Charles University in Prague

Faculty of Humanities

Bachelor thesis

Future of Economics: The Notion of Technological Unemployment

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Study programme: Studium humanitní vzdělanosti/

Liberal Arts and Humanities

Prague 2016

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I declare that I have written this Bachelor Diploma Paper myself and on my own. I have duly referenced and quoted all the material and sources that I used in it. This Paper has not yet been submitted to obtain any degree.

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Contents

I. Introduction

Like in many shops before, automatic cashiers[1] were installed at my local grocery store. They had their bugs at first (sometimes they wouldn't recognize some items) and people looked at them suspiciously, avoiding them, preferring to stand in line for a human cashier they were familiar with.

I took advantage of this fact immediately. Automatic cashiers were right next to the human ones, so people in line were just standing by them. I asked if anybody intended to use them, and when silence was the only response I got, I cut the line, paid the automat for my groceries, and went out of the shop. All of that happened before any of the other shoppers had a chance to advance in line for a human cashier.

In time, more and more people started using the automatic cashiers. Eventually, there was only one human assigned to a cash register, where previously there had to be up to three.

I was delighted with the fact. Automatic cashiers were always ready, there was no need to wait for an extra human cashier to arrive when the line was getting longer. It seemed that everybody is getting better off - us, the customers, having shorter waiting periods when paying for the goods we wanted to purchase, and the grocery company, having more satisfied customers, and, since there was no need for so many human cashiers, cutting the expenses on payrolls.

I began to think about the last fact when I realized I don't see familiar faces in the shop anymore. I was fine not seeing some of them, actually - they were grim most of the time, looking not particularly happy that their job is to scan price tags all day long. Yet there was this older lady, who didn't mind smiling and even occasionally briefly chat with customers. I never saw her in the shop after they've installed the automats.

I started to wonder - if she got laid off because of automation, what are her prospects nowadays? Will she work in some other shop, until they'll automate it too? What then? Will she acquire some training that will increase her chance of getting a better job? Since she was around her fifties, and probably hasn't done so yet, I didn't find it likely. And what about all the other cashiers? Shouldn't they already be slowly looking for other job opportunities?

[1] Also known as self-service checkout and as semi-attended customer-activated terminal, SACAT

Because it seems that most of their jobs will be redundant in a not-so-far future. But as the technology evolves, will they be able to find employment that wouldn't be prone to automation?

Economics already has a term for my concerns. It's called the Luddite fallacy, named after the infamous Ned Ludd, who supposedly smashed stocking frames in early industrial revolution, and later became associated with the hostile attitude towards automation - rooted in the belief that machines will steal our jobs, which will create troublesome unemployment (Hammond and Hammond, 1919). The argument against the Luddite fallacy is a simple observation pointing out that new technologies in the industrial era haven't created permanent overall unemployment (Tabarrok, 2003). As many economists would explain to you, the system of private markets will always create new jobs - in other words, unemployment caused by implementation of the new technologies is structural, so people will simply re-educate themselves and find jobs elsewhere, or they will invent new occupations entirely (Ridley, 2014). As we don't have need for switchboard operators nowadays, so may one day cashiers disappear, without causing any significant social problems.

Yet recently some authors begun to argue that changes that our society is undergoing are different from the era of the industrial revolution, same as the changes of the industrial revolution were different from the changes in the agricultural revolution (McAfee, Brynjolfsson, 2014). They warn that innovations that are transforming our society are not only different, they are and will be exponentially faster. And if technology evolves faster than unemployed people can adapt to, we will have a problem (Pistono, 2014).

As Brynjolfsson and McAfee predict in their book *The Second Machine Age,* technological development will bring us much benefit, and create enormous wealth. But they also point out that *"there is no economic law that says all workers, or even a majority of workers, will benefit from these advances"*(McAfee, Brynjolfsson, 2014: 61).

It is difficult, if not impossible, to predict the future with any reliability. This thesis will not try to make any predictions. Its aim is to explore an issue, which may cause significant societal problems in a not so distant future - technological unemployment.

The question it is trying to answer is if there is a reason to believe that changes and issues that accompany technological innovation will be different from those in the past.

Since no catastrophic “jobless” scenario caused by the implementation of new machinery has been ever fulfilled in the history of mankind, I will consider the “optimistic view” - that is, the view that there is no need to worry about massive unemployment in the future - as my baseline, and try to find arguments against it. The first acknowledgment that has to be made is the fact that if something didn't happened in the past, that does not mean that it won't happen in the future.

At first, I will explore how the notion of technological unemployment was perceived and dealt with in history. I will then analyse the current state of technology in relation to its capabilities to replace human labour, and summarize premises that it implies. And at the end, I will discuss proposed scenarios and solutions to the problems in question.

Even though it is relatively easy to dismiss any utopian or dystopian predictions about the future, we need to pay attention to the issues that may arise. We live in an era of innovation. The world around us constantly changes; it always did. Yet technology seems to be transforming our world and our society in a rate previously unseen, and we need to be prepared for the challenges that come with it.

II. A Notion of "Technological Unemployment" in the Past

The term "technological unemployment" and its popularization is attributed to John M. Keynes, who in 1930 wrote an essay titled *Economic Possibilities for our Grandchildren*. In it, he says:

> "*We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come--namely, technological unemployment. This means unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour."* (Keynes 1930: 3)

Keynes wrote this in the second year of the Great Depression, when massive unemployment began to emerge, along with pessimistic views on the future of economics. He remained quite optimistic though, stating that current problems are caused not by the end of progress, but rather by the rapidity of economics changes, by transition from one period to another. For him, technological progress and technological unemployment meant that mankind is solving its struggle for subsistence - its economic problem.[2]

However, concerns about displacement of human labour due to implementation of new technology accompanies mankind since ancient times. The oldest recorded comment that we may use for today's discussion comes from Aristotle's Politics: *"if each of the instruments were able to perform its work on command or by anticipation, (...) master craftsmen would no longer have a need for subordinates, or masters for slaves"* (Aristotle, Pol.I.4, 1253bl35-40, 2010).

Even though that in its context describes Aristotle's explanation of the societal order in sense of a servants role (because, as he explains, the servant himself is an instrument), it is interesting to see how millennia later, these words could be perceived in a whole different perspective, hardly imaginable in his time - describing the fact that work and slavery would become unnecessary if our instruments would become sophisticated enough.

[2] which, he speculated, may be resolved, or at least be within sight of solution, within a hundred years, i.e., in 2030 (Keynes, 1930).

But his era did know problems of technological unemployment. According to John Forbes (1932), in Ancient Greece both competition from slaves and advancement of labour saving technology lead to unemployment, where sometimes free labourers ended up in slavery themselves. In other cases, they survived on alms or were supported through public work policies (Douglas, 1932). Similar cases can be found in the Roman Empire; there is even some evidence of banning new technology, as Suetonius tells us about emperor Vespasian: "*When an engineer offered a low-cost contrivance enabling the transport of heavy columns to the Capitol, Vespasian paid him handsomely for his invention but declined to use the machine, saying: 'You must allow my poor hauliers to earn their bread.'"*(Suetonius: Book Eight: XVIII, 2014)

Through the medieval and pre-industrial era, implementation of new technology in Europe would often encounter obstacles from authorities, siding with interests of guilds, whose conservative approach aimed to preserve established monopoles in their fields, and their economic status. In some cases, those who tried to promote or even trade with banned technology would face the highest penalties: violators were hanged, broken on wheels and sent to galleys (Heilbroner, 2011).

Another famous example of rejecting new labour-saving technology comes from England in 1589, where William Lee presented his stocking frame knitting machine to Queen Elizabeth I., who refused to grant him a patent, claiming it would make her subjects into beggars. Due to high opposition from the guilds, Lee had to eventually leave England (Frey, Osborne, 2013).[3]

Yet it was in Great Britain, where innovation begun to appear in a higher scale, eventually evolving to what is now described as the Industrial revolution. This shift in attitude towards technological innovation is attributed to change in government structure, namely the Glorious Revolution in 1688, which led to the establishment of parliamentary supremacy over the Crown, thus shifting the political power towards property owners, who were not as concerned about the impact of new technologies on labourers. On the contrary - much of them benefited from the export of manufactured goods, so productivity-increased technologies were a

[3] The full quote of Elizabeth I., cited in the works of above paraphrased authors, goes as follows: *"Thou aimest high, Master Lee. Consider thou what the invention could do to my poor subjects. It would assuredly bring to them ruin by depriving them of employment, thus making them beggars."* (cited in Frey, Osborne, 2013:6) Authors suggest that her main concern was a hosiers guild manifestation.

welcomed asset. Some authors state that another force that contributed to this change of attitude was the fact that unskilled workers, inventors and consumers benefited from these mechanizations, even claiming that unskilled workers were the biggest beneficiaries of the Industrial Revolution (Frey, Osborne, 2013).

