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Reflections on the OECD-Project "The Role of Data in Promoting Growth and Well-Being"

BIG DATA and Analytics

– What are the perspectives?

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Introduction

This paper deals with OECD's work on "The role of Data in Promoting Growth and Well-Being" and gives the reflection of the authors, building on more than twenty years of scientific involvement with the issue. The paper is influenced strongly by a close follow up of the innovations in ICT, based on a long research about the nature of human intelligence, the "intelligence" of humankind as a superorganism and the potential of machine intelligence, up to the level of consciousness or "qualia".

The present document goes first into the potential of data-driven innovation (DDI) for automation and labour productivity growth (Chapter I), then deals with the historical perspective (Chapter II), goes into critical implications for employment (Chapter III), this with strong reference to the available literature. In Chapter IV, we give considerations concerning categories of jobs that we think will stay for a long time to come. Chapter V goes into policy challenges, by which to judge future scenarios and come to conclusions, what to do. Chapter VI describes policy objectives on this route. Essentially we ask, what happens, if sustainability within open global markets, organized as today, cannot be achieved. To put it in another way, what happens, if politics cannot implement the regulations, incentivizing the way to a green and inclusive economy and society. What might happen then, taking the potentials, induced by DDI, into account? We close with Chapter VII, giving policy options and a conclusion.

I. DDI – POTENTIAL FOR AUTOMATION AND FOR LABOUR PRODUCTIVITY

Where does the power of BIG DATA and analytics come from?

With information and communication technology (ICT), we have seen the highest innovation speed and the greatest penetration rate of new technologies, ever. At the heart of the development is the extreme speed in cost reduction of the price of a basic unit of computation. This phenomenon is called Moore's Law (Moore, 1965). Since decades, we witness at least a doubling of performance of processors every two years. We thereby have achieved a factor 1.000 each 20 years, which means we have seen an improvement factor of a billion over the last 60 years, when work on the first transistors or chips started. These are almost unbelievable achievements – never happened anything like that before. And never has there been so much change induced in such a short time.

What is the reason for this explosion of improvement? It is the possibility of miniaturization of the encoding of information that means that the encoding of one unit of information (one bit) requires always less physical space. This is because the coupling of information and its physical manifestation is very loose. We can make the encoding of information (e.g. numbers) always smaller, without changing the results of subsequent algorithmic computations on the information, be it e.g. arithmetic or Boolean operations. That means that in order to add numbers, it is not of principal importance what the size of the physical representation of the numbers is, while when building a car, humans have to sit in the car, so the size of the car is, essentially, not a variable.

The progress in hardware is coupled with huge progress in basic and application-oriented software systems, in communication, in input and output devices, in networks and network technology, in standardization, platforms etc. All this is related to much more data generated and to an access to data of all kind in unbelievable abundance. This

development is in a sense unavoidable and allows most impressive new applications. The OECD (2014b) synthesis report on "Data-Driven Innovation" hints e.g. at two powerful examples:

Algorithmic trading systems and driverless cars. Algorithmic trading systems are already very effective today. They are core instruments in the financial market and almost irreplaceable in the area of high frequency trading (HFT). That cars may go driverless is a gigantic progress from a technical point of view. It will have dramatic consequences for the life of people, but potentially also means the loss of many jobs in the taxi business. Only a few years ago, this achievement, i.e. cars that drive on their own, was considered out of reach for the foreseeable future by the Artificial Intelligence community. BIG DATA has changed the picture, but maybe even more the Internet of things.

We will now look into this newest revolution, the internet of things, which is already well on its way, and will also multiply the fields of change enormously – one important application field being Industry 4.0.

Box 1. Internet of things – a total game changer

One of the main reasons for the sudden breakthrough in technologies like driverless cars or indoor robots is the "internet of things". Or to put it the other way round: a new feature is, that the infrastructure and other cars, tells a car essentially what it needs to know. So it isn't necessary to equip a car with a technical image system, as powerful as the image systems of humans to be able to drive on its own, as was assumed before.

The power of the human image processing system is so huge that it will take a long time to develop a technical alternative of comparable power. But this is not necessary for a car to drive on its own. Because the car will receive huge amounts of information from the outside world that it needs in order to be able to drive. This way, the car will know more about the world around it than humans, though the image system of the car is much more restricted. This is by the way also the reason why a lot of robotic applications will become possible, which seemed un-reachable before. It is not that the sensor systems of the robot are exceptionally good. It is more that all devices in a room will give the robot the information it needs to know. Furniture will tell the robot their CAD model, their material composition, relative coordinates etc.

As a result, the robot will know more about its environment than a human, using his biological sensor systems, in the same situation. Of course, we will also see progress in making such information available to humans, thus enhancing human capabilities, take Google glasses as an example. But nonetheless, once the car can drive on its own and performance is regarded as sufficient, we will no longer need a human driver under most circumstances.

Humanity is transferring itself into a hybrid human-machine superorganism

If we combine humanity, already closely interlinked, and the components of the internet of things, something gigantic is developing. One could say that humankind, technological components and artificial intelligence interconnected through a digital nervous system, evolves into a complex intelligent "superorganism". Note in this context that communication and sharing of information is one of the most powerful intelligence enhancing processes we know. Communication is what glues the components of a superorganism together. Communication has a quadratic growth behaviour with respect to the number of components involved, because communication can take place between each pair of members of the organism and their number is n(n-1)/2. The resulting effects are discussed in detail in (Kapitza, 2005) concerning the development and size of humanity over the last 3 million years (see also Radermacher/Beyers, 2007/2011; Solte, 2009). In a sense, this is an observation that shows positive network effects, as we also know them from other areas.

On this route, billions of people and even more billions of technological devices will soon be interwoven by one single huge information network. For 2030, we may think of 8 billion people and maybe 25 billion active technical components. Already today, most internet communication is between machines or involves machines, and such communication is part of always more processes going on. A gigantic powerful, "intelligent" superorganism, based on never-ending streams of communication, is constituting itself.

Human versus technical manifestations of intelligence

In these ongoing processes, we observe the increase of power of technical forms of intelligence. What does that mean? Let's take as a first example the challenge of flying (which is a mechanical and a cognitive challenge), and the comparison between an eagle

and an airplane. Obviously, the technical solution for flying (an airplane) is very different from the biological one (an eagle), and the biological one can do things that the technical solution doesn't offer. Still, for most transportation issues based on flying, the technical solution outperforms the biological one by orders of magnitude.

Secondly, let´s look into chess. We have a similar situation there. The way that humans play chess is much different from the way computers do. Obviously, humans cannot rely on brute force when bringing in "computational power" into this task, instead they rely – to different degrees – on interesting forms of intuition, based on their neural network processing power, which is only partly understood up to now. However, as chess computers prove convincingly, certain types of analytics combined with the possibility to check huge numbers of alternatives, in the end makes the machine much superior in playing chess to humans, particularly to lay persons and ordinary people. And to be true: it is not only brute-force that a clever computer relies on. His evaluation function for the potential of a particular constellation on the chess board is also very powerful. Most human chess players do not have such a powerful personal evaluation function available.

We usually see that the technical solution is different from the biological one. It needed and needs (for the time being) the ingenuity of human individuals and teams to find these technical solutions. They did not fall from heaven. The solution found is then the scheme, or in other language, the algorithm for doing the job. It is the way of how to make use of the unbelievable computational potential of modern powerful computers. I.e., when the algorithmic scheme is then combined with computational power, the results will almost more often outperform humans, even the inventors. This also means, that we as a highly developed civilization can and will find (in always more cases) a technological solution to a practical problem, requiring intelligence, that allows the implementation of a routine, that outperforms (by far) humans, in particular most humans. We again refer to the examples that OECD (2014b) discussed for good reasons in the context of the project referred to in this document, e.g. high frequency trading and autonomous driving.

Of course, humans can combine their skills with that of machines, as is done today routinely in chess by world champions, analyzing positions, or other people who play chess against another person while, simultaneously, seeking help of a machine. Also, certainly, machines allow people, not trained in chess, to play brilliantly, while relying on help by a machine. Still, if for a practical application or certain job, a certain high level of chess playing competence is needed, (sufficiently trained) humans today will no longer be needed to do the job in difference to earlier times.

If we now combine what was said with the obvious fact that such machines can work permanently, they need not to be paid salaries (though they need electricity), they don't ask for holidays, they don't get ill (though they need maintenance) and if we take into account that we can update those intelligent systems software-wise, thousands and millions at a time and that there is no resistance of these systems to change (though, maybe, problems with migration) and, on top, no deprivation of past investments into building up skills etc., except for experiences of users with certain (now outdated) services, then it is not surprising that happens what is happening now since many years and always more often, viz. that such technical intelligence is seen as being of enormous practical and economical use and power.

This, of course, is – for good reasons – a major issue in the OECD project "The role of data in promoting growth and well-being". Obviously, humans will, in the future, profit from always more powerful machines. At the same time, we might find it always more often difficult to compete with always more capable technical systems. So, obviously, machines have a great potential of replacing humans and eliminating jobs that used to be reasonably paid until the moment that the technical alternative became available, because machines are becoming really smart. When saying that, a deeper scientific basis in argumentation and understanding is helpful. For that purpose, we will refer to more than twenty years of work of FAW/n on the issue. What is similar and what is (still) different in human and in machine manifestations of intelligence?

A four-level architecture of cognition

Box 2. Cognition and intelligence in systems: Working from two ends

It is a general issue within a long and not finished debate between representatives of different scientific fields to what extent cognition, intelligence, emotions or consciousness are possible in technical systems. This is also a central issue concerning the Big Data and analytics topic. The issue today extends to the future potential of robots and humanoids.

There is agreement that technical systems will eventually be able to mimicry humans to a great extent and outperform them in many fields. However, concerning the issue of Qualia ("true" feelings instead of simulated ones) there might be a principal difference.

