 15 000 subjects are presented. Part of its activities directly aims for SMEs and the Industry 4.0 through international program CERIEcon. CERIEcon should improve competitiveness across SMEs and start-ups placed in the Central Europe by sharing reached results or knowledge exchange. (The Czech Chamber of Commerce, 2017) Furthermore, the Czech Chamber of Commerce (2018) created last year, 2017, the Research Institute for Entrepreneurship and Innovation that should improve awareness of the Industry 4.0 in the Czech Republic through launching own programs and initiatives towards this topic, organizing workshops and events or publication materials and analysis.

The Association of Small and Medium Sized Entrepreneurs in the Czech Republic was created in 2001 in order to strengthen the voice of SMEs in the Czech Republic. The organization provides mainly informative and legal services to its members in areas such as export, financing or tax questions. It identified 10 different groups of SMEs, where start-ups can be placed into group “beginner entrepreneurs”. What is more, it also collects data across the Czech SMEs from the various ankles and provides them to its members. (Asociace malých a středních podniků a živnostníků ČR, 2017)

Co-working places have been rapidly growing during last few years in the Czech Republic, mainly in the bigger Czech cities such as Prague, Brno or Ostrava. Co-working places primarily aims to start-ups or people starting their own companies as they offer place and office utilities for very small prices compare to traditional office solutions. Companies can use variety of options provided by different co-working places and even some of them are focused on particular sectors of economy. These places can also offer its own accelerating or incubating programs, contacts for potential investors and so on. One of the most known place is Prague Impact Hub, where companies can use local accelerating programs, networking sessions or rooms for organized events. (Dočkal, 2014) (Impact Hub, 2018)

10. Evaluation of the Current Situation and Suggestion of the Future Steps

Innovation and technologies are the decisive factors of the potential success of the 4th Industrial Revolution or the Industry 4.0. Changes, in the meaning of globalization, robust networks or inter-connection, have been constantly bringing innovative ideas and thoughts. Nowadays, the potential success of the companies does not depend on “just” luck or idea itself but more on complex process of activities connected to innovation and steps forward. The journey towards promising results is without any doubts difficult, especially in the beginning.

In the current days, hardly any business cannot rely on its own activities and be competitive in the environment. Companies are pushed to collaborate with each other or other market subjects. In the value-creating chain, small and medium sized companies, start-ups respectively, have unreplaceable spot. (Tomek & Vávrová, 2017)

However, the Industry 4.0 is still shrouded under many unanswered questions. The pioneer of the overall concept Industry 4.0 in the Czech Republic, professor Mařík (2016) asks in his book following:

- 1) How will the traditional and new fields/disciplines look like in 10 years?;
- 2) What key competences will be needed in these new areas in 10 years?;
- 3) What will the key technologies be in the nearest future and how they will shape the exporting fields?.

In order to answer these questions, more detailed analyses or ad-hoc needs are crucial and calls for the further research. Implementation of the Industry 4.0 principles has to be understood as an on-going process.

What is the role of the start-ups within the Industry 4.0 then? OECD (2016) recognizes the importance of the start-ups as they often play the crucial role in innovation activities and they usually introduce the markets with advanced or developed products and services. These solutions push the market forward, economy grows, and new jobs are created.

Another point is that the Czech Republic cannot be put into the same “technological group” like France, the United Kingdom or Finland. This creates pressure on the Czech Republic to catch up with these countries. Many of the large companies in the Czech Republic have

foreign owner so they are at least partly dependent on the decisions made abroad. These companies, compare to start-ups, are generally much slower in decision making and its further implementation into the practice. According to Jiří Holoubek (Dostál, 2016) and other Czech experts on the Industry 4.0, support from the government and its institutions is crucial for the success of the Czech SMEs and start-ups. However, Holoubek sees the tension in the governmental progress so far at this area such as neglected development of the digital infrastructure or determination of responsible offices for the concept fulfilment. In the same time, the Czech start-ups are recognized in the world for flexibility and improvisation in unexpected situations.

10.1. The Role of the Czech Government and Its Institutions

In order to answer the first research question: *“How can the Czech government and its institutions support and strengthen the role of the Czech start-ups within the Industry 4.0 concept?”* few main points are identified and evaluated below. This part also touches the other aspects that the Czech government should take into consideration when making any steps further as the aspects even indirectly can influence the role of the start-ups.