However, even though the attitude of authorities changed, as is shown by passed legislations which made destruction of machinery punishable by death (1769), concerns about the impact on employment were not over, especially by those who were threatened by it. This was vividly shown during the before mentioned “Luddite” riots between 1811 and 1816, which were eventually suppressed by the army (Frey, Osborne, 2013).

2.1 The compensation theory

It was in these times, when the discipline of modern economics began to take form, rejecting mercantilism and discussing issues of the time, including technological unemployment. Most of the early 19th century economists discussed the issue, including J. B. Say, D. Ricardo, J. R. McCulloch and N. Senior (Woirol, 1996). The prevailing opinion was that technological unemployment would not be a long-lasting problem. Building on initial works of J. B. Say, first arguments supporting this optimistic view were formed, which were later criticized and labelled “the compensation theory” by Marx (Marx, 1961). However, the optimistic view was challenged even by contemporary authors, such as S. de Sismondi, T.R. Malthus, and J. S. Mill (Woirol, 1996).

A well-arranged summary of discussions about the compensation theory and its criticism is offered by Marco Vivarelli (2012). As he describes, the theory is made up of six different market compensation mechanisms, triggered by technological change:

1) The compensation mechanism “via additional employment in the capital goods sector.”

Based on the works of Say, it says, in short, that the employment reduced by an introduction of new machinery will be compensated by new employment created in a sector where these machines are made.

This argument is no longer used, since it is widely believed that Marx disproved it, pointing out that the employment of the machine is profitable only if it's the annual product of fewer men that it replaces. Moreover, the new labour-saving machines spread even to the capital goods sector, and so the argument fails.

2) The compensation mechanism "via decrease in prices."

Argument used by Stuart states that technological innovation leads to the decrease in production unit cost, and therefore to the decrease in its price. This leads to a higher demand for that product and thus additional production and employment.

At first criticized by Malthus and Mill, arguing that the aggregate demand is lowered by displacement workers, who were suppressed by the innovation. Another counterpoint consists of the fact that this compensation mechanism is dependent on the existence of a highly competitive market[4], and the argument regarding difficulties in effective demand, such as the low value of the marginal efficiency capital, which can lead to lower demand elasticity and delay in expenditure decisions. In other words, even if the price of a certain product would fall, we might not instantly want to buy more of it, since we might not see a favourable return to our investment, and so no additional production would be created.

3) The compensation mechanism "via new investments."

Proposed by Ricardo, this observation states that entrepreneurs may gain extra profits from innovation, since decline in prices won't match the decline in cost of production instantaneously. New profits are invested into more production, which leads to more employment.

This argument is undermined by its reliance upon an assumption that accumulated gains are immediately and entirely invested into more production. If not, its effectiveness in its compensation declines. Marx also pointed out that the nature of additional investments matter, since accumulation of capital is effected by its qualitative change, and compensation in cases of capital-intensive investments can only be partial (Marx, 1961).

[4] In a monopolistic or oligopolistic scheme the compensation mechanism is strongly weakened, and decrease in price might not happen.

4) The compensation mechanism "via decrease in wages."

Since machines would compete against humans, wages would decrease. Firstly proposed by Wicksell, he stated that lower wages would lead to increase in demand for labour. In other words, if labour and capital are substitutable, proper price adjustment would be the answer.

Again, problems of before mentioned effective demand arise - companies may be incentivized to hire more workers by the lower cost, or they may have, in this situation, lower expectations from workers and hire fewer of them. The substitutability of labour and capital is also questioned, since technological change may be cumulative and irreversible.

5) The compensation mechanism "via increase in incomes."

A different scenario, standing in sharp contrast from the previous compensation mechanism, states that gains from technological changes may be used to increase wages of workers, and due to the higher income, workers consume more, which leads to a higher demand for goods, leading to an increase in employment. This argument was proposed in a later period by Keynesian and Kaldorian traditions. Even though it may seem that employers may not be incentivized to transform new savings into higher wages, it might be the case when e.g. unions are involved.

This scenario indeed happened in times of "fordism" and in the fordist mode of production, which was, as Victoria de Grazia describes, *"the eponymous manufacturing system designed to spew out standardized, low-cost goods and afford its workers decent enough wages to buy them"* (Grazia, 2006:4) , but Vivarelli points out that this *"mode of production is no longer relevant"* and describes that "*On the whole, this compensation mechanism has been strongly weakened in the new institutional context*." (Vivarelli, 2012:10)

6) The compensation mechanism "via new products."

Technological innovation may in some cases lead to the development of new products, which create or contribute in the creation of new sectors of economy, where new jobs are created. This argument was proposed by Say, and even critics like Marx acknowledged the positive impact that new technologies might have in these cases (Vivarelli, 2012).

Yet, new products and their impact on employment may considerably vary - as Vivarelli points out, effectiveness of this compensation mechanism is a subject to a context of time and place in which it is happening, and it might have a very different final result.

Same words may conclude the discussion on the compensation theory, which so far does not provide the final, conclusive answer on the topic of technological unemployment. Even though it is clear that we must not forget or underestimate the opportunities of compensation mechanisms described above, criticism of this theory suggest that their effects may only be partial or even non-existent, and vary in different circumstances.

2.2 Recent history

Discussions on this topic faded by the end of the 19th century, as benefits of the Industrial Revolution on overall prosperity became clear, just to emerge again in 20th century, with its peak in 1930s and 1960s (Woirol, 1996). The 1930s debates were held in the context of a neoclassical school of thinking and its theory of a general equilibrium, while the 1960s theoretical framework moved under the influence of Keynesianism and Phillip's curve. Economic historian G. R. Woirol describes notable similarities in these debates: Both of them were preceded by popular discussions, started by concerns about the recent rise in unemployment, but haven't started in the professional sphere until recent data clearly suggested an issue. In both cases, prevailing opinion on the issue was that there is nothing dramatic to worry about, and in both cases, concerns about the issue faded due to the events that significantly changed the political-economic situation - namely World War II in the 1930s and the Vietnam War in the1960s - rather than by reaching a consensus on the topic. Woirol also points out that in both cases, little attention was paid to the previous works on the topic, but states that this is somewhat compensated by the knowledge gained through the conducted empirical studies, and by the quality and quantity of data made available due to these discussions (Woirol, 1996).

While academic work continued its research of the negative effect of technological innovations and its mitigation, examples of other approaches could be found elsewhere in the world. In China during the reign of Mao Tse-tung, innovation was purposely slowed down. For example, in his policy “walking on two legs”, introduced in the 1950s, the aim was to provide work opportunities for rural China, and so, when people could be employed, the implementation of technology was deliberately reduced (Vepa, Vepa, 2003).

Similarly yet differently, Gandhi is known for his opposition to the 'craze for machinery', though he emphasizes that he is not opposing machinery as such, but rather ruthlessness towards displaced workers:

> *I want to save time and labour, not for a fraction of mankind, but for all. I want the concentration of wealth, not in the hands of few, but in the hands of all. Today machinery merely helps a few to ride on the back of millions. The impetus behind it all is not the philanthropy to save labour, but greed. (Ghandi, 1924:6)*

As the technology became more sophisticated and the Internet era began, more authors raised their concerns on technological unemployment. D.F. Noble stated in 1995 that the information revolution resulted in 'worsened working conditions, with longer hours, greater anxiety, stress and less pay' and that 'technology was used to deskill, discipline and displace human labour' (Noble, 1993:XI)

J. Rifkin in the same year criticized the notion that displaced workers would be simply 'retrained', since for many people with lower skills and abilities, opportunities would tighten, as new jobs created by machines that displaced them require higher knowledge and thought process that wouldn't be in their capacity to reach. In his words, *"it is naive to believe that large numbers of unskilled and skilled blue and white collar workers will be retrained to be physicists, computer scientists, high-level technicians, molecular biologists, business consultants, lawyers, accountants, and the like (Rifkin 1995: 36).*"

And U. Ayres points out that even if displaced workers would find new employment, it might not be as satisfactory as their old ones. He argues that in perspective of competitive free market equilibrium, everyone would find a job with some wage, but "*there is nothing in the theory to guarantee that the market-clearing wage is one that would support a family, or even an individual, above the poverty level* (Ayres 1998: 96)."