Certainly, the digital approach of computerized systems is in general totally different from the more holistic, analogue, neural network-based approaches followed by biological evolution. Correspondingly, biological systems started with sensomotoric capabilities, and stimulus-reaction mechanisms for organizing their survival, while computers started with mathematical operations and algorithms to be processed. The principal power of both approaches is identical as proved by corresponding mathematical theorems (see Radermacher, 1996a, 2007, p. 415). At this point, it is however interesting to note that both approaches are totally different in nature. The biological approach is of the type of approximating smooth functions, while the digital approach is of the type of precise logic. While the biological solution can perform most impressive sensomotoric tasks such as riding a bike or playing tennis, but cannot give an algorithm to others of how this works, the digital solution usually is able to give a description how things operate.

With humans, the biological evolution after a long history eventually created something like a (small) digital machine emulated and embedded in a biological neural network-type brain – the logical machine within the brain of humans. To repeat this: Our brain in part works like a digital computer – however of quite limited capacity. One can "build" such computers using tubes, or transistors, or a biological neural network. This "small digital computer" is that part of our brain that can process logical operations and algorithms. This "small digital machine" works quite slowly and is limited in scope and makes quite a number of mistakes because of it being an emulation on a neural network basis, which is not the most robust technical basis for doing this. Still, this "small computer" in our brain is the reason why humans now dominate the globe and developed an unbelievable technical power.

With computers, things started exactly the other way round. Computer systems started as machines to perform mathematical and logical operations, such as arithmetics. In the beginning, that was the only job they performed, e.g. they processed algorithms such as adding numbers, and they did this always faster and totally reliable, something that humans are not good in. On top, humans find this task totally boring. This is a reaction of the main part of our neural machinery with its many emotional capabilities or properties. Of course, we might also build robots that find computing boring. The question is, however, whether boring within a robot is just a software state or something related to an own experience of something being boring – an emotional state of a living being (a form of qualia).

We make use of neural network-type holistic associations as is typical for some forms of analytics in the context of using Big Data to deal with situations we not really understand but can manage via (statistical) assumptions.

Much more details on these fundamental issues can be found in the paper "Cognition in systems" (Radermacher, 1996a). Citing from this paper, we summarize and give a four-level

architecture of knowledge processing, helpful to understand the different levels of information processing involved.

Box 3. Citation from ´Cognition in Systems´ *(Radermacher, 1996a)**:***

Radermacher (1996a) proposes a four-level architecture for the cognitive apparatus of future autonomous systems, addresses the handling of nested time scales, i.e. the issue of dealing with events on the level of milliseconds, seconds, minutes, etc., tries a first step toward a technical approximation of consciousness, which is understood as one abstract control channel, working linear, i.e. performing one step at a time, only. This takes place within a massively parallel architecture, and describes a number of interplays between an intuitive (subsymbolic) and a symbolic level of information processing. Furthermore, concrete models, namely a task model, model of the environment, partner model, and eigenmodel of a system (i.e. a certain understanding of a system of how it operates), are distinguished. In this context, the interplay between subsymbolic and symbolic forms of information processing is of particular importance.

Fig. 1: *Four-level architecture of information processes (Radermacher, 1996a, p. 4)*

With reference to the four-level architecture of (Radermacher, 1996a, 1996b), the historical process of automation via computerization followed a top-down and a bottom-up strategy. From top-down, the first computations dealt with algorithms within mathematical theories. Consequently, computers did mathematical computations, a famous example being the “Apollo Mission”. This leads to the automation of tasks on the theory level. Further developments were implementations of rule-based processing. And also text

processing and all other kinds of symbol processing could be seen as cognitive tasks at the symbol level.

From bottom-up, a huge set of technical sensors and actors have been developed. Big data and analytics have now been proven useful by examples such as the driverless car of Google. Obviously, computers have now the potential to automate cognitive tasks on the feature level where several forms of pattern recognition are of high importance.

Take as an example medical records with vital signs, Magnetic Resonance Imaging (MRI) and other medical images. Each record represents a pattern that corresponds to diagnoses, therapies and treatments. The whole time series of the well-being of an individual could be made available for that purpose. From a statistical point of view big data forms a huge sample space of data for a specific decision context. Regression analysis makes it now possible to programme an artificial intelligence (AI) system that is built on considerable parts of the world wide experience of medical diagnosing and therapy. Such systems are currently under development (e.g. the Watson project of IBM).

Why are computer systems so powerful in making decisions?

First, it is true from an empirical point of view that systems are very good in making decisions in structured fields, e.g. underwriting in the insurance business or high frequency trading in the financial sector. Learning to improve decision making (relative to a certain modelling frame) helps systems to improve the decision's quality. There are good tools from multi-attributive decision-making (Keeney/ Raiffa, 1976), that allow to tune system's decision making behaviour in such a way, that the intentions of an owner are reflected adequately, as system decide. By using always more data, systems can eventually outperform humans.

Box 4. Why can machines be good in making decisions?

Decision making is a core ability of humans. Essentially, our life and what we make out of it is the consequence of a never-ending series of decisions we make. It is known, for instance, that humans influence twenty years of their expected life span by the decisions they make concerning three topics: (1) their lifestyle, (2) their profession and (3) the partner / spouse they decide to live with. All three issues involve most crucial decisions and are in part interrelated (Hammond/Keeney/Raiffa, 2002).

From scientific analysis we know that decision making of humans is often flawed (Tversky/Kahneman 1971, 1982). The quality is often not good, which by the way is often the judgement of the decision maker himself. This is true for single person decisions (the scientific framework is called decision theory) and even more for more-persons´ decisions (the scientific framework is game theory - with a multitude of special cases). While making decisions allows for a deep theoretical insights and a multitude of applications, the situation with game theory is much more restricted.

Generally, scientific insight into the nature of decision making allows to confront people with the quality of their decisions, often leading to the result that people are not satisfied with how they decided, if alternatives are compared and discussed. People then often want to improve their decision making routines and want to be closer to the systematic routine of scientific insights into the issue. I.e., people, when informed, want to decide as systematically as machines do – to the extent that machines follow the same preferences as the humans when dealing with trade-offs. Note that trade-offs are at the "heart" of decision making.

A good reflection is available for the case of multi-attributive decision making under uncertainty with known probabilities. The main result is the theorem of von Neumann-Morgenstern (1953). It gives a complete characterization and operationalization of best decision making under reasonable axioms of rationality. Best decisions maximize expected utility for the assumed probability constellation and a multi-attribute subjective utility on higher-dimensional outcomes, related to chosen evaluation criteria and corresponding scales. The von Neumann-Morgenstern theorem allows a good algorithmic operationalization of human decision making that is consistent, including learning and adaptation, though the way to get to the decision is completely different from the way that humans do the job. In a sense, in many situations we can build an intelligent system that systematically does what an owner would want to do if he had the data and the systematic capabilities available in his brain in a particular situation, that decision theory and powerful computer systems offer.

On top, the machine can do its job unbiased and uninfluenced by a personal stake on an issue. Of course, the machine is limited in what it does by the quality of data available and subjective probabilities and utility functions being used. That shows how important a good data quality is.

To the extent that an optimal strategy in a game-theoretic context (which is much harder to deal with for humans and machines in decision situations) requires randomization, a machine is also much better than humans in randomizing relative to a given probability measure (by using pseudo-random numbers).

It is, in summary, not surprising that we witness machines to be good in routine decision making. They very often do better than humans would do. And with more and more data becoming available in a digitized form, the machines no longer need the human to input the frame and data and later to deal with the machine output. Increasingly, frame, input data and output data are there and can be processed by machines much easier than by humans. For more details on all the issues see (Keeney/Raiffa, 1976) and Radermacher (1996b).

Efficiency and effectiveness – BIG DATA and analytics´ potential to contribute

The obvious profit coming from BIG DATA and analytics is that we can do much more things right, from the very beginning – "Right First Time". This is because we know and understand more things, e.g. what a consumer wants or is interested in. We therefore more often will produce the right things and the things produced more often will reach the right people. This means less waste, less frustration, more time etc. Also, we will need less human input, so we will win extra time, while goods and services may become cheaper. As a consequence, we may be able to do more things and, on top, more interesting things. Also, powerful systems may help less educated people to become smarter. That may contribute to social balance and to a more balanced income distribution by empowering people, who have less talents and/or qualifications.

A long list of efficiency gains may therefore be ahead of us. The new technology, be it ICT or BIG DATA or analytics, certainly also allows dematerialization per unit value produced at a great scope (Schmidt-Bleek, 1998; von Weizsäcker, 2009). Here, dematerialization means that we deliver the same goods or services while utilizing less critical resources such as e.g. electrical power. and by contributing less to climate change. This is exactly what is required from an environmental and resource point of view, e.g. this may add to the "greening" of our society. Unfortunately, so-called rebound effects are still to be studied (Neirynck, 1994; Radermacher, 2004; Radermacher/Beyers, 2007/2011), because they may alter the positive dematerialization results, possibly into the opposite direction. This means that the more efficient a solution, the more resources we may use in the end, because of induced growth processes due to e.g. falling prices. Therefore, one interesting question is whether negative feedback loops are also to be expected for BIG DATA and analytics-based applications?

Box 5. BIG DATA and analytics: opportunities and questions

Big Data can reduce the cost of transactions to find something we are looking for. We might more often find we what are looking for. We do not need to change so much after purchasing. A lot of stuff not needed will not be produced and will not be thrown away. We more often can calculate risks better and can adapt insurances to that risk. Over all we will be better supplied with goods and services, with less working time and time to find something of interest needed. We can reduce marketing costs and we can have more goods and services because we don't do so many things wrong. We also produce less waste.

The question is, of course, what we will do with the time and people set free, because many of the not so efficient processes to be eliminated guaranteed, up to now, jobs for many people. Reasonably, we could put these people into e.g. research and development. More innovation means more wealth. However, the problem is: Will the economic process move into this direction or not? Will people be able to fill such jobs? And if the answer is yes to both questions, can people adapt fast enough?

Box 6. Problems with an ideal solution

To understand what is at stake, we look into an illustrative example. We assume an ideal solution for the health problems of humans.

We assume gigantic innovations in the medical system within the next years. For instance, we might invent small scouts with sensors and digital communication capabilities that are positioned everywhere in our bodies. They can witness the "birth of diseases" in the very moment when they start to develop. We have all knowledge needed to counter these illnesses immediately. In a sense, apart from accidents, people more or less will not be ill anymore. Assume we can do all that for one fourth of the cost of the health system today. Assume on top, as a consequence, we on average will become 10 to 15 years older. Assume the whole programme is so cheap we can do it globally.