10.1.1. Simplification of the Current Initiatives and Their Promotion Across the Start-ups

OECD (2016) recognizes that the Czech government should boost the tools and initiatives towards the SMEs and start-ups respectively. These instruments (for example: grants, subsidies or consultation services) should be simplified. This is also evident from the previous text that many different institutions and ministries are responsible for various fields and some supervising authority is missing. Furthermore, programs are fragmented, partly overlapping each other. Without any doubts, start-ups seek for variety of the support from the financial one, such as OP PIK, or consultation and analysis provided by the CzechInvest.

Based on the survey among the 1000 Czech SMEs (Asociace malých a středních podniků a živnostníků ČR, 2018), SMEs do not have sufficient knowledge and consciousness about the Industry 4.0 concept and its principles. This is also supported by Mařík et al. (2016) as he claims that the awareness about the concept is generally low in the Czech Republic. Results from the above mentioned survey showed that government or its institutions have not shared almost any information towards this topic. Furthermore, companies stated that they

are not aware about practically any program or initiative around this concept. On the other side, companies have knowledge about the document Initiative Industry 4.0, but there is not specific part targeting SMEs or start-ups.

It is also visible that start-ups have been facing overwhelming bureaucratic barriers not only connected to starting the company but also during application process to grants or subsidies. Government should aim to decreasing these barriers and focus more enhancing innovative or entrepreneurial activities. Further, it is clear that governmental budget has resources to support relevant programs and initiatives. However, start-ups area need to be more specified and the overall system of initiatives and available programs have to be reorganized in order to provide applicants with better transparency and clarity. Programs should target directly the area of the Industry 4.0 even through smaller projects, where start-ups can participate.

10.1.2. Government as a Moving Force of the Industry 4.0

Author supports Mařík et al. (2016) as he claims that government should play the central role in redistribution of public resources and should prevent fragmentation of the initiatives. Another tension here is seen in quite low level of cooperation between start-ups (or companies in general) with the public institutions, including universities. At this case, the Industry 4.0 has to be seen as a one potential way to transfer from the “traditional industrial country” towards more “innovative country”, where the latest technologies are applied, as the Czech companies are relatively small, compare to multinational companies and they usually have insufficient financial resources for R&D. On the other side public institutions stand, which usually make the research independently. How this situation can be improved and how can the Czech start-ups benefit from the potential solutions?

Mařík et al. (2016) suggests building on previously created infrastructure, such as Technological Parks or R&D institutions and extend their activities to the Industry 4.0 topic. Companies and start-ups should participate at this extension in order to precisely target the support and activities. By creating supervising organ for the Industry 4.0, duplicities or irrelevant projects should be spotted and stopped. Also, companies should be encouraged to collaboration with these institutions by increasing support rather than innovating alone. This fact is already visible from the available programs. Another important aspect can be encouraging start-ups to participate at these cooperation programs despite their size or financial issues especially in the beginning. Here can be taken example

from Geenhuizen (2003) and Kelley et al. (2016), who promoted the university collaboration with the local start-ups as new companies can emerge and awareness about the entrepreneurship activities can be increased. Perfect example of the collaboration can be even found at this thesis in the case of Pocket Virtuality, which started collaboration with the Czech Technical University after the venture capital entry.

Other option author sees in the creating so called testbeds mainly due to lack of successful examples of the Industry 4.0 benefits. The first testbed was created at the end of 2017 year in Prague under the Czech Technical University in Prague. In the Czech environment, these testbeds can be created under the existing structure of the Technology Centres or universities. They can also test the potential technological solutions of the Industry 4.0 and each testbed can have different scope of technologies, mainly depending on the current focus of each institution/university. Testbeds can be also combined and create environment of cooperating entities in order to simulate real world. (Dvořák, 2017)

10.1.3. Other Consequences of the Industry 4.0 in the Czech Republic

As it was written in the beginning of this thesis, the Industry 4.0 has not been touching just industries themselves but has been affecting society in general by its technological development and results. Education and labour market sphere should not stay behind these changes.

Government is responsible for the educational system in the Czech Republic as it “provides” the labour market with workforce after finishing their education. Without any doubts, government should identify priorities in the educational system, and furthermore target its resources close to knowledge areas related to the Industry 4.0. It is visible even nowadays that companies seek for different skills and knowledge than government supports.

The Czech Information portal about education and PwC (EDUin, 2017) analysed the current educational situations and highlighted 3 main areas for the future development:

- 1) Public debate should be triggered in order to emphasize the importance of upcoming not only economic but also social changes;
- 2) Promote the successful examples of educational subjects that flexibly react to the unexpected situations and needs;
- 3) Look for inspiration abroad and best practices.