Interest in the matter seems to be even higher in the recent years. Among others, often cited Paul Krugman added in 2013 his insight in an article called "Sympathy for the Luddites", in which he states that the new technologies will be disruptive even to the 'knowledge work', referring to the *McKinsey Global Institute's report on disruptive technologies* (Manyika, Chui, Bughin, Dobbs, Bisson, Marrs, 2013). This report suggests that even jobs that previously required a higher education may be automated by the proper software, and so Krugman points out that pushing for more education, which, for many, was the answer to technological unemployment in earlier periods, may not be the answer in the future (Krugman, 2013).

That doesn't mean that there are no objectors to the ‘pessimistic’ view, far from it. Many believe that these concerns are just other variations of the Luddite Fallacy, pointing out that even though the technology progressed and the productivity has risen, no jobless catastrophe scenario caused by the implementation of the machines happened (Campa, 2014, Tabarrok, 2003).

However, technology does tend to qualitatively change. We can learn a lot from history and its discussion on the matter, but the future ahead may be entirely different.

The next chapter will discuss the argument of why that might be so.

III. Where we are

As we saw in the previous chapter, mankind was dealing with problems that accompanied technological innovations ever since the times of the first implementations of technology. However, even though some people were without a doubt negatively affected by those changes, so far our technological progress has not caused any intensive, lasting disaster in its impact on unemployment, at least not on a massive scale. The question is, will that be the case in the following years?

3.1 The nature of digital technologies

Many authors argue that it will not. The reason behind this thinking is the fact that technology is progressively improving. More precisely, it is improving at an exponential rate (Kurzweil, 2006, McAfee, Brynjolfsson, 2014, Pistono, 2014).

Erik Brynjolfsson and Andrew McAffe describe in their book "The Second Machine Age" nature of the digital age, the state of current technology and its potential. They argue that we are at an inflection point, where things begin to change rapidly. As the Watt's steam engine, that allowed much more efficient use of steam power, enabled the full force of the Industrial revolution ('The First Machine Age') to happen, overcoming limitation of our muscle power and starting an unprecedented boom for humanity in terms of population and abundance, so are we now in a time where computers and digitalization are doing the same for our mental power (McAfee, A., Brynjolfsson, E.,2014:8).

There are multiple evidences to support this statement. The first and probably the most important one is based on the famous 'Moore's Law.'

This law is not actually a law, but rather an empirical observation about the computer industry predicted by Gordon Moore in 1965 in an article in Electronics magazine called "Cramming More Components onto Integrated Circuits." In it, he said that "*The complexity for minimum component costs has increased at a rate of roughly a factor of two per year (...). Certainly over the short term this rate can be expected to continue, if not to increase. Over the longer term, the rate of increase is a bit more uncertain, although there is no reason to believe it will not remain nearly constant for at least ten years."*(Moore, 1965:83)

The complexity for minimum component cost means the number of transistors on a computational chip, essentially meaning the computational power available to purchase for a certain amount. This means that each year, we would be able to buy twice as powerful computational capacity, at the same price. In 1975, Moore adjusted his prediction of doubling power from one year to every two (Moore, 2006: 74), and his prediction lasted, not only for ten years, but for the past four decades. Discussion about how long this trend can last, along with predictions that it will slow down or come to an end, accompanied Moore's law during these times, but has never proven to be true (McAfee, Brynjolfsson, 2014).

Furthermore, variations of the Moore's law are observed in many other components of digital technologies, for example in computer hard discs, or in the number of pixels available to capture via digital cameras.[5]

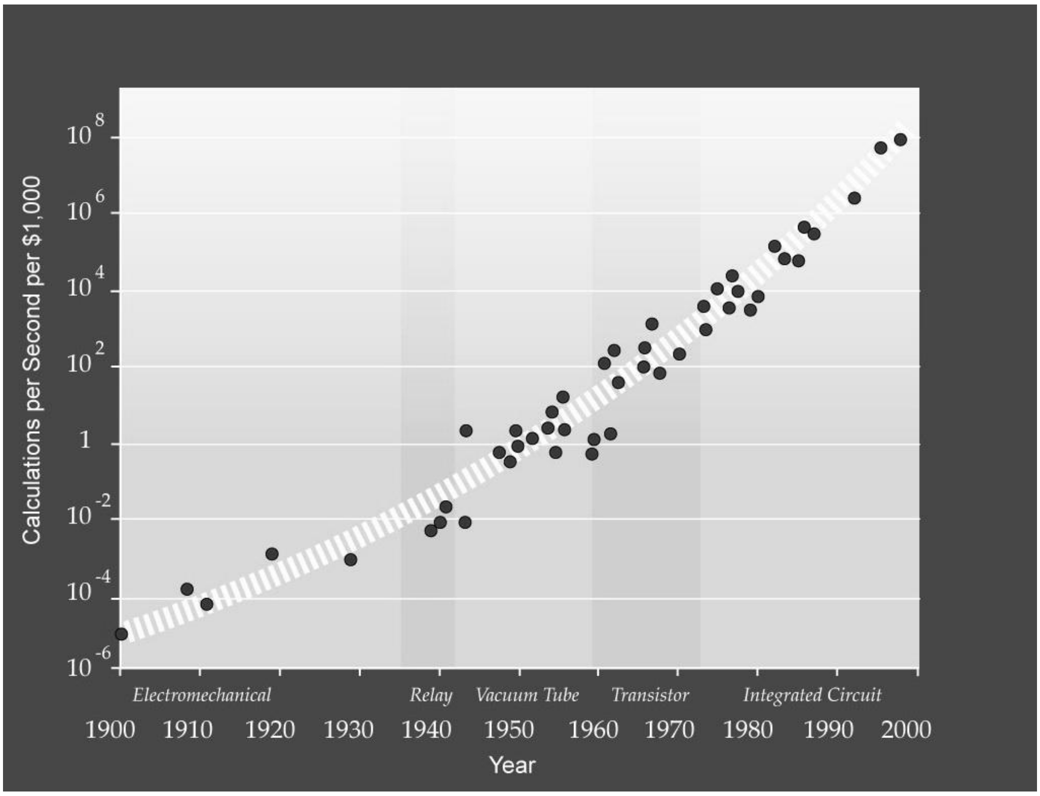

Image 3-1: steadiness of exponential development of the amount of calculation available to purchase for a fixed price in the course of the past century (Kurzweil, 2006)

This shows that digital technologies have a tendency to develop fast. The implication of the exponential rate of improvement is accelerating change, that is, increasingly higher

[5] These observations are called ‘Krynder's Law’ for hard drives and ‘Hendy's Law’ for digital cameras, named after Mark Kryder and Barry Hendy, who first documented the respective trends.

technological transformation, which suggests that we won't just see continuous technological development in the following years, we will see it happening substantially and increasingly more.

To fully understand the implication of the exponential rate, computer scientist and futurist Ray Kurzweil retells an old legend about the invention of chess. As the story goes, emperor of an old empire is so delighted with the new game, that he offers the inventor the fulfilment of anything he asks. The inventor, seemingly humbly, asked only for a bit of rice: one grain of rice to be put on the first square of the chessboard, two grains of the rice for the second square, four to the third one and so on - until all of the chessboard squares are filled. Emperor generously agreed to what it seemed to be a negligible payment. However, already after the first half of the chessboard's rice amount on the squares were counted, emperor owed the inventor about 4 billion grains of rice. So it comes as no surprise that he couldn't pay the full demand of 2^{63} of inventor's rice, which equals to more than 18 quintillion.[6] In some versions of the story, the emperor goes bankrupt, highlighting the inventors wit and intellect, in others, the emperor, when he realizes that he has been tricked, bursts into rage, and orders that the inventor is to be executed (Kurzweil, 1999).

There are many more ways to illustrate how rapid the changes can be when high exponents are in play. If we were to say that a water barrel is contaminated with some kind of bacteria that doubles its presence each day, and that the barrel will be full of these bacteria on the 100th day, the most notable changes are going to happen over the last few days - with the barrel not half full until the 99th day.

What Kurzweil is trying to show with a story like the invention of chess, and by his works, is how we tend to underestimate the impact of accelerating change. In his point of view, as we enter the twenty-first century, we are entering into the second half of the chessboard (Kurzweil, 1999). This point is perhaps best summarized in his later works, where he states that the exponential trends have existed in the past, but they were at an early stage, hardly notable, and we therefore tended to expect the future to be similar to the present, unaware of the fact that the technological change is accelerating. As he explains, "*most long-range forecasts of what is technically feasible in future time periods dramatically underestimate the*

[6] 18,446,744,073,709,551,615, to be precise. The story is sometimes known and illustrated as the wheat and chessboard problem, to illustrate how quickly the exponential sequences grow.

power of future developments because they are based on what I call the "intuitive linear" view of history rather than the "historical exponential" view." (Kurzweil, 2005: 11).