At first sight, this is a wonderful development. This is something, humankind is dreaming of since ever. We will essentially all be healthy. And, yes, we may be able to spare a lot of cost, because we have to invest much less into our health and still are much healthier. Of course, it means we will have much more time for work, because we will not be ill and we have, of course, a much longer lifespan, on average 10 to 15 years more. But of course it also means that in all organizations, the workforce we have today will then be too big, if we keep the efficiency standards we have, because today, we have to compensate for all those illnesses and resulting times off. What extra jobs will the extra work force perform? Who could generate these new jobs? What do we do with 10 to 15 years more life time? Who should finance it? Will we work longer? Are the required jobs available?

What is with the worldwide situation? Poor countries, confronted with extremely prolonged life time of people and a resulting gigantic demographic challenge will be a consequence. World population would grow massively beyond 10 billion. What would all those people live from, how would the needed jobs ever be created for all of them?

To be clear: If the regulation would be right, and if we had enough time to adapt, the program described could result in a major improvement of the living situations of humans. It

would be a wonderful development. That means, however, we need other forms of distribution of participation rights than only income from jobs or capital, other forms of sharing goods and services produced, other forms of ownership – something that is very far away from the mind sets, we are presently in.

Therefore, there is a big difference between a technology that seems to help at first sight, even in the sense that it increases efficiency and allows for dematerialization and, in contrast to that, the resulting societal consequences under a given regulation frame and ownership structure. The question is to what extent there will be an accompanying program helping to improve the situation of a society in real, given the power situation, the wealth situation and the control of ownership that we have today. Taxing intelligent machines and giving entitlements to humans for consumption or giving full salary to people for much reduced working hours could be answers, if technical systems take over our work, but it is not clear whether and when this will happen and – if it happens – whether the needed political changes can be achieved politically.

Let´s recall at this point that the potentials of BIG DATA and analytics may go far beyond efficiency gains. This gives these technologies a particular importance. If the aim is not to spend too much time on "nonsense", if the aim is not to have so much waste, if the aim is not to use so much resources in total, then we can make steps in the right direction, using BIG DATA and analytics, because using these new tools, we might do things right from the first moment, e.g. we avoid garbage. Modern developments in the field of BIG DATA therefore have a huge potential to add to a green economy. So, there is a positive potential for contributing to greening as much as to improving productivity. This is obviously true for ICT, but also for analytics. Both can contribute to avoid garbage. Of course, as always, we have to stay cautious concerning the rebound effect (Neirynck, 1994). Or to put it the other way round: If politics does not deal with the rebound effect, then a lot of the described positive potential cannot and will not be realized or will even be transferred into the opposite direction.

II. THE HISTORICAL PERSPECTIVE OF CURRENT DEVELOPMENTS

The historic process

The trends to discuss for BIG DATA and analytics are in a sense similar to trends we observed in the past. When we look into the history of the mechanical weaving loom, we see that from a certain point on, technology completely outperformed humans that did the job before by hand. And in the same way, the railway outperformed the stagecoach. Those were painful processes at that time, cultural revolutions, in part connected with huge misery of people, because social security systems were not in place at that time.

In the same way, we see today that all kind of jobs, e.g. the handling of accounts in hotels, are much better performed via machines than humans could ever do this. It should be noted that accounts require today always more details, which is a co-evolution to having machines, able to perform the job. This is then the basis for all kinds of analyses on these data, performed by machines, that we now need and expect from a business leader's point of view to optimize our business processes.

All this is progress and needs not to cause a problem with jobs, humans loosing jobs as a consequence will find other jobs - maybe hopefully even better jobs. Here, for developed economies, it is today also standard to have social systems in place to bridge transition periods, while looking for a new job, help with further qualifications etc. This is the right way to deals with change induced by innovations and part of an economic system that is inclusive.

Starting with agriculture

Why should change be considered positively at all? Because it moved humankind forward in a historical perspective. Starting with agriculture, eventually changing into the industrial society and, finally, reaching the state we are in now, i.e. on the way to a knowledge society, this was a long way. The hope and experience along this route always has been that with always better education and always more powerful machines, people in general would move towards a more comfortable, more rewarding lifestyle, connected with more attractive jobs, always more characterized by requiring the permanent use of intelligence, knowledge, analytics etc.

This is a process that in another context is called the race between education and technology (Goldin/Katz, 2008). For a long time and up to now, we have been successful in that race, i.e. other and better jobs have been a consequence of technological progress, although it often took a time and also, not everybody could be included in the long run.

How is the picture today?

As long as the transformation of societies due to innovation follows the given route, things are more or less o.k. with our job system and how we organize entitlements for humans to goods and services. That means that the status quo finds general approval, e.g. in elections in democratic societies.

This, consequently, means broad acceptance for new technologies. And this will be the same with a massive use of BIG DATA and analytics by computers and with systems like IBM´s Watson and resulting application systems, as long as this will offer us progress of the type, witnessed in the past for a great majority of people. Systems that are becoming available now offer efficient solutions with a high potential for many societal needs. Some of our great societal challenges ahead may be solved this way. We will describe this below in the context of green and inclusive growth as a dominating societal issue. No wonder,

BIG DATA today is seen by many as a huge opportunity, something to nurture, something to make best use of, a key for a better future.

The future - does the old pattern recur or not?

Will the old pattern recur? From the point of view of the authors, this depends on the time frame to look at and on societal decisions concerning the organisation of societies. The new technology in discussion has a huge potential to help to deal in a more insightful way with our environment. It can also empower the less able. It will create opportunities for interesting new jobs. It will destroy, however, whole categories of decent jobs of today, as will be described in more details below. Massive change comes in sight for the next 20-50 years, very fundamental change.

The authors expect a systematic decline in jobs, particularly in many categories of well paid jobs of today when looking further into the future. Arguments from research into the topic by many authors will be given. Potentially, the developments foreseen will have negative effects on income balance and wealth balance in the OECD countries, if the development is not counterbalanced by corresponding policies. On top, with industry 4.0 developments, we expect problems within the classical leap-frogging route of developing countries via intermediate steps of an assembly-line type. If this comes true, global cooperation between the developed world and developing countries will require new mechanisms of burden sharing for more social balance and new forms of a creation of entitlements.

Negative effects for balance are therefore an issue: within OECD states, within non-OECD states and between states. So for the first time, fundamental problems with the economic system we rely on up to now appear on the horizon. And while humans would try to cope with new technological paradigms, the next waves of change might come faster than we can adapt to earlier waves of change. Always more often humans as workforce might no longer be at the core of economic activities. What is going on here?

Another look into history

Looking into the history of humankind, into the development of humankind from 20 million people ten thousand years ago to 7 billion now, we see the great picture. Humans in the beginning essentially did hunting or collecting and later agriculture and livestock breeding and for a very long time essentially were occupied with finding or producing enough food to eat. Even in the 17th century, hunger was still known and present in Europe, even at a time when 50 percent of population worked in agriculture and world population was only 10 percent of today.

Then, we had the industrial revolution and eventually the computer revolution, thereby solving some of our most pressing problems. Now we come into modern times, all this in combination with an unparalleled growth in population developing towards 10 billion in 2050, and even faster in economics. We are now more than 7 billion which only became possible because of all the technological breakthroughs we saw – this is a typical rebound effect. All this came along with an enormous increase in global GDP and in average living standard, with the rebound of induced environmental and private stress and a possible climate catastrophe. Why, on this route, we created always more jobs for better educated people? What happened is sometimes described as a successful race between education and technology. One can also put it somewhat different, thereby identifying the deeper reason why things worked well for humans up to now.

The job-creating mechanics in progress up to now

The technological innovations and the organizational and political innovations and everything that came along, were powerful tools that made it possible to massively increase the added value per person, i.e. in particular the productivity of work. But this was only possible with always better educated humans that used the new technologies, machines and devices. This way, humans became always more efficient, they became always more productive. And with the humans involved, the same was true for the new

tools, they used. For private investment and for the activity of states, it made obviously sense to invest into the education and power of humans who would activate and unlock the potential of always more powerful machines. There was no other way to make use of machine power than to involve always better educated humans. There was therefore a kind of balance between the options of capital owners and the options of people as workforce. This led to reasonable compromises, where democratic political regimes obviously helped to achieve and stabilize such reasonable balance.

Of course, this process was always controlled via ownership rights and it were comparatively small groups of people that had those ownership rights (Piketty, 2014). But the interesting thing is that those groups could make use of the assets, machinery and the powerful tools they owned only with the right kind of workforce and these workforces had to be adequately educated and paid.

Something comes on top: Until the time of the First World War, there was massive competition between nation states to the extent of using war. The competition required developing the full potential of countries, i.e. their people and technological, infrastructural and resource base in competition with similar steps in neighbouring countries, eventually also involving military struggle. All that meant multiple needs for a good education of one's own people, the fostering of the middle class and of workers to increase political loyalty to the state and to generate economic growth as well as massive technical and societal innovation, also with respect to be prepared for military struggle.

All these constellations were generally favourable for balance, participation and jobs. Another ingredient over the last sixty years has been the loss of considerable parts of inherited wealth as a consequence of World War II as well as the high growth rate after this war. Both effects add to imbalance, as is described in detail in the very insightful recent book by Thomas Piketty: Capital in the Twenty-First Century (Piketty, 2014).

Box 7. Atkinson, Piketty and others

The topic dealt with by Piketty (2014), meaning the fast accumulation of always more capital in relation to total income will be enhanced, if intelligent machines should replace whole categories of well-paid jobs. The same would then be true for the income distribution which would become more unbalanced. E. g. the income distribution would be modified towards more inequality, towards more precarization or a neo-feudal pattern. One should take into account the results on this issue for instance by Herlyn/ Radermacher (2014) as well as Wilkinson/Pickett (2010), Stiglitz (2012), Atkinson (1975) or Herlyn (2012). This will mean an impaired societal situation with respect to balance. Interesting enough Randers in his recent Club of Rome Report 2052 (Randers, 2012) ends up with a dominating scenario of the neo-feudal type, namely overshoot and managed decline. His argumentation is oriented to the resource side. But concerning technical intelligence built on Big Data and analytics could also lead in this direction. So we have to be prepared, e.g. on the OECD level, to counteract, if such a development would start to materialize. Otherwise, we might witness a mutual enforcement in the direction of a global two-class society to the extent that it may not be possible to build a political counterforce later.