The Ministry of Labour and Social Affairs reacted to the Industry 4.0 by creating the Initiative Labour 4.0 in 2016, followed by the Action Plan in 2018. Starting from the Initiative, it identifies that 10 % of the total work places are strongly threatened by the influence of automatization and other 35 % work places should be affected by this as well, which is showed in the figure 26 and in the same time, it is on one of the highest level across OECD countries. It is also expected that in general the Czech society will age, however, this trend is visible practically everywhere across the European Union countries.

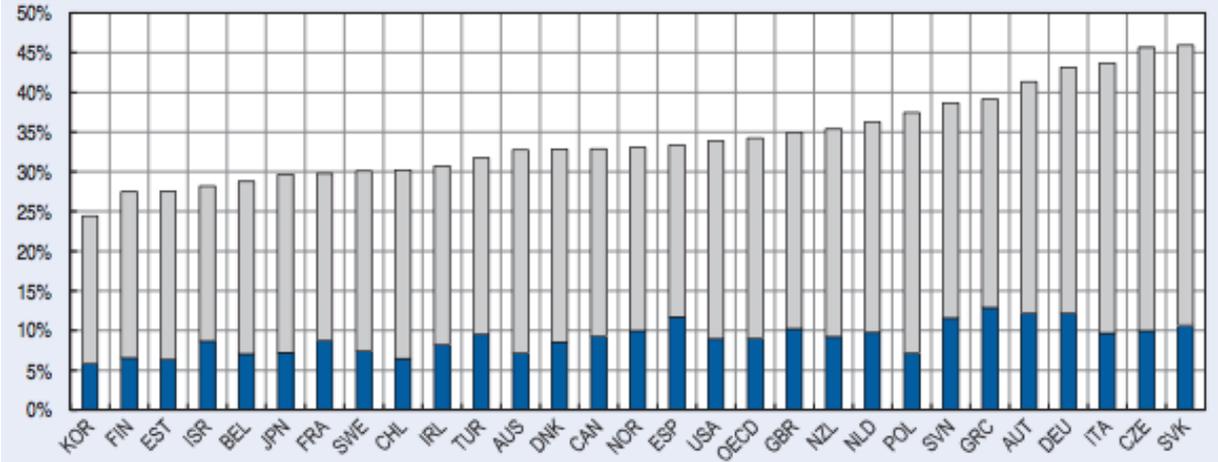


Figure 26- The Risk of Automation in OECD Countries

Source: (OECD, 2017)

On the other side, the Industry 4.0 will create jobs in areas influenced by this concept, such as information technologies, data analysis, cyber security and other fields. These market changes should also open space for creation of new start-ups as they should be able to benefit from global networks and demand. This is also supported by Gerard (2016) and Shabangu (2014) that claims that start-ups seek for favourable conditions at this case potential labour work force. It can be assumed that jobs created within the Industry 4.0 will be closely connected to the scope of the start-ups activities.

Close to this is topic of ongoing learning as employees and companies have to quickly adapt to the new challenges. Ongoing learning is currently on the very low level compare to other EU countries. The barriers are mainly financial due to high costs of provided trainings and approach that “classic education is sufficient”. However, ongoing learning is not only question for the Czech government, but start-ups have to be aware as well.

In the beginning of 2018, the Action Plan for the Labour 4.0 was released. It identifies 4 strategic goals:

- 1) Regulation of the technological influences on work power demand;
- 2) Support of ongoing learning;
- 3) Condition setting on labour market due to the technological changes
- 4) Regulation of the technological influences on selected social aspects.

However, all Action plan is rather descriptive and analytic rather than setting the precise steps what needs to be done. It is heavily based on analyses, which should be finished in 2018/2019. In the majority of the points, future steps after analyses are not described or planned. Author sees here tunnel vision of the Czech government as the overall Initiative started more than 2 years ago and precise targets are missing or not clearly defined. (The Ministry of Labour and Social Affairs, 2018)

10.2. Available Supportive Instruments and Initiatives for the Czech Start-ups

The second research question: “*How can the start-ups in the Czech Republic benefit from the available supportive instruments and initiatives within the Industry 4.0 concept?*”, is distributed into 4 main parts, financial and non-financial support from the point of view of the Czech government and private subjects, in order to give reader more accurate view.