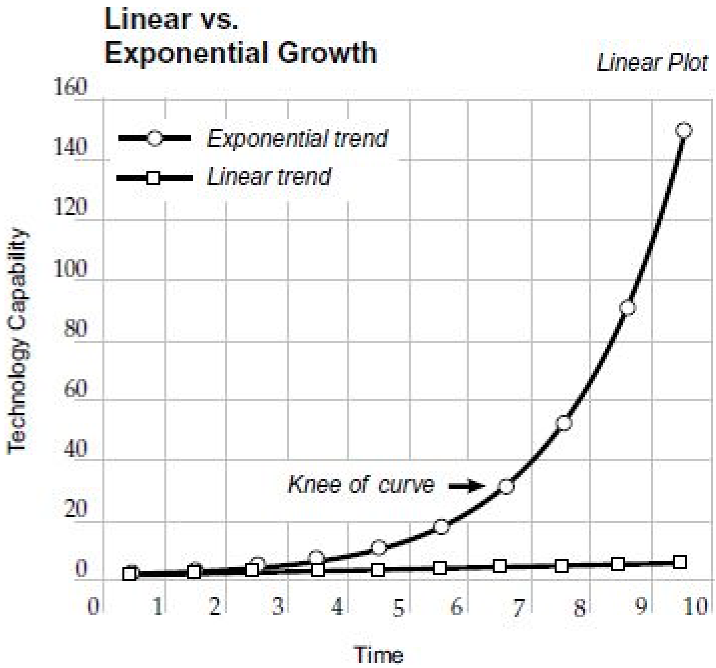

Image 3-2 - Comparison of exponential and linear growth (Kurzweil, 2005)

There are other properties of digital technologies to take into consideration. Probably the most significant resource for digital technologies to work with, excluding electricity, is information that they process. Things around us are constantly being digitalized - whether they are texts, spreadsheets, images, sounds, videos, or virtually any information or data available - we can transform them into easily sharable bits, with little or no cost. In terms of economics, these media, which continue to be increasingly more quantitatively and qualitatively available, have close to zero marginal cost of reproduction (Rifkin, 2005). In other words, even though it may be costly to produce the initial information, e.g. a movie, its duplication, share ability and overall accessibility poses minimal cost in the digital environment. What is more, these 'goods' of information are non-rival, meaning its consumption does not prevent other people from consuming it as well.

Another interesting point about digitalized information is that people are often willing to produce it for free (McAfee, Brynjolfsson,2014). Indeed, we can see countless videos on YouTube that don't even seek monetization via advertisement, we can list through countless articles on Wikipedia, made by people who didn't seek money in return, we can download tons of applications on our mobile phones, made by programmers out of sheer enthusiasm.

User-generated content floods the internet, making available vast amount of never-before retrievable data. Due to these factors, it seems that abundance will be the prevailing trait and norm for digital information, rather that scarcity.

Moreover, not only the data and software we use to process and consume are non-rival, we can actually benefit from more people using it. This phenomenon is called ‘the networking effect’, and it may significantly contribute to overall usage of a medium. Observation of this effect describes that for some products, value increases with every additional user, and where this effect is strong, massive growth in usage follows, as positive feedback reinforces adaptation of the technology, creating a positive loop, where more users adapt the technology as its usage spreads (Shapiro, Varian, 2005). Communication technologies from the previous century, like telephone or fax, were the earlier examples, success of the social networks like Facebook and Twitter are the later ones.

3.2 Limits of innovation

These points underline the argument for accelerating improvement of digital technologies. We can see its potential, and possibilities that comes with it. Multiple observations of Moore's law and its variations across the computer industry provide a persuasive illustration of the accelerating development. However, many have asked the question, ‘Can it last?’ Hasn’t all this progress merely been a consequence of invention of a particular technology, like the personal computer, and its capacity for further improvement is slowly reaching its maximum? Wasn't this all just a historical anomaly, won't progress slow down? Among most cited authors on the topic of decline of innovation, as well as on the topic of the end of economic grow this Robert Gordon, proposing answers to these questions. He acknowledges that technological improvement was the main force behind economic growth, mainly due to what he calls the three industrial revolutions[7], but suggests that *“it is useful to think of the innovative process as a series of discrete inventions followed by incremental improvements which ultimately tap the full potential of the initial invention”* (Gordon, 2012:2) and

[7]First industrial revolution happening between 1750 and 1830, with introduction of steam engines, railroads and cotton spinning, second (supposedly the most important), with electricity, combustion engine and running water with indoor plumbing in 1870 to 1900, and finally the third - the computer and internet revolution between 1960 and 1990 (Gordon, 2012: 1-2).

subsequently, he demonstrates the growth in real GDP per capita, where data[8] suggests that the rate of economic growth is declining since the computer revolution. To be clear, he does not predict a complete end of growth. He states that "*The benefits of ongoing innovation on the standard of living will not stop and will continue, albeit at a slower pace than in the past. (...) Future growth in real GDP per capita will be slower than in any extended period since the late 19th century, and growth in real consumption per capita for the bottom 99 percent of the income distribution will be even slower than that.*" (Gordon, 2012:2)

Two important counter points can be found to Gordon's proposition of declining growth. First, by previously mentioned Brynjolfsson and McAfee, who suggest that nowadays, GDP is no longer a good way to measure our welfare. As they pointed out, much of the digital content is now produced and consumed for free, which is great for a consumer, but bad for the statistics of GDP. These services are invisible to these statistics, but that does not mean that they don't present any value for us. Instead of paying a telecommunication company for a call, we use Skype for free, instead of going to the movies, we watch films or clips online, for free. They argue that official statistics are missing much of the real value crated in economy, that GDP, due to new technologies now more than in history, fail to capture what is important to us, and therefore is only loosely related to our economic welfare (McAfee, Brynjolfsson, 2014).

Second point attacks the notion of Gordon's view of innovation as 'a process of incremental improvements, which ultimately tap the full potential of the invention.' As Paul Romer argues, this is not how innovation works in most cases. He says that we tend to underestimate the number of ideas that remain to be discovered. Economy does not only grows when we make more of the same product, it also happens when we rearrange the resources in a way that makes them more valuable. In other words, it's about recipes we find in countless possibilities of merging and recombining of what we already have. He demonstrates this view on a simple example of combining elements: if we want to combine two, there are about ten thousand combinatorial possibilities, with four elements, there are more than 94 million, with five, more than 9 billion. And that does not takes into account the different ways of merging, in different temperatures, pressures, chemical reactions etc. Mathematical effects of combinatorial explosions, where possibilities grow rapidly, are strong points for Romer, as he notes *"possibilities do not merely add up; they multiply"* (Romer, 2015: 1). Given the previously mentioned points about the increasing number of digital information, we can see

[8]data represents the world leader in the real growth in real GDP per capta, specifically UK until 1906 and subsequently U.S., until 2007

that even in the case of digital technologies, our ability to process these combinatorial possibilities will be an important factor in innovation.

3.3 Capabilities to replace human work

But even if innovation is not slowing down, even if our technology tends to get more powerful, how does it affect the notion in question - human worker's replaceability? How significant are the capabilities of computers and robots in replacing human labour?

Hans Moravec described a phenomenon in robotics, which later became known as the Moravec's paradox: that it is easy to make computers do abstract, logical and reasoning tasks, like playing chess, yet difficult to make them perform even simple tasks regarding perception and mobility (Moravec, 1988: 15). The computational resource requirements for robots in these areas are simply much more demanding and complex. On a similar premise, economists Levy and Murnane based their reasoning for their book, titled *"The New Division of Labor"*. Inspired by words of Adam Smith, who used the term 'Division of Labour' to describe ways in which first factories reorganized their work in order to boost their productivity, Levy and Murnane presented the new division of work, between man and computer.

They distinguish between "rules-based" work, which involves logical procedures and step-by-step tasks that can be easily measured and automated, where computers simply have the comparative advantage over humans: they can do it better and faster, thus, they reduce relative demand for human input. They argue that these kinds of jobs, like, for example, decision making on whether or not to approve someone's mortgage, which can be done through application of a specified formula, is and will be the domain of computers. However, they also say that there are many kinds of work that require the skill of pattern-recognition: the ability to assess a situation and determine the proper course of action, based on previously encountered patterns. Tasks like interpersonal communication and driving a car are complex situations, where many inputs have to be recognized and analysed. According to Levy and Murnane, these situations, which, we can say, reflect the essence of the Moravec's paradox, are the ones where computers cannot easily substitute humans (Levy, Murnane, 2004). These are jobs where humans are superior.