Many of these factors have changed in the meantime to a considerable extent. Capital concentration, even in the OECD states, may be back on a route to pre- World War I patterns. We have to be very attentive to this possibility and be prepared to counter-act as described by Piketty (2014). Growth is expected to be comparatively low in the coming years when compared with the past-World War II situation in Europe. Global capital no longer needs to seek permanently a coalition with the working class of a particular country, it now is firmly embedded in global systems with global legal regimes and methods of legal enforcement.

So, we now have a situation in which the pressure to stimulate the power of the 90 or 99 per-cent of the population is no longer a dominating need for capital to flourish. Global sourcing is obviously an attractive alternative, when following a free market philosophy. This goes along with increased competition, involvement of developing countries as assembly lines etc.

On the other hand, there is a probability, too, that we will witness massive degradation of people. Certain countries have witnessed a massive relative decline in economic wellbeing when compared to pre-World War I time, because of changes in the markets. Following

the recent financial crises, great parts of populations in some southern European states had to accept massive losses of income, pensions and prosperity.

It is deeply embedded into the present world economic system, that if the opportunity arises, workers will be dismissed in huge numbers, instead intelligent machines will be put in place, in case there are machines available at a reasonable price that can do the job. Massive automation today even in China assembly lines is a good example for that. The central question is therefore: Will humans have in big numbers an added value potential in rigorous global markets of today and in the foreseeable future in an interplay always more intelligent machines or not? And what is to be expected in this respect over 20 years and over even longer time horizons?

Box 8. Who will take advantage?

Primary winners of technological advance towards more intelligent systems may be those already in control now. Investors will be rewarded, we will have "winner takes it all" situations, if humans in large numbers in different kinds of occupational categories can be substituted by machines. This will, within the next 20 years, also happen in a number of those attractive occupational fields, that have built on good education and analytical skills, which up to now meant a reasonable and future-proof occupation income for the job holders.

The job issue – taxation and income balance

As pointed at above, the history of progress is essentially a history in which always better educated people using always more powerful technology could increase the global output of goods and services. As Piketty shows, this in a natural way leads to higher salaries with work being remunerated always in total with more than half of the GDP produced. The capital side takes maybe 30-35 percent. The ownership of that capital is essentially restricted to ten percent of the population, with the greatest share going to the one percent TOP segment, with again the main share going to the 0.1 TOP percent. This pattern seems to be o.k. from a social acceptance point of view. Up to now, it was enforced by the need

for capital owners to pay an always better educated workforce to make use of all kind of powerful technical innovations they own. Politics in democracies helped to stabilize this picture. If the need to pay such a huge educated workforce should be eliminated via intelligent technologies, that can (partly) perform the value adding without so much well educated and reasonably paid staff, the known pattern of distribution could be in danger. The question will then be, if politics can counteract on a supranational basis, e.g. via the OECD. Recent results achieved on the G20/OECD level concerning automatic data exchange on tax-relevant data and the ongoing work on taxation of international business activities and aggressive tax planning by certain multinationals, give a certain hope concerning co-ordinated political action, if needed – but this is open for the future.

As a consequence of the World Wars and political reactions after World Wars I and II, we are (still) living today in the OECD states, particularly observed in Europe and Japan, with a kind of patrimonial middle class. This means, a middle class that has accumulated over the last sixty years about 20-25 percent of property, while the lowest 50 percent of people altogether not even make it to 5 percent.

This distribution of wealth has direct consequences for the income share, as there is an average 5-6 percent return per year on capital with increasing returns the bigger the capital is, altogether making up for some 30 percent participation on the income side for capital.

Computers start to do amazing things

In the past, jobs that have become obsolete due to productivity growth and technological innovation were overcompensated after a while by new offers of goods and services. This process is known as “creative destruction”. The question to be discussed is whether the “creative destruction paradigm” holds to be true in the future and argumentations and estimations for higher unemployment in the future will show to be a luddite fallacy (The Economist, 2011). The proponents of the creative destruction paradigm compare those giving warnings about job impacts of big data and analytics with the machine destroyers in

the late 18th and early 19th century with Ned Ludd being one of the first. One could see the argumentation of those seeing big data and analytics having positive impacts on future employment as being based on empirical evidence from past experiences: On the long run, in history there has always been a possible correlation of productivity and employment.

The important question thus is: Do we have reached some kind of threshold, because of which the current situation is different from the past? The arguments for "this time is different" can mainly be qualitative. They are connected, from the view of the authors, with what is called a singularity, though with a weak form of it. This is to say that computers are starting to do real smart things such as high-frequency trading, autonomous car driving and beating human champions in Jeopardy. We will describe this next.

What is new, what is different – The game changer

The initial situation with computers was such, that only humans could understand the world and then translate problems into a computer-fit modelling frame and corresponding data structures, so that computers in connection with tailored algorithms might work on them. Humans then had to re-interpret the results of computations back into the world. It were the humans that were adapted to the world and that were able to adapt themselves to always more information becoming available.

Similarly, it was humans – and only humans – that could make use of computers as a tool to deal with increasing volumes of data, but also with putting the results into real life consequences. Particularly, it were up to today mostly humans, that are able to use huge and expensive and most powerful technologies, such as cars, busses, planes, ships, trains, cranes, harbour docks, etc. in value added processes. In doing this competitively, they today make use of powerful IT systems. Still, the systems alone can do almost nothing. So, up to now, there is no way around humans as workforce. Interestingly enough, Germany, which is presently confronted in its train system with massive strikes of the small group of

train conductors, is talking for the first time about automatic driving of trains. Similar considerations concern automatic flying of aircrafts.

Approaching singularity

If we ask what might be new this time, it is the fact that we are now developing a "technical brain" that can do in many areas precisely what always had been our advantage and let to all the areas, where we found new jobs always by a law of nature, i.e. develop the availability of technology to deal with powerful machines, without having to rely on humans. The automatically driving car is a striking example of this.

The same would happen, if a machine develops into a reasonable partner to listen and speak with a "flavour" of empathy to humans. The issue then is not coordination of huge machines, but dealing with human social needs in a way, that is regarded as satisfiable. This is the topic of the movie "Her". On a lower level of sophistication, this is in reach already now. A weak form in routing telephoning today is to do as much pre-communication via machines as possible, so that resulting costs and time losses go to the caller, not to the work force of the company called.

If machines do such things, their abilities reach out into the direction of most involved human abilities. Reaching them is a vision, called by some authors a singularity. From the point of view of the authors, a singularity is still far away – if it will ever be reached.

But a (full) singularity is obviously not needed for the developments described. Because from an economic point of view, systems might soon be good enough to be used in therapies instead of much more expensive specialists – and users will like it, because it is cheap and always available. So, such a system would obviously have positive societal effects while taking over jobs, until recently not thought to be in reach for machines – as much as automatic driving.

So machines might not have to pass the threshold of “singularity”, i.e. develop human-like power, to do unbelievable things and to outperform humans in the job area to an extreme degree, not seen so before. Take automatic car driving as described above. Cars will do it, making use of the internet of things. They will not have available the image system power of the human brain. No singularity in this respect. And yes, humans making use of the data that becomes available might still outperform the car. But for car driving, “intelligent” systems will be good enough. And therefore they will replace human drivers.

Therefore, it may be that the new machine is “too good” in comparison with us, if the issue is to compete against the machine in the job area. There are already a lot of people today, who are not able to adapt to working place requirements, often resulting in over-stress and burnout. Obviously, always more people seem to reach their biological limits under the competitive stress we have, either when using machines or when being in competition with them. So, staying employed – with good payment - under the present job regime could turn out to be no option in the future for large numbers of people, if politics not counteracts, should the problem arise.

Odds are shifting towards machines

The dominant and up to now unchallenged role of humans as gate keepers controlling the information flow is changing with digital information created almost everywhere. Big data, like e.g. “clicks”, geospatial information, sales ships, surf-trails through the web and what else could be stored as data, this digital information not necessarily suited for humans but absolutely suited for use by machines. e.g., to make it accessible to humans needs extra “translation” efforts plus processing time on the side of the humans involved. The machines now have access to all kinds of data directly, information is extracted by data-mining techniques, information is concentrated to their mode of processing from the very first moment. Machines now do most of the traffic in the internet among each other

and all this information is available to them. Net traffic statistics give the respective information.

With machines being on the way to “read” journals, e.g. scientific journals and books, as is the case in medical applications based on IBM´s Watson system, they will more and more often have access to what has been compiled as knowledge by humans over the last centuries. The balance is shifting towards machines, which can do things on their own. McKinsey Global Institute (MG, 2011) refers to sensor-driven operations in process manufacturing in oil refining as a prominent example.

On top, machines do analytics, check statistics, look for old legal cases with certain patterns. These are really hard intellectual tasks. Until recently they were only accessible with human brains and were the starting point for jobs, reasonably jobs created over the last 30 years in reaction to modernisation and innovation. Humans are no longer the only ones to make use of powerful technical tools. Machines can now deal with language (i.e. Google´s translating system) and have meaningful conversation in the therapeutic applications of limited intellectual requirements. A long history of achievements of automation processes in information processing is reaching a threshold. Not yet a singularity, but a powerful incarnation of machine potential.

III. IMPLICATIONS FOR EMPLOYMENT

The job issue in the context of BIG DATA and analytics

BIG DATA and analytics carry a potential for technical obsolence of huge categories of well-paid jobs. Therefore, the debate concerning this issue is growing in size and differentiation. Some topics have already been discussed in Chapter II. We go now more into the debate, strongly building on the relevant literature.

The recent debate concerning the job effects of BIG DATA and analytics primarily deals with jobs of a transactional nature. This concerns whole categories of well-paid desk work such as underwriting in the insurance business. More information on this is given below. BIG DATA and analytics applications will also most probably reduce labour demand in manufacturing (in the context of Industry 4.0). This may bring – at least to some extent - manufacturing back to developed countries and, thereby, will make leap-frogging for development much harder. Unfortunately, this development will not mean significantly more jobs in the developed world, either. I.e., Industry 4.0 is about doing the assembling of e.g. cars by a much smaller workforce.