10.2.1. Governmental Financial Support of the Czech Start-ups

Projects related to the Industry 4.0 will be financially very demanding as the overall concept is still in the initial stage. Despite this fact, it is evident from the text in the Chapter 9 that government has already many tools and initiatives available, but one of the most aspects is that programs of support are disintegrate and more or less randomly used. This is also supported by the Ministry of Industry and Trade (2016) and Mařík et al. (2016). Government should follow the previously mentioned logic in terms of building on existing solutions, such as OP PIK, TRIO and others mentioned at this thesis. What is more important, the Czech government has to come with clear definition of targets and milestones that need to be reached towards the Industry 4.0 and with appropriate programs for different areas should follow.

As the Industry 4.0 has been influencing many areas of daily life, the financial support should also aim other fields and not only industries. Here can be mentioned previously described education, social aspects as well. During the previous period of subsidies into the R&D in the Czech Republic, around 250 projects were identified as they were connected to the Industry 4.0 practices and gained support from 7 various institutions and funds.

Speaking more precisely about the start-ups options, the core of potential support from the governmental side should lay in the OP PIK program as it has the biggest financial amount dedicated and in the same time it is the most relevant program for the Industry 4.0. It also does not need any dramatical changes in terms of compliance of the Industry 4.0 practices. What government can improve at this case is favouring projects that follow the Industry 4.0 principles. It is visible that SMEs, where start-ups are included, have favourable conditions compare to larger companies in order to decrease the inequality between the companies.

Furthermore, program TRIO is one of the programs where priorities are precisely named and specified. The Technology Agency of the Czech Republic should also play one of the biggest roles with its programs, such as Epsilon mentioned at this thesis. TACR touches more areas of the Industry 4.0, however only Epsilon is the closest one to the start-ups area.

All in all, start-ups focusing on the Industry 4.0 can use variety programs that are already available and open for them by the governmental side. However, identifying the program focusing particularly on start-ups it is not possible. Majority of programs speak about SMEs, which include start-up community and can be definitely used by the Czech start-ups. Author sees a potential at these financial resources available for start-ups as the Czech start-ups primarily uses its own capital as a financial resource, which is visible from the figure 21. Another advantage of the governmental program is that finance gained does not necessary need to be used only for purchasing the assets but in some cases for employee trainings or their salaries, which can also lead to hiring new people into the company.

Nevertheless, mainly bureaucracy and administration connected to this form of support create barriers and unwillingness of start-ups to use these options. One of the main roles of the government and its institutions is to not only financially support relevant projects but also creation and maintenance of favourable business environment from which all participating subjects can benefit.

10.2.2. Private Financial Support of the Czech Start-ups

On the other side stands private or venture capital support of the Czech start-ups. This way is relatively new and can be said unexplored. However, author thinks that venture capitalists, business angels and venture funds will gain much more attention than nowadays. This trend is also visible from data collected from Staszkievicz and Havlíkova (2016) in the Czech Start-ups Report 2016, where start-ups primarily preferred, after reinvesting own profit and resources, mainly support from business investors, venture funds and business angels. Another gentle advantage of the private support is that National Innovation Fund is probably not going to exist, which open space for private subjects. Government more or less does not want to participate in risk capital activities and rely more on private investors and funds at this sphere. Following this, by cooperating with the European Investment Fund mentioned at this thesis, venture capitalists can combine their own resources with the European Union one, as for example Credo Ventures already did.

Non-governmental subjects primarily aim to start-ups that bring to market some non-traditional solutions and can attract attention not only within the Czech Republic. Many of the Czech start-ups, few of them mentioned in the subchapter dealing with the successful examples, have been operating worldwide. Start-ups can also benefit from the investors' networks and contacts, furthermore, it is evident that especially venture funds have created specialized portfolios based on particular technologies, such as Rockaway Capital have been doing around its e-commerce and traveling activities and Big Data or analysis tools connected to these areas.

Using the distribution mentioned at this work by Steve Blank, it is clear that start-ups receiving the support from the private companies or investors belong to the 3rd and 4th group, Scalable Start-ups and Buyable Start-ups. These start-ups have inspiration change the world and (or) be sold to a larger company as an acquisition. All mentioned examples at this thesis have features of at least one of these groups. As mentioned in Hathaway (2016), the venture capitalists and funds look for start-ups that can bring some unique feature. But also, for some investors the importance lies in the high profit.