Based on this proposition, it would seem that technological unemployment would present a threat only for 'rules-based' jobs, leaving dominance in many areas to humans.

Rather than citing another author on the topic of current technology's capacity and potential in substituting human labour, I've compiled a list of some technologies available today. *The New Division of Labor* came out in 2004. Let's see how its division held out. What kind of tasks is current technology capable of doing?[9]

Baxter: A two-armed robot equipped with a space-recognition sensors and an animated face on a display is what can be called a first general-purpose stationary robot. Developed by the company *Rethink robotics,* its main advantage is that it is not pre-programmed to do a specific task, but designed to map the environment and the tasks its owner wants it to do. To implement it into the working process, no software engineers are needed, someone just needs to grab its arm and show it how to do a task, and Baxter is able to repeat it. Even though initially slow at performing these tasks, Baxter doubled its speed since his introduction in 2013. With its current price which now roughly equals an average US production worker's annual salary, and costs for its maintenance including electricity consumed, it is now used in manufacturing for kitting, packaging, loading and unloading, machine tending and material handling (Rethink Robotics, 2016).

Atlas: A humanoid robot with relatively high mobility, designed to cope with even difficult outdoor terrain. Equipped with two hydraulic hands, arms, legs, feet and a torso, it can walk, carry, lift and manipulate with its surroundings, balance when being pushed around, even stand up when thrown down. Created by *Boston dynamics,* it is aiming to overcome the challenges of computerizing human mobility (Boston Dynamics, 2016)

Google's Self-driving car: Developed by Google X, it is equipped with sensors and a computer that allows it to process key components of complex situations in traffic, it evaluates its position and surroundings, classifies objects based on their size, shape and movement patterns, predicts possible actions of the surroundings including other cars, cyclists and pedestrians, and based on these results determines safe speed and trajectory. Cars equipped with this technology travelled more than 2,4 million kilometres so far, and are nowadays legal parts of traffic in several parts of the U.S. Creators suggest that this technology could dramatically reduce accidents, where human error is statistically the most significant cause. Earlier models were installed on existing types of automobiles, such as the

[9] Sources for compiling this list were mainly web pages from respective manufacturers, see appendix for further details

Toyota Prius, but as of 2014, Google has introduced their own prototype car, without the steering wheel and pedals (Google, 2016).

Terex Fully-Automated Container Terminals: Another example of automated transportation, these computer-guided mobile platforms are capable of handling huge cargo movement in places like ports or storage houses. Using pre-programmed navigation through mapped grids, these automated guided vehicles, or 'AGV's', complemented with other automated machinery, like automated stacking cranes, are capable of sorting and storing shipping containers (Terex, 2016).

Amazon Robotics: Known as Kiva systems before its acquisition from Amazon, its parts consist of AGV and portable storage units, which autonomously operates in warehouses in order to retrieve items from their inventory. Similarly as Terex's AVGs, they are mobile platforms, only operating with smaller objects. Worthy of mentioning is also Amazon's unveiled project 'Amazon PrimeAir' - aiming to deliver packages under 30 minutes via unmanned, automated aerial drones (Amazon, 2016).

Shop24: I've already mentioned automatic cashiers, but advanced machinery in handling sales is already available. Shop24 is the world's first fully automated convenient store, consisting of several interconnected vending machines, accessible non-stop. Available to contain up to 200 different products and guarded by multiple video security cameras, it requires no human worker to operate (Shop24global, 2016).

Watson: Probably insofar the biggest breakthrough in computer 'thinking', Watson is a computer built by the IBM Corporation, capable of answering questions presented in ordinary human language. Gaining world-wide attention when it won the U.S. game show of 'Jeopardy' in 2011, a quiz show, beating top players at the time, Watson is able to analyse unstructured data - the content, context and grammar of an ordinary language, evaluate possible meanings, determine what is being asked, research the subject in question by searching through millions of documents - like web pages, uses algorithms to rate the quality of information acquired and rank all possible answers based on the supporting evidence. And it can do it almost instantaneously. Watson may be referred to as the first cognitive computer. It is now being used in the medical field, serving as a clinical decision support system, helping to analyse data and form hypotheses (IBM, 2016).

Automated writing: Data-driven articles are now being generated by writing software, like the one offered by Automated Insights. This software allows its users to upload data which they work with, design the length, tone and variability of an article, and it applies the desired narratives in an informative article, with a possibility to continuously generate thousands of them, based on the data provided. These auto-generated articles are now being used in many data-driven areas, like financial services, media, business intelligence and others. Even though the software can't compose beautiful poetry or write an original story, when it comes to the quality, it is hardly distinguishable from articles written by humans on the same topics. The following article is shown as an example of a software-written text: "*This October, Verdant Valley soap saw an unusually high 1.8 million dollars in sales volume. Despite the increases for that brand, sales decreased moderately across the entire soap category. At 31 million in volume, overall sales are down 5% from last month. This month's soap sales largely agree with expectations for this time of year, just 1% above the three year October average."*(Automated Insights, 2016)

DoNotPay.co.uk - *The World's First Robot Lawyer:* From another spectrum of writing, which usually required college-educated specialists, comes automated appeal-writing software created by Joshua Browder, able to generate a letter usable in order to appeal for parking tickets, payment protection insurance claims and delayed flights or trains. On the site donotpay.co.uk, users are asked by a bot about specifics of the situation against which he or she wants to appeal, the software assesses them, and if their legal claims are based on justifiable grounds, compiles an appeal (DoNotPay, 2016).

Emily Howell: Created by David Cope, a professor of music, Emily Howell is a computer program that, via human input of encouragement and discouragement, attempts to teach itself to compose music. With songs hardly distinguishable from human composers, Emily Howell released an album titled *From Darkness, Light* in 2009 and *Breathless* in 2012. Even though this program is not winning any musical awards yet, it serves as an example that even the creative sphere is not unreachable for computerization (Cope, 2016)

3D printing: With technology like for example *Stratasys J750*, a full-colour 3d printer which uses various rubber-like materials, all sorts of printed-objects are imaginable, from industrial components and medical prosthetic parts to art and even buildings. So far, due to prefabricated parts, it was possible in China to build a 30-store modern skyscraper able to withstand earthquakes of magnitude 9 in 15 days' time (Pistono, 2014), however, the current objective of institutes like Contour crafting, which develops robotic constructive systems that, so far, can layer-print foundations for a house, is to print the whole buildings - with reduced costs, time, waste and labour (Countour Crafting, 2016).

As the list shows, current technology already operates in areas that the *New Division of Labor* considered to be too complicated to substitute machines for humans. The exponential growth discussed before is here demonstrated by the fact that none of the listed technologies was available in 2004, when Levy's and Murnane's book came out. As some authors noted, the 'new division' is pretty out-dated - already after little more than a decade (McAfee, Brynjolfsson, 2014).

Many more inventions could here be used to describe the trends in development of current technologies. Due to the reasoning behind accelerating change and evidence of the list of robots and software here presented, I consider the implications of Moore's law's exponential growth on the technological improvement's capabilities to be justifiable. It is also the reason why I expect this list of 'breakthrough technology' to be, in terms of performance, considered outdated pretty soon.

The next chapter will discuss the implications of accelerating change on future employment.

IV. The premises in question

Due to the reasons described in the previous chapter, it comes as no surprise that many previously mentioned authors consider the increasingly faster developing technologies to be the cause for a significant disruption of human labour in a not so distant future. It takes just a little effort and imagination to see how many of the machines presented here could mean rational economic investments for many companies, lowering demand for, and displacing, human labour in respective fields. Moore's law's predictions of declining prices and rising productivity only underlines these trends in years to come.

This chapter will try to analyse the predicted outcomes in the context of the previous points. Firstly, let's take a look at the substitutability of human workers in the largest areas of employment.