Jobs that need highly developed sensomotoric skills (interaction of complex human abilities or the signal and feature level) do not seem to be negatively impacted. This covers many everyday jobs, such as services in restaurants and trains. Certainly, it will be a long time until robots can compete with humans in fields using high sensomotoric skills and operating close to other humans. To put it the other way round: It was much easier to build machines that do analytics perfectly than machines that can move around, dance, ski, bike etc. This is not surprising, because we profit from a much longer biological evolution of our sensomotoric body skills (hundreds of millions of years in the long chain of “ancestors” of humans) when compared to elaborated analytical-symbolic reasoning (which is quite recent in biological systems / probably only one million years, possibly much less). Still, there is no reason to believe that this will be true on the long run. Some

service robots, as limited as their abilities are, play already a role today, e.g. in hospitals or rehabilitation centers, and this role is increasing. But really huge effects for the labour market are still quite a time ahead.

Other capabilities and human skills that seem to be advantages against technical systems are creativity (especially to raise new meaningful questions), the handling of logical paradoxes and high levels of sociality. (Levy/Murnane, 2013) are categorizing the employment opportunities left for humans as “working with new information”, “solving unstructured problems” and “non-routine manual tasks”. We go deeper into this issue below.

Box 9. Job effects

There is a broad debate concerning the job effects resulting from the innovations in the field of BIG DATA and analytics. Many observers see a high risk that intelligent systems will take over a lot of jobs in the middle and higher level of payment of today, held by people in the middle of our societies that glue our societies together.

This means that jobs could be affected, which are not simple service jobs. These are jobs, which are transactional in nature, that up to now require the ability of analyzing and understanding complicated domains or of using and coordinating the use of powerful technical systems. More and more intelligent systems are able to perform such tasks and also are able to make other technical systems work. By that, it is no longer true – as it used to be in the past – that the human with his brain is the only intelligent agent, having the exclusive role of making always more powerful technical systems work. This is a new situation and this new situation may potentially be different from the transformations in technology we have seen in the past, e.g. the industrial revolutions. Still, change will be slow, for practical, legal and other reasons.

As the changes ahead will also affect industrial production and reduce the number of jobs needed in this field, states in transition may find themselves in huge new problems, as they may no longer be needed to be the place of low-sophisticated assembly, to start with their own industrialization process. The historical route to development and leap-frogging may be cut off.

Why is it not easy to see a future of always more decent jobs around the world to allow to overcome poverty and to come to more balance?

The reason is that our economic system is constructed in such a way that it will try to get rid of paying salaries, whenever there is a technology that allows to substitute human

input. BIG DATA and analytics seem to offer interesting potentials, pointing in this direction. As discussed, this concerns areas that have been safe until recently: Coordinating huge and powerful machines and technical tools and operating close to humans and language. Why we may not yet be in reach of what is called a “singularity”, we seem to approach it in many aspects that are economically very relevant.

Therefore, several authors are careful and critical. We refer to authors who have recently published on the issue (Brynjolfsson/McAfee, 2014; Cowen, 2013; Cukier/Mayer-Schönberger, 2013; Elliott, 2014; Ford, 2009; Frey/Osborne, 2013; Levy/Murnane, 2013) and combine it with our own considerations. This includes information onto what job segments might get under pressure and what job segments might not.

Will humans find new jobs?

In the book of Tyler Cowen (2013), the idea is that humans using their intuition might be able to improve proposals by intelligent machines, so that cooperation and division of labour between humans and machines will still make sense – at least for some time. This means we might stay in the old paradigm. However, how many specialists of this type will be required for this type of work? And how many people will be able to add value this way? And what is the quality of such teaming? Since Big Data and analytics is complex, Cowen (2013, p. 131) predicts on anecdotal evidence: “The future will bring us The Unaccountable Freestyle Team, The Scary Freestyle Team, and The Crippled Freestyle Team, all at once”.

(Brynjolfsson/McAfee, 2012, 2014) discuss the issues very broadly. They expect that the income spread in society will grow due to the availability of always more machine intelligence, if politics does not act against it. This is what we call precarization and neo-feudalization – as does the Club of Rome. The recommendation of Brynjolfsson/McAfee: accelerate growth and run with machines. It is, to some extent, the next round in the old battle between education and innovation and the recommendation is: run faster. But has

this a chance, or is it a hamster wheel? In the long run, how can we stay on top this way forward? The authors therefore also mention the probability of negative effects on employment and equity in the medium term and recommend to revisit the idea of a basic income.

Social innovations could be needed in form of new responsibilities and/or entitlement for humans. We go into that future to give an outlook of how to cope, if the economic system should turn out to be even much less than today able to supply society with a sufficient number of decent jobs for all people interested and adequately educated.

Frey and Osborne (2013, pp. 24-27) identify three areas of future employment left for humans from their point of view, viz. jobs that seem not to be highly susceptible to computerisation. They argue with reference to other literature that these capabilities remain hard to be automated.

- complex perception and manipulation

  Tasks that relate to an unstructured work environment

- creative intelligence

  Because creativity, by definition, involves not only novelty but value, and because values are highly variable, it follows that many arguments concerning creativity are rooted in debates about value. A computer will, for a long time, not be an informed and accepted partner in such debates.

- social intelligence

  Is similar in character. In particular, real-time recognition of natural human emotion remains a challenging problem, and the ability to respond intelligently to such inputs is even more demanded.

Based on the O-net data, an online service developed for the US Department of Labor, the scientists analysed a set of 702 occupations with respect to the above capabilities. Their result showed an estimate around 47 percent of total US employment in a high-risk category to be automated relatively soon (maybe within the next twenty years), which means, the respective people will need new jobs. Levy and Murnane (2013) analysed the occupational distribution from a slightly different perspective. Work left for humans on a long run they see in the areas

- solving unstructured problems

  Tackling problems that lack rules-based solutions.

- working with new information

  Acquiring sense of new information for use in problem-solving or to influence the decisions of others.

- non-routine manual tasks

  Carrying out physical tasks that cannot be well described via rules because they require optical recognition and fine muscle control that have proven difficult to program.

Martin Ford (2009) in “The lights in the tunnel” gives anecdotal evidence to a high risk of technological unemployment and massive capital accumulation. He argues for new forms of entitlement to respond to this set of problems. He does not argue for unconditional basic income, but for a type of incentive income. He wants people to go on for qualification in the sense of lifelong learning, to contribute to community or civil services, to engage for the environment and other people´s needs.

We add one further voice: Very prominently, Jeremy Rifkin argues in the given direction since many years and via a number of books. His latest one “The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of

Capitalism" (Rifkin, 2014) massively addresses the issue of new types of entitlements, which from his point of view are urgently required if we want to have a balanced future.

Environment and resources – further dimensions of the issue

There is a big and rising gap in demanded value added and the capability to produce all those demanded goods and services without destroying our environment. That is why the world is at its limits, has problems to get forward with sustainability, has problems to avoid a climate catastrophy. At first sight, dealing adequately with environmental and resource topics means less economic activity, less growth and consequently less jobs and lower payment, i.e. could add to the job and income problems ahead.

Because of the environmental and resource challenges, we cannot just multiply what we have, e.g. using more fossil fuels to produce energy. So, strong innovations and faster innovation cycles are needed to face our problems. The historical consequence of a growing population to innovation and innovation cycles has been discussed in a report to the Club of Rome by Sergey P. Kapitza (2006). He found out that throughout human history growth of population implied an accelerated growth in innovation.

Big data and analytics is such a kind of innovation with an enormous impact on productivity. Presuming that the world aim is to reach sustainable development, what is primary needed is a strong growth in natural resource efficiency, parallel to inclusive growth for more social balance and for overcoming poverty, hunger, malnutrition etc. As discussed above and figured out by the work of OECD, BIG DATA and analytics have potential in this direction.

Still, there is the uncomfortable perspective that Keynes' vision about "economic possibilities for our grandchildren" that he expressed nearly hundred years ago could become true: "*Technological unemployment. This means unemployment due to our*

discovery of means of economising the use of labour outrunning the pace at which we find new uses for labour." (Keynes, 1930).

At least this trend could become true for all goods and services to meet all demands in basic necessities – this, however, only to the extent that enough natural resources are available for fulfilling all these demands. All the "needs must" goods and services demanded by customers with purchasing power are already provided with high productivity and further innovation could fully automate their production. A further productivity growth implies lesser employees and a rising GDP share of capital yields in this segment. To prevent technological unemployment, new and decently paid job opportunities should arise in "nice to have" segments of goods and services. Several authors like Tyler Cowen (2013) and Erik Brynjolfsson / Andrew McAfee (2012, 2014) discussed the new innovations in big data and analytics in this respect stating, however, that they might automate a growing portion of median and higher paid jobs.

As an economist, Cowen (2013) synthesizes several facts and findings concluding that for several areas of society, there will be a drift from the middle to the extremes. He is anecdotal evidencing this in the fields of work and wages, big earners and big losers (wealth and participation) and even in the field of science.

Based on statistical data, one of his starting points is the observation that already a decade before the global financial crisis hit the real economy most severely in 2008/2009, the labour income as a share of total income has steeply declined. "In 1990, 63 percent of American national income took the form of payments for labour, but by the middle of 2011 it had fallen to 58 percent." (Cowen, 2013, pp. 38-40). *"Most developed countries – including Germany, France and Japan have seen similar trends. "Demand is rising for low-paid, low-skilled jobs and it is rising for high-paid, high-skilled jobs, including tech and managerial jobs, but pay is not rising for the jobs in between. This is not just a story about America […], in sixteen major European nations from 1993-2006 middle-wage occupations declined as a share of employment."* (Cowen, 2013, p. 40) analysed the great recession 2008-2009 and its aftermath, his findings are *"after the first quarter of 2009 per*

labour hour productivity grows dramatically" (Cowen 2013, p. 58), arguing *"it's because we laid of a lot of workers who weren't producing enough for their level of pay."*

Brynjolfsson/McAfee are anecdotal evidencing this trend strongly arguing that it is caused by a further accelerated innovation speed. Figuratively, the metaphor they use to describe the consequences of Moore´s Law (doubling of technological capabilities within every two years) is the old story placing one single grain of rice on the first square of the chess board, doubling it to the second, doubling that number to the third and so on. They argue that with respect to digital technologies, the second half of the chess board has been reached, *"it would take a millennium to reach the second half of the chess board at that rate, in the second machine age that doublings happen much faster and exponential growth is much more salient"*.