10.2.3. Governmental Non-Financial Support of the Czech Start-ups

Nor government or private investors do not possess unlimited financial resources, which leads to alternative way in the form of non-financial support for start-ups. Mařík et al. (2016) suggests that systemized networking or knowledge markets should be promoted. He highlights the importance of connections between the companies and public institutions, respectively

government. Start-ups leading to the Industry 4.0 practices should receive expertise support from the government.

One of the critical aspects identified here is relatively separated public and private (in terms of inside the companies) R&D activities. Despite the fact that public research institutions and universities are financed from the public resources, they primarily focus on publication activities and more theoretical researches rather on practical gains. Building on this, currently existing network of the Science and Technology Parks in the Czech Republic should create environment for promoting cooperation activities. Governmental programs already focusing on strengthening connections between companies and public institutions (including the technological parks) can serve as an intermediate in this process as they can build on existing infrastructure, available work force from the sphere of academia and students or equipment.

However, it seems that the technological parks are not that attractive place for start-ups. One of the reasons can be that too many of the technological parks exist and none of them reached any critical mass of participating subjects/start-ups. Majority of them is under the structure of local universities so it means that more parks can be placed in one city. This fact raises question of consolidation of the existing parks, which should attract more attention. These parks have been also focusing more on localised start-ups that usually operate on smaller scale. This also follow the distribution by Steve Blank, where smaller and “less” ambitious start-ups belong to first 2 groups, Lifestyle Start-ups and Small-Business Start-ups, and to the group of Social Start-ups. These start-ups have definitely value for the local environment as mentioned in Potente (2015) and the technological parks as they can transfer the entrepreneurial awareness at the local area, employ local work force and collaborate with the local companies despite the fact that they do not have the highest ambitions.

Incubators, as a part of the Technological Parks, have showed more favourable conditions towards start-ups in the Czech Republic. Incubators are in the most cases based in universities, where the potential cooperation and knowledge share can begin. This approach is also supported by Rubin et al. (2015) as he mentions university collaboration as one of the options.

Moreover, the CzechInvest is the leading governmental organization that partly focuses on start-ups through variety of programs like CzechStarter or CzechDemo. By using available financial resources, CzechInvest help start-ups with consultation services or giving them opportunity for growth by participating on the international activities and events. Author sees that despite variety of offered programs which partly overlap each other, CzechInvest offers robust options for start-ups and clearly defines program needs. It also partly gives overview of existing incubators and accelerators in the one place.

10.2.4. Private Non-Financial Support of the Czech Start-ups

Nevertheless, author thinks that accelerators have reached better position than incubators mainly due to fact that they are often funded by the private investors who focus on the recent technologies and solutions. Beside the financial support, which is part of acceleration programs in many cases as well, accelerators are based on the cooperation with market experts and their knowledge. This fact is also visible in Hathaway (2016), where he mentions that one of the specific characteristics about the accelerators is combination of financial and non-financial aspects, at this case mainly mentoring programs. Many of the founders of the Czech accelerators are successful businessmen, whose companies are top ranked not only in the Czech Republic, but also abroad. They can use existing connections for promoting start-up activities.

To extend this, some accelerators have been focusing on particular areas which are in the scope of investors. However, for the majority of the start-ups, accelerators are too demanding programs as accelerators often seek for the best of the best in certain fields. Start-ups have to show that they can bring into market revolutionary solutions and in the same time they think globally rather than locally. On the other side, when start-ups get the opportunity to participate in the accelerator, the future potential grows exponentially as start-ups can get into contact with potential investors, receive consultations services and other supportive features of the accelerators. Here is again visible the Steve Blank's distribution and focus on the 3rd and 4th group of start-ups that have ambitions to get worldwide or get acquired by larger company.

11. Conclusion

The Fourth Industrial Revolution should not bring dynamic and rapid changes only across the industries, but it should affect humankind in general by touching many aspects of daily life. Without any doubts, the Industry 4.0 is mainly relevant for industries itself, but it has been also bringing changes to other areas. Experts in different fields have been discussing potential outcomes of this concept for many years and even nowadays there are no clear conclusions. However, one thing can be said for sure that world has been facing rapid technological development than ever before. This technological development contains the variety of technological solutions, such as Big Data, Internet of Things or Artificial Intelligence and many other relevant. The Fourth Industrial Revolution should be understood as an opportunity for the future growth rather than existing threat as it should bring Revolution to human thinking.