4.1 Automatability of present occupations

The extent to which jobs are automatable can be illustrated by the table below. This table has been compiled from two sources: Frederico Pistono's table representing the number of people working in respective fields, which he created using public data of the U. S. Bureau of Labor and Statistics[10] (Pistono, 2014: chapt.9), and from findings of Carl Frey's and Michael Osborne's study titled *'The Future of Employment: How susceptible are jobs to computerization?'*, which outcome is the estimate of the probability of automation for 702 detailed occupations. In some cases, I present a range of automation probabilities rather than a single number, for the reason that sources do not fully overlap - Pistono, for example, uses the overall number of cooks, while Frey and Osborne differ between cooks dealing with short orders, that are more susceptible to computerization, and chefs and head cooks, whose probability of susceptibility is significantly lower. Probability is shown on a scale of 0 - not computerisable - to 1 - computerisable *(Frey, Osborne, 2013).* In the context of the above mentioned list of currently available technology, the results are fairly expectable:

[10] Data of the U.S. labor statistics used for the illustration have been chosen for two main reason: their availability and representativeness: many other industrialized countries are in similar situation *(Pistono, 2014)*

Occupation	Number of workers	Percentage of workers%	Probability of automation (0-1)
Driver/sales workers, bus and truck drivers	3,628,000	2.61%	0.89 - 0.9
Retail salespersons	3,286,000	2.36%	0.92
First-line supervisors/managers of retail sales workers	3,132,000	2.25%	0.28
Cashiers	3,109,000	2.24%	0.97
Secretaries and administrative assistants	3,082,000	2.22%	0.96
Managers, all other	2,898,000	2.08%	0.25
Sales representatives, wholesale, manufacturing, real estate, insurance, advertising	2,865,000	2.06%	0.85
Registered nurses	2,843,000	2.04%	0.009
Elementary and middle school teachers	2,813,000	2.02%	0.0044 - 0.17
Janitors and building cleaners	2,186,000	1.57%	0.66 - 0.69
Waiters and waitresses	2,067,000	1.49%	0.94
Cooks	1,951,000	1.40%	0.1 - 0.94
Nursing, psychiatric, and home health aides	1,928,000	1.39%	0.39 - 0.47
Customer service representatives	1,896,000	1.36%	0.55
Laborers and freight, stock, and material movers, hand	1,700,000	1.22%	0.85
Accountants and auditors	1,646,000	1.18%	0.94
First-line supervisors/managers of office and administrative support workers	1,507,000	1.08%	0.014
Chief executives	1,505,000	1.08%	0.015
Stock clerks and order fillers	1,456,000	1.05%	0.64

Maids and housekeeping cleaners	1,407,000	1.01%	0.66
Postsecondary teachers	1,300,000	0.93%	0.032
Bookkeeping, accounting, and auditing clerks	1,297,000	0.93%	0.98
Receptionists and information clerks	1,281,000	0.92%	0.96
Construction laborers	1,267,000	0.91%	0.88
Child care workers	1,247,000	0.90%	0.084
Carpenters	1,242,000	0.89%	0.72
Secondary school teachers	1,221,000	0.88%	0.0078
Grounds maintenance workers	1,195,000	0.86%	0.95
Financial managers	1,141,000	0.82%	0.069
First-line supervisors/managers of non-retail sales workers	1,131,000	0.81%	0.075
Construction managers	1,083,000	0.78%	0.071
Lawyers	1,040,000	0.75%	0.035
Computer software engineers	1,026,000	0.74%	0.042 - 0.13
General and operations managers	1,007,000	0.72%	0.16
Total of Occupations Listed Above	63,383,000	45.58%	
All Other Occupations	75,681,000	54.42%	
Total Employment	139,064,000	100.00%	

As we can see above, many of the most numerous professions have a high probability of automation. Indeed, with technology like self-driving cars available, driver's profession does seem not so far from being obsolete, and replacement of human labour in this area is merely a matter of cost-benefit calculation. And there are many incentives for companies to substitute: self-driving cars don't require wages, they don't get tired or emotional, companies do not have to pay taxes required for the human drivers, and so on. Moreover, automated machinery doesn't have to be perfect in order to be implemented, it just needs to be, in terms of production and avoidance of mistakes, as good as or better than humans. However, it is important to stress out that even though the previous examples describe the tendencies of current qualitative technological change, suggesting that their impact on employment will be different in the future than it was in the past, it does not directly predict the real and final shift in the employment-market equilibrium, since that is determined by many other factors than that of qualitative change of available technology, like the actual cost of labour and capital, as well as by government interventions (Borjas, 2012).

Yet, these factors are influenced by the state of current technology, and as the previous points suggest, this technology is becoming increasingly effective, posing threat of worker displacement in many areas. In their study of employment susceptibility, Frey and Osborne base their measurement of automation probability by ranking occupations according to the mix of knowledge, skills and abilities they require, to the several key ‘bottlenecks’ of computerization, that is, insufficiency of current technology and engineering obstacles prevents them from effectively perform certain task. These involve perception and manipulation, creative intelligence, and social intelligence.[11]

Based on those factors, they measured the automatability of occupations, as illustrated above, and further divided these occupations into three categories: those with a low risk of automation, with automation probability ranging from 0 to 0.3, those with a medium risk, 0.3 - 0.7, and high risk occupations, 0.7 - 1. According to their estimates, 33% of all occupations are in low risk of automation, 19% are in medium risk, and 47% are in the high risk category. These estimates are made roughly for the next decade or two. Authors suggest that the first workers to be substituted by computer capital will be people employed in transportation and logistics, administrative support, and in production occupations, with the ‘next wave’ - which are occupations requiring more social intelligence, creativity and knowledge of human heuristics - follow depending on overcoming the ‘engineering bottlenecks’ (Frey, Osborne, 2014: 37-40).

[11]Each of these areas consists of variables, ranked base on their difficulty to perform: For instance, in relation to the attribute “*Manual Dexterity”* [which is the variable for perception and manipulation], *low (level) corresponds to “Screw a light bulb into a light socket”; medium (level) is exemplified by “Pack oranges in crates as quickly as possible”; high (level) is described as “Perform open-heart surgery with surgical instruments”* (Fry, Osborne, 2014: 31).

However, I would point out that the fact that even though a job is not in the high probability of automation does not mean that demand for it couldn't fall. Lawyers, for example, have a very small probability of automation - figure of 0.035 on the Osbourne's and Frey's scale, yet as we have seen above, the first bot lawyer is already writing appeals against unjustifiably imposed parking tickets, making a human lawyer obsolete in this specific task. It won't, so far, replace the human lawyer in its social qualities, it won't represent someone in court, yet many legal questions are probably about to be resolved in the future without the necessity of paying a lawyer by the hour, at least in certain cases.

Moreover, while 47% of all occupations are definitely not a negligible figure, it represents only the situation in the U.S. In their recent study (2016), they state that this number is even higher for other counties: ranging from 35% in the UK to as high as 85% in Ethiopia. Other figures of large economies include 69% high risk of automation in India and 77% in China (Frey, Osborne, 2016), suggesting that the high risk of job automation is a world-wide phenomenon.

Of course, incentives for automated innovations are present for companies in other countries as well as in the U.S., and does not avoid even developing countries, so in some cases, not even relatively low labour cost can compete with automation. A study conducted by Graetz and Michales, 'Robots at Work' (2015) on a similar topic that of Frey's and Osborne's, notes that robots are increasingly used in developing countries, with China possibly the world leading buyer of robots already.

4.2 Labour market polarization

There are other notable findings. While the main aim of Graetz and Michales was to analyse the economic impact of industrial robots in 17 countries using data from years 1993 to 2007 (which, due to the growing rate of technological development, could be considered relatively outdated), didn't find any significant effect of industrial robots on overall employment happening during this period, it notes that there is some evidence it crowds out employment of the low skilled workers, and, at a lower rate, even middle-skilled workers (Gratz, Michales, 2015).

In this area, they are in agreement with Frey and Osborne, who suggest that in the future, automation will mainly substitute low-skill and low-wage jobs, since high-skill and high-wage occupations are the least susceptible to computers. This statement is supported by their findings of a negative relationship between both average median wages and attained education with their assessed probability of occupation's computerization. In other words, they find that jobs with lower wages are also the jobs that ranked as the most-easily automatable. Based on these findings, they note that there has been a shift from historical employment trends: *"this finding implies a discontinuity between the nineteenth, twentieth and the twenty-first century, in the impact of capital deepening on the relative demand for skilled labour. While nineteenth century manufacturing technologies largely substituted for skilled labour through the simplification of tasks, the Computer Revolution of the twentieth century caused a hollowing-out of middle-income jobs. Our model predicts a truncation in the current trend towards labour market polarisation, with computerisation being principally confined to low-skill and low-wage occupations."* (Frey, Osborne, 2014: 45) Evidence of the growing market polarization is found in other studies as well (Autor, 2010), showing that the employment sphere is indeed undergoing changes in recent decades. But if the tendencies are towards market polarization, meaning growth in demand for high and low skilled jobs at the detriment of the middle skilled, what prospects are facing the low-skilled workers, if previously stated probabilities of automation of these jobs are taken into account? Frey and Osborne are offering their premise on possibilities for the low-skilled workers followingly: "*Our findings thus imply that as technology races ahead, low-skill workers will reallocate to tasks that are non-susceptible to computerisation –i.e., tasks requiring creative and social intelligence. For workers to win the race, however, they will have to acquire creative and social skills.*" (Frey, Osborne, 2014: 45) However, as I mentioned in the first chapter, the extent to which the acquisition of new skills for low-skilled workers is possible is questionable - since capabilities for acquiring these skills may be out of their reach (Rifkin, 1995).