They figured out that starting around the late 80ies, there has been a clear trend of a rising profit share vice versa a declining wage share in GDP. This means that especially during the last twenty years, the role of capital and especially knowledge-based capital has increased with the effect of a decreasing participation share via wages. This is similar to the findings of Piketty (2014). Referencing to several economists, they call the trend a "skill-biased technical change" that "can be vividly seen in Fig. 2, which is based on data from a paper by MIT economists Daron Acemoglu and David Autor".

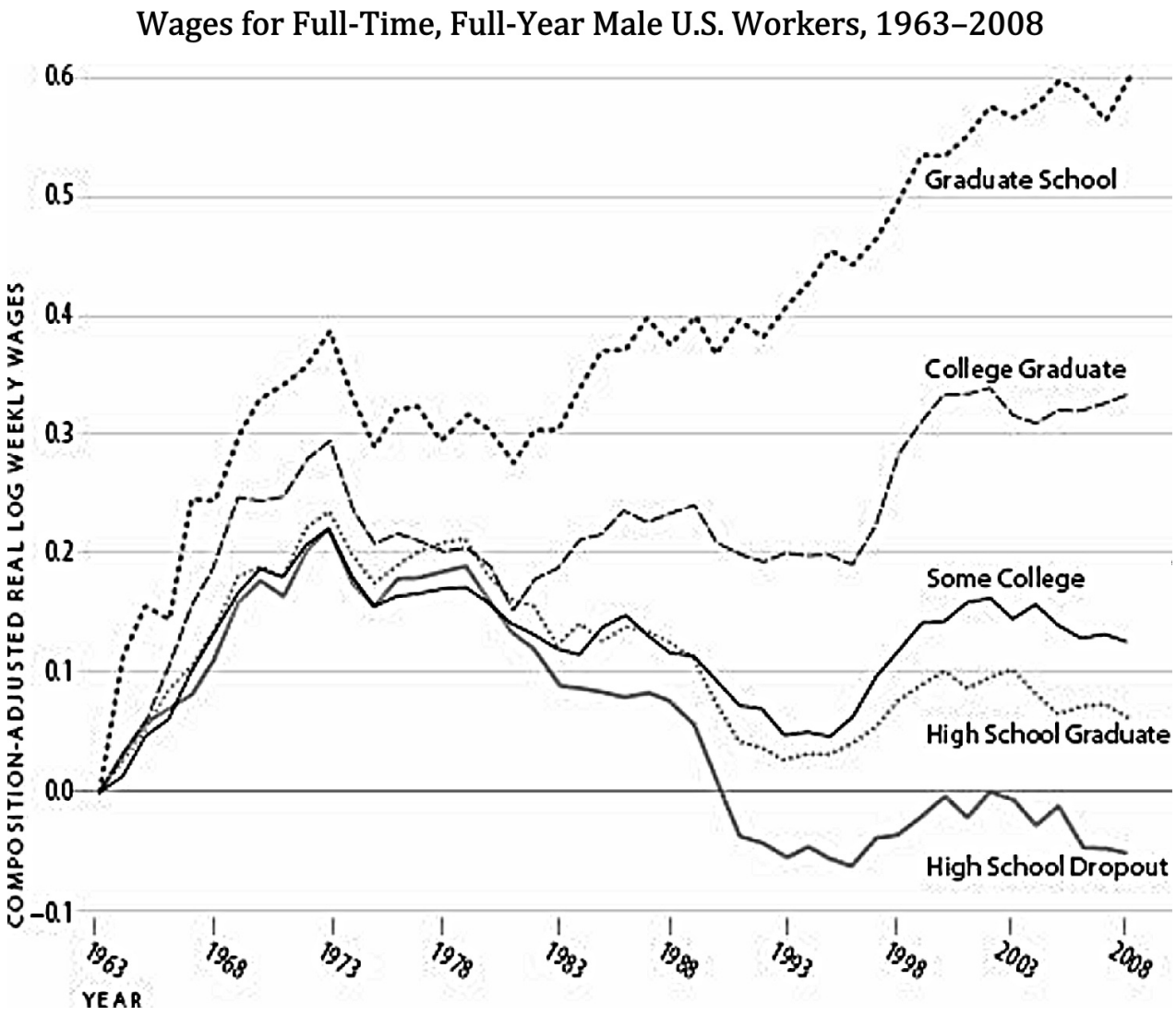

Fig. 2: *Wages for Full-Time, Full-Year Male U.S. Workers, 1963-2998 (Brynjolfsson/McAfee, 2014)*

What is left for a growing number of job seeking humans are lesser employment opportunities in the fields of “solving unstructured problems”, “working with new information” and “non-routine manual tasks” (Levy/Murnane, 2013). Based on their work “The new division of labor”, they discuss the new wave of automation opportunities. With respect to the four-layer architecture of the FAW, (see Box 3) Levy/Murnane (2005) explained the top-down automation process in the upper two layers of theories and rules.

In “Dancing with robots”, they highlight the importance of pattern recognition as a next level to be more difficult to programme.

Increasingly Difficult to Program →

	Rules-Based Logic	Pattern Recognition	Human Work
Variety	Computer Processing using Deductive Rules	Computer Processing using Inductive Rules	Rules cannot be Articulated and/or Necessary Information cannot be Obtained
Examples	Calculate Basic Income Taxes Issuing a Boarding Pass	Speech Recognition Predicting a Mortgage Default	Writing a Convincing Legal Brief Moving Furniture into a Third Floor Apartment

Fig. 3: *Varieties of Computer Information Processing (Levy/Murnane, 2013)*

Together with the MIT economist David Autor, they have examined the changes in occupational distribution in the U.S. by categorizing the work in five areas: (1) solving unstructured problems, (2) working with new information, (3) routing cognitive tasks, (4) routine manual tasks and (5) non-routine manual tasks. The result shows a clear trend, as described in the following figure.

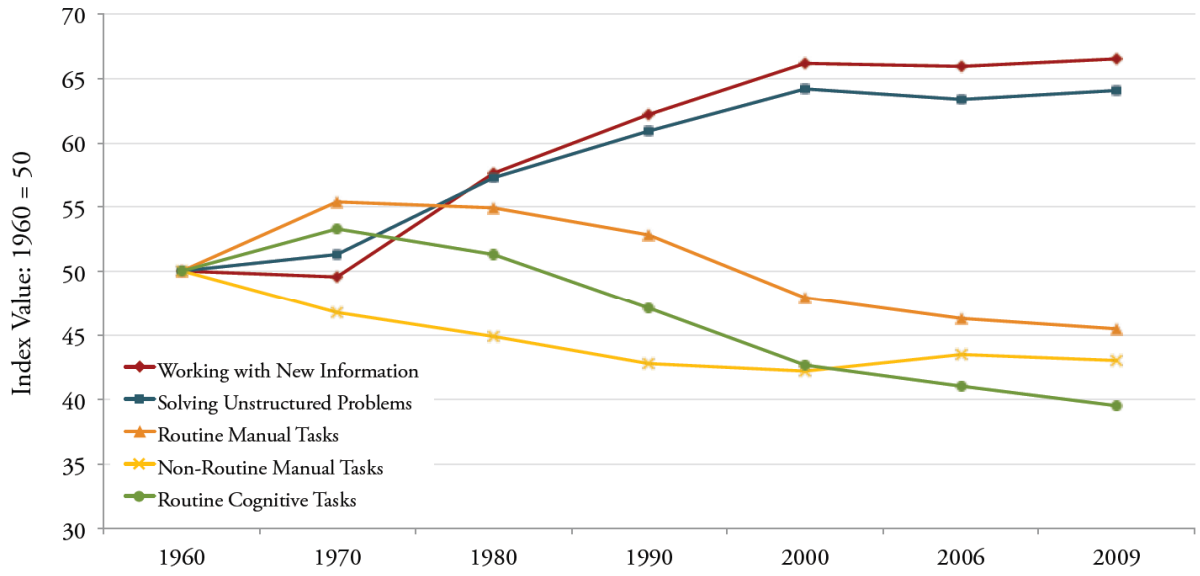

Fig. 4: *Index of Changing Work Tasks in the U.S. Economy (Levy/Murnane, 2013)*

„Today, work that consists of following clearly specified directions is increasingly being carried out by computers and workers in lower-wage countries. The remaining jobs that pay enough to support families require a deeper level of knowledge and the skills to apply it" (Levy/Murnane (2005, p. 19). They note that *"labor market will center of three kinds of work, solving unstructured problems, working with new information and carrying out non-routine manual tasks"* and *"that occupational projections show rapid growth in high-end jobs, but they also show rapid growth in low-paying jobs carrying out non-routine manual tasks"* (Levy/Murnane (2005, p. 28-29). This is in line with the findings of Brynjolfsson/McAfee who state that a small group of people, able to "race with machines" and a large group of people competing for lower waged job opportunities could be the result of the innovation processes around BIG DATA and analytics that we witness at the moment (Brynjolfsson/McAfee, 2012, 2014).

Brynjolfsson/McAfee (2012), Brynjolfsson/McAfee (2014) and Cowen (2013) describe the observation that after the last big recession in the aftermath of the global financial crisis that started in the year 2007, the prospect of job recovery when economic growth

took off again was not detectable. Instead more and more companies are announcing to replace jobs by machines. A prominent example refers to the company Foxconn (c|net, 2012; Spiegel Online, 2014). Foxconn, one of the biggest companies for electronic products, announced to replace human workers by ten thousand robots in China. Some studies have looked in depth to the potential of jobs that could be afflicted by the current new automation opportunities based on the development of big data and analytics.