The Czech Republic can take the Industry 4.0 as an opportunity arriving mainly from the long industrial history. Despite the long, more than 40 years, influence of the former Soviet Union, it has made steps to catch-up with its neighbouring countries, mainly Germany and Austria. The Czech Republic enjoys the advantages and benefits brought by the participation in the European Union, as it receives financial support from the EU funds, trading barriers almost do not exist, or its citizens can gain knowledge in different EU countries and use this knowledge in the Czech local environment.

From the author's point of view, little steps have been done towards the Industry 4.0 in the Czech Republic. Without any doubts, one of the key roles in this concept should play the local government and its activities. One of the biggest obstacles for the Industry 4.0 in the Czech Republic is general awareness about the concept. It can be admitted that the Industry 4.0 is still in the beginning and its future is uncertain, but rapid technological development is already here. The current situation calls for more precise steps and specification of the targets. However, nowadays, few governmental documents dealing with the Industry 4.0 exist, but they can be characterized as a descriptive and analysing one rather than setting the future way, where the Czech Republic should go. The main document, Initiative Industry 4.0 issued by the Ministry of Industry and Trade, analysed several areas of the Industry 4.0 influence and it sets the basics for the overall concept in the Czech Republic.

Another part of this thesis dealt with the Czech start-ups within the Industry 4.0. Generally speaking, start-ups in the Czech Republic have not gained that much popularity and attention like in Western countries or the USA, they are more considered as a part of small and medium sized companies. However, start-ups, compare to SMEs, can be characterized as companies that try to bring new and in the same time radical solutions, products or services to the market, which is also supported by Lim, Ken and Minshall (2015). Another characteristic is that they usually grow very fast in the contrast to other companies. In the majority of cases, they start from particular solutions and explore them further. This can be associated with effectuation approach, where potential results are unknown, but the current options are set.

By combining the existing instruments and initiatives within the Industry 4.0 and start-ups in the Czech Republic, very narrow research area emerged. The Czech start-ups have been facing more or less the same challenges as start-ups located around the world, mainly in terms of insufficient financial resources and high failure rate in the early stages. However, several instruments and initiatives should support start-ups in their growth and development in the Czech Republic. Author groups existing options available for the Czech start-ups into four groups, financial and non-financial support and from the point of view of the Czech government and private subjects.

It is clear from the previous text that initiatives and programs share many common features and partly overlaps each other, especially in the case of the governmental programs. Also, the line between financial and non-financial support is quite questionable as for example accelerators and incubators combine both forms in terms of providing finance and mentorship or consultation programs.

Variety of financial options exist in the Czech Republic, starting from governmental programs OP PIK, TRIO through European Investment Fund to private investors or venture funds like Credo Ventures or Rockaway Capital. Governmental initiatives have long history in the Czech Republic, but they are, in the majority of the cases, connected to the high level of administration, unclear rules and overall complexity. However, their focus is much broader compared to private investors or subjects, as they aim to start-ups in general rather than selecting only the best from the best.

On the other side, private investments into start-ups are relatively new for start-ups but target more specific areas, however, only a few start-ups have received support from these resources. Without any doubts, these start-ups must have at least partly target to become the Unicorn start-up, in other words, their ambitions have to be high. Private investors have also created many incubating and accelerating programs that offer mainly consulting services or access to the existing networks. These programs usually have a demanding selection process.

Speaking about the Czech government, it builds non-financial initiatives around the CzechInvest institution and the Science and Technology Parks places across the Czech Republic. The CzechInvest dedicated to start-ups part of its activities and their programs are mainly beneficial for start-ups that seek consulting services or want to gain experience from the abroad. The Science and Technology Parks are more locally based and provide start-ups with benefits in terms of offices or equipment. Start-ups can also establish close connections to public research institutions or local universities and help to diffuse the potentially gained knowledge.

Only a few programs directly target the Industry 4.0 concept, which shows the overall unpreparedness of the Czech society towards this concept. Furthermore, the start-ups have been dedicated only relatively little attention in the existing programs and options. Despite the fact that private investors do not use the Industry 4.0 terminology at all in the Czech Republic, it seems that they recognize the importance of the technological Revolution and have been making steps towards such as establishing accelerators and incubators or creating venture funds that invest into the technological companies and mainly start-ups.

To conclude this thesis in a positive manner, author assumes that *the time* of the Czech start-ups will shortly come, and they will become the valuable part of the Czech business environment as the Industry 4.0 should bring dynamic changes, where start-ups should be in the foreground of these changes. Without any doubts, they cannot directly compete with large multinational companies, but still, they can fill the market gaps by their solutions and be pioneers in terms of the future technological outcomes.

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