4.3 Other social implications

The implications of accelerating change are discussed in many other social areas as well. Even though the displacement of labour is one of the main concerns associated with this phenomenon, more social change may be caused by the hereby described nature of technology, which enables attainment of more wealth. Specifically, the continuing polarization of the overall distribution of this wealth acquired.

Premises on this topics focus mainly on the rising inequality, with predictions of increasingly more divided societies, going as far as describing scenarios where the small minority - those with the right skills, capable of collaborative work with the computerized systems - owns most of the worlds wealth, thus becoming the new elite, while most of the world's population owning and earning little or nothing (Cowen, 2013).

This may not be an issue of the distant future. Wealth inequality is a growing phenomenon, which is widely underestimated by the public (Norton, Ariely, 2011). So far, the top 20% of the U.S. wealthiest control more than 80% of the nation's wealth, and their share continuously increases. This is shown by the rising difference of the average and median income: even though the overall average growth of GDP per capita is continuously rising, the median income - that is, an income measured for a person exactly in the middle of the distribution, rather than the total income divided by the total number of people -slowed down around the year 1975, in contrast to the average income. This is due to the fact that the top earners make more, while the middle more or less the same (McAfee, Brynjolfsson, 2014). The concern is that while we live in a relatively unequal society right now, these differences will be even greater in the future.

There are multiple arguments supporting this possibility, most of which are related to the nature of digitalized technology hereby described: close to zero marginal cost of reproduction of digital information, its non-rival quality, network effect contributing to the overall interconnectivity and increasing digitalization of the world around us. All these factors contribute to the spread of so called winner-takes-all markets (Frank, Cook, 1995), where small differences in performance mean large differences in income - where we, the consumers, have an easy access to the top performers through the ever present and various medias, yet the second-bests and other subsequent participants don't reach the earnings that would be proportionally adequate to their performance. This ‘superstar effect’ (Rosen, 1981) widely extends the gap between rich and the poor, concentrating most of the rewards into the hands of a handful of people. Absolute domination in a field means great benefits for the lucky winners, can benefit society overall, yet some people probably lose out.

Simply put, some innovation can be double-edged: while the person who invents a bot able to answer legal questions and perform tasks that so far remained within the area of expertise of college-educated lawyers, that person can with his product reach millions of people regardless of their location, thus quickly becoming rich. Even if he gives access to it online for free, the

1,040,000 of lawyers from the Frey and Osborne's table suddenly have less work to make money from. Some jobs, like accountants of auditors, can become obsolete entirely with proper software. We live in an era where one person can create an innovation that benefits almost everybody, making themselves rich, while ending millions of jobs at the same time.[12]

As McAfee, Bronjolfsson, Cowen and others suggest: technological innovation drives inequality, and as improvements accelerate, we can expect inequality to accelerate as well. The winners of the future, the new ‘elite’, will be those who can complement the automation, and those with the right assets. These are either non-human capital - those who own significant properties, or human capital - those with right complementary skills and talents. While the impact of wealth inequality on society is a topic for another thesis, it is argued by some authors that these impacts are significant, possibly responsible for multiple major undesirable elements affecting overall societal well-being, such as health, trust and community life, making both rich and poor worse off (Wilkinson, Pickett, 2013), yet discussion on the topic is far from over.

4.4 Possible growth obstacles

So far, I have described the premises discussed in relation to accelerating technological change - the high probabilities of jobs automation, recent tendencies of labour market polarization and predicted societal impacts in form of accelerating technology's by-product: rising wealth inequality.

However, these predictions stand on the premise that digital technology will continue to rise, as it had so far, and that innovations enabled by technological improvement will be implemented increasingly more and without any obstacles. But are there any counter arguments to that premise?

Firstly, we must admit that, regarding the future, any reasoning will always remain speculation. Even though reasoning hereby provided is based on serious studies and works of recognized authors, who provide sound arguments on the subject, we can't predict future events which may shift some of the essential equilibriums. Even though current trends suggest that it will be increasingly feasible to automate many current jobs, the actual implementation

[12] Not instantaneously, of course. It takes time to spread the word about the new technology, to implement it and rework organizational structures. The example is meant for the long-term.

is dependent of scarcity of cheap labour, price of the required capital and its expected return rate, governmental interventions, world-wide events such as wars, and other impossible-to-predict situations.

But from the spectrum of other possible factors that may slow down or diminish implementation of certain technologies, it can be pointed out that adaptation of certain technologies is considerably dependent on public acceptance. If smart goggles are introduced, allowing an easy access to personal files as well as online content by displaying it on the glass of those goggles, but the general public think it not fashionable or good looking, the technology probably won't be widely accepted. Another reason may be the fear of new technologies. If some newly-introduced robot accidentally causes a death of some human and the story goes public, people may be more reluctant to adopt the technology.

Other examples may include governmental restrictions, trying to regulate new technologies. Frey and Osborne demonstrate this on an example of a start-up company called Uber, which connects passengers with drivers via a mobile application. Political activism arose from local taxicab services, resulting in legislative pressure from the regulators on the company. Moreover, for some technologies the legislation itself must be changed to allow new inventions to operate, like in the case of Google's self-driving car (Frey, Osborne, 2014).

4.5 Benefits

The last, but definitely not least point I'll briefly mention about premises discussed in the context of current technological trends are the expected benefits. The main point for innovation is the aim for increased production, by which more products are created. Studies support the evidence for increased labour productivity and value added from industrial robots (Graetz, Michaels, 2015), and when the exponential rate of growth is taken into account, there is a reason to believe that our society will continue to be increasingly wealthier. Even though I mainly focused on the possible negative consequences regarding employment and societal impacts, this notion of improvement - that new technologies will generate much wealth, bring us unprecedented possibilities and enhance many areas of our life - is put forward by many authors (Pistono, 2014, Kurzweil, 1999, 2006, Ridley 2014, Brynjolfsson, McAfee, 2014, Cowen, 2013, et al.), However, based on previous points, we can also see many negative consequences accompanying this phenomenon that may leave a significant number of people behind, unemployed, or even unemployable.

V. The Promises of tomorrow

The notion of technological unemployment is rarely discussed without projections to the future, without ideas accompanying imagined possible scenarios and proposed solutions. I feel this thesis would not be complete if I wouldn't include them. After all, the problem anticipated in the future may be evaded by taking actions in the present.

5.1 Projected scenarios

If we take seriously works of Kurzweil and others, who emphasize the significance of exponential growth and changes that are constantly accelerating, as well as Romer's point of combinatory possibilities of innovation, we can see that the consequences of technological change can be significantly different from those in the past: faster, broader, greater.

The social impact can thus be equally greater, and so can be their consequences. Noble stands in defence of Luddism, as he explains that it was not technophobia, but sheer necessity that drove people to revolt against machinery, smashing looms and starting riots. Their other options were starvation, or to attack directly the property owners (Noble, 1993). Examples like these spark more impulses to imagine our dystopian or utopian future.

The possible scenarios are discussed in serious manner for example by sociologist Richard Campa, who points out that many futurological speculations are based on a view that technology is a cause for which the resultant societal structure is a consequence, and never the other way around (Campa, 2014). He argues that the inherited social and industrial policies have a large impact on shaping the future, and that whether the future will be dystopian or utopian will be determined by the attitudes and beliefs of the ruling class in crucial moments - when the important decisions will have to be made. He also extrapolates possible attitudes, that is, rejection or acceptance of technological growth, industrial and social policies, and the current political system as a whole, to project four possible scenarios for our future. The first one is the unplanned end of work, which basically covers the societal concerns outlined in the previous chapter - rising inequality caused by technological growth in a scheme of market distribution, brought to its extreme, where the minority controls vast armies of productive robots while the majority is left with nothing. The second scenario is the planned end of robots, where due to concerns about the negative effects of technological progress, a political and economic system is radically changed, the technology is banned and consequentially degrowths. Even the author notes the impracticability of this solution, and the improbability that some degrowthist system would endure the technologically advanced opposition. The third is the unplanned end of robots, where technology degrowths not as a direct result of a governmental ban, but rather due to its implementation of ineffective policies, causing social instability and unwanted deindustrialization. The last proposed scenario is the planned end of work, where conditions for technological growth are the same as in the unplanned end of work scenario, but where the political and economical system is changed towards a market redistribution system, where, besides the salaries, people would receive additional income, liberating them from obligatory work (Cappa, 2014).