Stuart W. Elliott (2014) gives a detailed analysis of impacted fields of employment by analysing all types of employment with two criteria: a) Vision Movement and b) Language Reasoning. They analysed the O*NET Database, translated all job descriptions into groups attributing weight factors corresponding to levels of capability. By assuming a higher level being approached by new innovation for automation, they conclude "*that there is the technological potential for a massive transformation in the labour market over the next few decades.*" Levy and Murnane (2013) come to a similar result that „*technological change has also created tremendous dislocations in labour markets, especially the elimination of routine cognitive and routine manual tasks that provided work for generations of highschool graduates.*"

IV. JOBS TO STAY IN MEDIUM-TERM PERSPECTIVE

We have described the risk that a completely new situation might come up with intelligent computers using powerful technologies, doing all kinds of jobs which need intelligence, re-placing millions and millions of people holding those decent jobs today: analytical jobs, intellectual jobs. One could also say that in the race between humans with their abilities and technological innovation, the humans will be losing – will be losing hundreds of millions of decent jobs.

In a sense, there is hardly a chance to stand up in that race giving the factor of 1000 coming from Moore´s Law every twenty years. However, that is the picture taking a long view. Over the next twenty years, the situation is more mixed. On the upper end, bright humans with good education, using always better technology, will have to do maybe even more: use their unbelievably huge fantasy, their creativity, their imaginative power of their brains and/or be legally in a non-replaceable role by having to take responsibility, be the owner of property etc. Certainly, data-related skills will be required and properly rewarded. People with such skills will sit in a driver´s seat for the coming years.

On the other hand, jobs will stay for the foreseeable time that, though not exclusively based on intellectual achievements and skills, are based as much on the impressive sensomotoric abilities of our body to do interesting things, also in always changing environments or under very difficult terrain or surrounding conditions such as serving in overcrowded bars and restaurants. Handicraft people doing practical things live in a job world that may remain stable for a long time to come. The same might be true for jobs that are performed very closely to the human body, such as nursing or massage and all situations, where humans insist on interacting with humans and not machines and are willing and able to pay for it.

Box 10. Jobs that stay for a while

People working with their hands skilfully will be needed for a long time, still. So they have a good chance for not losing their job in the next decades. The same is true for jobs requiring an extremely high creativity. Also complicated tasks in building and construction in unstructured environments cannot easily be replaced (Levy/Murnane 2013; Frey/Osborne 2013).

Even here, on the long run, good robots will do a lot of replacement in the future. But this is much more complicated to achieve and will need much more time, and is not a pressing issue for the more foreseeable future.

Taking the twenty years´ point of view

An important question is: Are we reaching, in the next twenty years, some kind of fundamental change, that the situation this time is fundamentally different from the past? The arguments for "this time is different" can mainly be qualitative. In an essay in the year 1930, Keynes argued in this direction, as described above. Up to now, Keynes did not come true, in part of the great ability of humans to enhance their potentials by making use of always more powerful technologies, coupled with their own contribution (Keynes, 1936). Sergey Kapitza in his study "Global population blow-up and after" supports somehow the argumentation of Keynes from a different angle, based on statistical data, showing the evidence of a positive correlation between population growth and the growth of innovation speed (Kapitza, 2005). However, the main conclusion of his studies is that population growth has eventually to stop, which is a process already happening.

So, while the situation is going to be more tense and many people will be uncomfortably affected, the next twenty years will probably not lead to a complete change in occupation, but instead to more pressure that we have to live with. Taking a longer view, however, 20-50 years, Keynes may be proven right, so that societies have to bring out new forms of organising entitlements for participation, which is discussed below.

Societal decisions that will heavily influence job opportunities for humans

(1) Requirement of personal responsibility

To the extent that we as societies will require humans/people to take personal responsibility for certain decisions, we will have jobs related to taking over this responsibility. So, even if a machine does do all the intelligence and makes suggestions concerning a particular decision, such as investing into certain financial products in high frequency trading or proposing a certain medical treatment, in the end a human has to take over responsibility for that proposal or decision. A comparable situation today is either to involve a judge who comes to a legally binding conclusion or as an alternative to go with a mediator mechanism making a proposal. This mediator proposal might also come from a machine.

As a society, we will have to make decisions concerning the degree of human personal responsibility required. Do we want to link responsibility in a quite general sense to people and not give it to computer systems, how intelligent they ever may be or not? Once people are required as ultimate agents to take over responsibility for proposals, they have to be involved in developing proposals or decisions to a certain degree, to understand what is at stake. This will slow down processes, because humans need time to understand issues to the level that they feel able and comfortable to take on responsibility. Obviously, our future will look different, depending on the degree, to which we want to see a human involved as responsible in processes of making proposals or taking decisions. This also applies to questions of automatic driving, be it cars, be it planes, because driving involves a stream of decisions to be made, online and on-going.

(2) Ownership

If activities are connected with ownership and property and with ownership rights and property rights, this generates jobs for humans connected with executing these rights that a

machine cannot overtake. The same is true if somebody has to be in charge in order to be allowed to make something happen. Then legal requirements constitute the starting point for certain jobs, e.g. to do the role of a notary, who has to be involved, if certain legally binding transactions should be valid.

(3) Customers require a human counterpart

In a broad variety of situations, a machine might do something or instead a human. To the extent that humans insist to partner with humans and not with a machine (for instance, looking for a child) and to the extent that financing is available, jobs will stay with humans and not with machines.

(4) Relative prices

We experience humans as being expensive as staff. Much of competition is about more efficiency, i. e. about doing it with less staff and/or via machines. However, machines, particularly if they are robots, will have a certain price, too. On top, they need energy, need maintenance, need repair, so they are not for free. This means that humans will have a chance, depending on the type of work and on the cost for a robot solution.

(5) Sensomotoric skills

Humans have unbelievable sensomotoric skills. We can do most complicated things in very complicated environments, using our body and its multitude of abilities. A good example is a waiter in an overcrowded restaurant or in a fully booked plane. Another is a handicraft person doing all kind of repairs in flats with different technologies involved under most obscure three-dimensional constraints. For the foreseeable future, there will be nothing in robots that could do those jobs.

(6) Creativity and our "simulation machine"

The human brain is a "simulation machine" of unbelievable power. It can create "new worlds" out of nothing. With our fantasy, we could do things and can do things that are

impossible at a certain time, like imaging to fly through the air a few hundred years ago or to visit outer space, today. We can image worlds that, from the point of view of physics, are not possible at all. To the extent, we want to make use in certain situations of this unbelievable power of creativity and imagination of our brain, this will create job opportunities. And by using always more powerful technical systems as input into the contribution of humans, we can further enhance our personal "creativity machines" and what they might be able to achieve.

Know How and Know Why viz. Manifest What

Since a couple of years there is a clear trend of a total datafication, quantification and financialization of the world. This makes big data available and the application of statistical and other mathematical methods are implementing a form of analytics for very different application scenarios that are currently performed through middle waged jobs.

Box 11. What is new in the BIG DATA and analytics (BD&A) field?

Concerning the probable future impact of BD&A to employment & equity, one has to define BD&A and distinguish it from conventional information processing.

There is a big difference between conventional ICT and data-driven innovations in the field of BD&A:

1. *BD&A is about providing a kind of "Manifest What" by implementing "Value Extraction" in a flat and unstructured "datafied universe of information-shreds" with unknown veracity, and that enables to answer questions on the basis of calculated approximation & correlation.*
2. *Conventional data & analytics is about providing a kind of "Know What" instead of "Manifest What" by implementing "Know Why" as value, and that enables to answer questions on the basis of implemented causation.*

The difference is thus mainly correlation and quantitative reasoning as the fundamental basis of BD&A, causation and qualitative reasoning as the basis in the "traditional" field.

It is important to mention that the analytical approach on big data is statistics. Such systems propose what to do, based on detected correlations without causation, without know how and know why. It is a kind of manifest what, qualitatively sanctioned by the law of large numbers. In contrast, middle waged jobs today often require massive know-

how which at least partly needs an understanding of the domain. To be creative the understanding of principles, “know why” is needed. Questions are answered differently whether the source of know-how is experience only instead of understanding and know why by means of causal models. Attempts to programme universal problem solver systems were not successful up to now. This is where humans are good if they are well educated, but this is expensive. To build systems that use big data as a source of experience - a purely data driven approach - is comparably cheap. Since the answers of big data type deal primarily with statistics but are based on a really huge set of experiences, the results will often conceal the fact that we deal primarily with statistics. But then, we may have to pay another price. We may lose the “Know Why” that has led in the past humankind to foster innovation or even “innovative jumps”.

The big data approach with statics is not much different from where we have been generations before. Knowledge was to know how - build on the experiences of the past. Master-builders for example had not known exactly why a specific way they built up houses made them stable, they only knew how to build that way. Human development followed the path from empiricism to qualitative reasoning, from correlation to causation. The new KBC-systems based on big data now offer the opportunity to make much more experienced decisions than any humans of today or before, since the experience base is much bigger and contains information and documents that have been developed due to “know why” kind of knowledge. But those systems do not have implemented this know why explicitly, it is implicitly hidden or contained in the sample space of information and documents.

Running with machines

The trends described offer an interesting approach for combining two kinds of knowledge, thereby leaving time for human involvement for some time to come. Obviously the best solution would be the combination of the deeply experience based capabilities of analytics

and the cognitive capabilities of a highly educated human. One question is whether this will be accepted under market conditions. Erick Brynjolfsson and Andrew McAfee suggested in their book “The Second Machine Age” that we have to learn to race with the machines that way by adding intuition and creativity to the capabilities of new developments driven by big data (Brynjolfsson/McAfee, 2014). Tailor Cowen in his book “Average is over” predicts freestyle teams where the humans’ add on could be specific know how to best use and connect several systems to get the best results (Cowen, 2013). Levy and Murnane (2013) name it “Dancing with robots”.

At a first glance, these predictions seem to be reasonable. If markets and employers demand best solutions, those who can offer them would have best opportunities to benefit. A question is whether quality is always measurable. Real life is not equal to games like chess. In games like chess freestyle teams can proof to be able to beat stand-alone computer systems playing against them. In real life it cannot be tested for example whether a diagnosis and a proposed therapy of a freestyle medical team with a physician and a computer system is better than that of stand-alone physicians or a machine.