5.2 Proposed solutions

As we saw in the first chapter, many ways were proposed and used to deal with unemployment caused by the introduction of new machinery, including banning the innovation, pushing for higher education, public work or by the belief that the market's compensation effects will sort out the problem. Another proposition was the voluntary reducement in working hours (Keynes, 1930), but this prediction wasn't so far proven to be true. Nowadays, the welfare state provides the safety net for the unemployed, leaving the questions about potential massive displacement caused by automation unanswered.

But among the proposed solutions, I always seemed to find one that kept reappearing. In relation to what Cappa labelled as ‘the planned end of work scenario’, propositions of additional wealth redistribution systems, such as the unconditional basic income were among the more popular and serious ones, and so I've decided to end this thesis by a brief exploration of this notion, which supposedly can lead to the planned end of work scenario, which seems, after all, among all other scenarios, to be the most desirable.

Basic Income was proposed even not in relation to the issues with technological unemployment. Those serve as a supportive argument in recent years, put forward, for example by Rifkin (1995). But most of the time, basic income or its variations were presented as a solution to poverty in general, regardless of its cause, by advocates such as Milton Friedman (1962)[13], J. K. Galbraith (1984) or Philippe Van Parijs (1995).

So, what is unconditional basic income and how does it relate to the notion of technological unemployment? In short, basic income is *“an income paid by the government to each full member of society (1) even if she is not willing to work, (2) irrespective of her being rich or poor, (3) whoever she lives with, and (4) no matter which part of the country she lives in” (Van Parijs, 1995: 35).* In other words, it is a social wealth redistribution system paid by the government, that is based on three pillars: that it is individual, universal and free of counterpart (Van Parijs, 2012).

The normative justifications for basic income are mainly based in the belief that those who are poor cannot be fully free. If one's means of living are scarce, his life choices are limited, and so he cannot pursue his life goals. That may translate to spending time with family, obtaining additional education, starting a business, etc. Theories regarding more just societies in the context of unconditional basic income are put forward by one of its main advocates, Phillipe van Parijs. He constructed the so called theory of real freedom, based on arguments that capitalist societies generate ethically indefensible inequalities, and that the freedom is one of the most important aspects of our lives. According to him, free societies are those where the system of rights for each person is well-defended, where the person is the owner of him/herself, and where each person has, within the boundaries of the system, the greatest number of opportunities possible, allowing to do what he or she might want to do. He proposes that real liberty includes both freedom from certain things, as well as freedom to do things, which, for many, would be enabled by unconditional basic income. Moreover, the justification is elaborated by arguing that people are not born with the same genetical equipment - some are fitter or more intelligent than others, meaning that our life opportunities are very different, and that the prospects for some are considerably lower. (Van Parijs, 1995)

Another point is that there are more socially beneficial types of work than what is commonly referred to as employment. David Raventos calls this type a ‘remunerated work’ (Raventos, 2007: 76) - the jobs related to the production of goods and services. However, he proposes

[13]He was not an advocate for what is formulated as unconditional basic income as such, he had his own proposition. In his book, Capitalism and Freedom (1962), he proposes a variation of an basic income in a form of a negative taxation, where the amount granted is measured based on a total income: high-earners would thus provide funds for low-earners to reach the minimum income. In his works, Friedman argues that economic freedom is a precondition for political freedom (Friedman, 1962)

that work presents a much broader range of activities, including unpaid activities whose results creates goods and services for our entire species. He refers to these kinds of tasks as domestic and voluntary work, suggesting that it would be unwarranted to say that these types of work are not truly work. He further describes incentives for remunerated work and their change if basic income were to be implemented, noting that neither the aim nor the effect of unconditional basic income is the reduction of participation in the labour market. Possible outcomes reasoned do however present voluntary decrease of hours worked - but at the same time, leaving some employment for others to take, rise of wages for undesirable jobs, and pointing out that the work in many areas is today sustained through massive subsidies from the government - pointing out the option to give these subsidies directly to the employees for them to decide which jobs are worth doing. Additionally, both domestic and voluntary work, sometimes being held back by the necessity of a wage, yet hardly without value - would benefit by the greater opportunity for participation (Raventos, 2007).

Objections against an unconditional basic income are not scarce. One of the main concerns is that it would encourage parasitism. The notion that people are lazy, and this system would only support them in their laziness is addressed by contemporary defenders of unconditional basic income, such as Raventos, however, I found a much simpler counter argument in works of a famous psychologist Erich Fromm, who addressed this issue in a paper '*The Psychological Aspects of the Guaranteed Income'* (1966) pointing out that the *"material incentive is by no means the only incentive for work and effort. First of all there are other incentives: pride, social recognition, pleasure in work itself, etc. Secondly, it is a fact that man, by nature, is not lazy, but on the contrary suffers from the results of inactivity. People might prefer not to work for one or two months, but the vast majority would beg to work, even if they were not paid for it."* (Fromm, 1966: 3)

Even if basic income wouldn't cause parasitical disasters in the individual sphere, there are other concerns. Probably the most significant concern regards the economic viability of the implementation of such a system. The defence in this regard is that all governmental economic actions, whether it being increasing military spending, subsidizing agriculture or maintaining the welfare state are social options. Introduction of this system is a costly, but comparable matter, and not impossible (Raventos, 2007). However, it does represent a significant political controversy, as does any shift regarding wealth redistribution, since it usually translates into conflict of various interest groups.

Recent trends in technological development with its implication of enhanced productivity, rising inequality and threat of technological unemployment do pose another supporting argument for the cause of an unconditional basic income, since it mitigates many of the negative effects accompanying them. However, it poses challenges not only in the area of economic implementation, which presents a radical shift in economic policies, it is also a challenge in a psychological shift. The prevailing belief in human history, justifiably, was that 'he who does not work shall not eat' (Fromm, 1966: 1) But nowadays and in the foreseeable future, it would seem that this view can be challenged.

After all, is the aim of our efforts, to keep as many jobs as possible? Keynes summarizes the possibility that may lie ahead of us beautifully:

> *"When the accumulation of wealth is no longer of high social importance, there will be great changes in the code of morals. We shall be able to rid ourselves of many of the pseudo-moral principles which have hag-ridden us for two hundred years, by which we have exalted some of the most distasteful of human qualities into the position of the highest virtues. We shall be able to afford to dare to assess the money-motive at its true value. The love of money as a possession—as distinguished from the love of money as a means to the enjoyments and realities of life—will be recognised for what it is, a somewhat disgusting morbidity, one of those semi-criminal, semi-pathological propensities which one hands over with a shudder to the specialists in mental disease. All kinds of social customs and economic practices, affecting the distribution of wealth and of economic rewards and penalties, which we now maintain at all costs, however distasteful and unjust they may be in themselves, because they are tremendously useful in promoting the accumulation of capital, we shall then be free, at last, to discard."* (Keynes, 1930: 5-6)

Who knows, maybe one day, technological unemployment will not be perceived as an issue, but as a desirable condition for humanity.

VII. Conclusion

This thesis explored the notion of technological unemployment in relation to its future probabilities and its predicted economical and societal impacts. As I showed, the issue of labour displacement caused by the implementation of new technology accompanied mankind throughout history, and was dealt with in various manners. However, it never posed a significant lasting problem.

With the development of digital technologies, concerns about labour displacement have risen once again, mainly due to their capability to replace human labour in many areas previously thought impossible, as well as due to the nature of accelerating change that suggests that their improvement will continue to increase, same as their ability to replace even more human labour. As studies suggest, almost half of all occupations are in high risk of automation today, posing significant societal concerns.

The nature of digital technologies also contributes in enhancing market polarization and rising wealth inequalities. As for unemployment, the actual shift of labour market equilibrium caused by technological change and human substitutability towards computerization, suggested by accelerating technological development, is speculative, and may be slowed down by governmental interventions or the unacceptance of the general public.

As concerns about a dystopian future rise, concepts of unconditional basic income are being put forward as a possible solution to labour displacement, poverty and inequality.

Based on these points, this thesis shows that the reasoning behind the belief that the issues presented by technological change will be much more significant and broad, than were the issues of technological unemployment in the past, is justifiable.

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IX. Appendix

<u>Images</u>

Chapter III

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