This raises the question whether humans are willing to take over responsibility when overriding the suggested decision of a machine. Instead of leading us into a future of human-machine collaboration the future could be a totalization of empiricism, a “dictatorship of data” (Mayer-Schönfeld/Cukier, 2013). An example showing the big danger that lies in such a science of prediction and action based on mathematics and correlation is the complete failure of modern economics before and in the aftermath of the outbreak of the current global crisis in 2007/2008. Risk management in investment strategies is already a partly quantitative approach. Rating agencies do not take over the accountability for their ratings, they see it as “recommendations”.

The proposal that humans have to team with machines is based on the observation that big data and analytics are a breakthrough into former mainly human domains of decision making. A prominent example is the IBM Watson project, already mentioned. This

machine has successfully combatted the two most successful champions in the TV game "Jeopardy". Brynjolffson and McAfee (2014) discuss the fact that the combination of experts and machines is performing best. Machines take over the task of detecting patterns in big data to suggest a decision. Experts use information and creativity to find new ways and solutions to complement the machines ´ capabilities. Humans may also take over responsibility for action. This would be the combination of the best of two worlds. What they also argue is that not everybody would be able to run with the machines.

Since a high level of education is needed (STEM, science, technology, engineering, mathematics) and the special capability of being innovative through creativity, MGI (2011) makes the point that these people need mathematical talent. Those humans who learn how to run with the machine could profit from the new innovative technologies. Other people might fall back. In consequence, those who do not have a chance to be in high-paid segments of employment will be joining a growing class of people competing for those jobs that do not need a very high education.

Cowen (2013) is arguing quite similarly from the perspective of the evolution of computerized chess. Currently, even chess software implemented on smartphones is strong enough to beat any single technology unsupported human chess player. In so-called freestyle chess competitions the combination of several computer systems together with one or a team of humans performs best even against other chess-playing computer programs. The experience shows that those humans in freestyle teams do not have to be high-level chess players by themselves. Their specific know-how is about weaknesses and excellence of all the specific computer systems and how to work with them fast and flexible. They use outputs of systems as an input to other systems, varying and filtering the results. In that way, a network of computer systems is used to derive a viable proposal for the next move to be done in the running chess play. All these computerized decisions are based on big data and analytics, motivating Cukier and Mayer-Schönberger to suggest that we have to perform a societal change in our principle thinking "***from causation to correlation***" (Cukier/Mayer-Schönberger, 2013).

This is why one could expect that computer systems like Watson will prove to be at least as good as any human physician in diagnosing a disease based e.g. on different kinds of images and vital data. One has to make the point clear that this would be true within the big data about all cases of the past, since this is the sample space on which the decision function is the best approximation. If something is different, it could be that the proposed decision does not fit. This should be seen as quite similar to what happened in the financial markets. Option pricing models and risk management are also already based on the techniques that are applied in big data and analytics. They are based on correlation analyses on quite huge amounts of data about the past.

The experience of the last years showed that Nassim Taleb is right when he made the point that black swans do exist (Taleb, 2005, 2010). Taleb ´s point is that any kind of correlation analysis based decision assumes that statistical distribution patterns are adequate models of the reality even in the future. And this assumption is the reason why something could happen that is unexpected but could have severe effects. In the financial markets an example has been the unexpected decline of most stock prices at once. In medicine, it could be the case that the vital data and images used as the basis for diagnostics is not enough to make a right diagnosis. Following the argumentation of Brynjolfsson/McAfee and Cowen, the best solution would be a combination of machines and humans (Brynjolfsson /McAfee, 2012; Cowen, 2013). A professional high-skilled physician with creativity and intuition and the personal interaction with the patient could overwrite the proposed decision by the machine. Those humans, teaming with the machine and taking over the accountability for the decision, have to be high-educated. There are skills necessary far beyond a data-focussed part of science, technology, engineering & mathematics (STEM) to enable people to detect in advance, “ex ante” those “Black Swans” via qualitative reasoning instead of quantitative reasoning. Huge and multidisciplinary know how and know why is required.

And as a further requirement, the regulation of responsibility and accountability is necessary, to enable people to “override” machine and correlation-based decisions in

situations where qualitative reasoning or even – what could be named – creativity or intuition contradicts statistical evidence, where causation contradicts correlation.

V. POLICY CHALLENGES

On the route into the future – what is our reference point?

In this paper, we analysed the impact of data-driven automation and analytics on employment and equality across the economy, with a discussion on the potential implications for income inequality. We did this as part of a contract with OECD, aiming at scientific and analytical input into the OECD project on “Data-Driven Innovation for Growth and Well-Being".

Wellbeing criteria and OECD´s Better Life Index

This OECD project is to be seen against the background of one of the most important technological breakthroughs and innovation processes of human history, namely Big Data and analytics and always improved machine intelligence. This innovation line obviously carries a great potential for a better future of humankind in a world of great troubles and unsolved development challenges. The question is what are the principal aims of the global society? This addresses the values and societal aims that are important for humankind. With the OECD prospect of green and inclusive growth, which is related to similar UN positions, the route to take seems clear: we want free markets, high standards of living for all and sustainability, requiring clear ecological and social-cultural regulations for global markets. The OECD Better Life Index gives a good indicator set of what to achieve (OECD, 2013d).

Peace, human rights, freedom for all, cultural diversity, overcoming poverty and, above all, sustainability are major criteria to judge future developments, as is the wellbeing of all people. We take this as a background for our argumentation. The possible role of BIG DATA and analytics for our future has to be followed in this context. Obviously, there is

huge potential for positive contributions, but also certain obvious risks. These concern, among others, job opportunities, political power and freedom of information.

Box 12. OECD´s better life initiative/index as reference

Obviously, there is a close connection between achieving human rights, a sustainable development and dealing with other global challenges and the OECD´s Better Life Initiative, which was launched in 2011 on the occasion of the 50th birthday of the organization. The OECD Better Life Initiative aims to promote "Better Policies for Better Lives", which is in line with the OECD's over-arching mission to improve the economic and social well-being of people around the world. In our time measuring well-being and progress has found its way into the heart of many national and international statistical and political agendas. One pillar of the Better Life Initiative is the Better Life Index, a composite index of well-being.

The OECD Index composes of two dimensions of well-being, ***material conditions*** *and* ***quality of life****. The fields looked at to measure the material conditions are:*

- *Income and Wealth*
- *Jobs and earnings*
- *Housing conditions*

The indicators to measure the quality of life are:

- *Health Status*
- *Work-Life Balance*
- *Education and Skills*
- *Social Connections*
- *Civic engagement and government*
- *Environment Quality*
- *Personal Security*
- *Subjective Well-being*

When discussing "The Role of Data in Promoting Growth and Well-Being" one has to consider the impact of Big Data and a further digitization of the society in many fields being looked at when composing the index of well-being. Those fields are e.g. income and health, jobs and earnings, work-life-balance, social connections and subjective well-being.

The following consideration seems to be crucial: When referring to values and criteria, we should also take the troublesome observation into account that humans, organizations, companies and, in particular, global fora are very good in formulating reasonable principals – but what really happens in the world is often something very different. The Millennium Development Goals (MGDs) from 2000 aiming at the period 2000-2015, which have been signed by all states and all international intergovernmental organizations, are a good example. The MDGs sound impressive; however, most of the aims were not achieved. And if they were officially achieved, this was often more a consequence of tricky statistics than of the Millennium process as such. So, the world needs more than insightful declarations – it needs global governance for green and inclusive growth, it needs a global green and inclusive regulation of markets. This has to involve enforced environmental constraints and guaranteed social minimal standards for all, worldwide.

Inclusiveness / balance concerning income

Of great importance within the list of criteria in the better life index is, with respect to our study, balance with regard to income distribution. (There is also a relation to the wealth distribution, but this is more indirect). The issue of the right kind of balance in income concerns the so-called “efficient inequality range” (Cornia and Court, 2001). There should neither be too much inequality concerning income (and property) nor too little, where the (appropriate) concentration of property, for obvious reasons, will be much higher than of income.

In the present world, participation of humans within our societies very much depends on having a good job with good remuneration. This is only different for people who directly or indirectly have access to huge property. For simple logical reasons, that can, however, only be very small parts of society. So the job issue and the payment of these is of crucial importance for individuals in respect of their lifestyles, options available and choices. The same importance is obviously in place for all determinants of decent job opportunities and

high salaries for individuals. This is education, but also personal relations, health, outlook and others.

Unfortunately, job opportunities are limited, in particular concerning decent jobs. Because for simple mathematical reasons, only small groups of people can have really attractive incomes, i.e. several times the average. Or to put it the other way round: most people will, for simple mathematical reasons, earn much below average to allow few people to earn several times the average. Obviously, open market economies historically did not even deliver even quite limited jobs for everybody willing to work (meaning with paying at least 20 percent of average). Around the globe, there is even an enormous, totally unacceptable level of unemployment, while low-paid jobs dominate the picture. Particularly, for many people there is no employment opportunity available according to their qualification.

How to protect the environment

On top of the social balance issues, the environmental issue is of utmost importance, particularly the resource question and the climate issue, if we want a sustainable future. So, while we have to deal with this issue of social inclusion, we have to deal with the environment at the same time. But caring for the environment with the technologies we have may limit economic activity and growth and thus add to the loss of jobs.

The interesting consumer group called LOHAS, i.e. consumers with a high budget, following a lifestyle of health and sustainability, are an interesting consumer group that is influencing companies that are concerned with their public image, their reputation and, eventually, their licence to operate (Herlyn/Radermacher 2014). This might add to more environmental awareness and social inclusion. But this is along and difficult route as long as prices do not tell the ecological and social truth. This leads again to the issues of global governance for green and inclusive global markets or a green and inclusive economy. This is OECD´s general position (OECD 2011, 2013, 2013a, 2013b, 2013c, 2014a, 2014b).

This is argued for also by the Henry Jackson Initiative for Inclusive Capitalism (www.inclusivecapitalism.org).

The world needs growth – green and inclusive

We cannot accept an overexploitation of nature and unbalanced participation pattern, if we want a good future. If a good future is the aim, the income distribution has to stay within the so-called efficient inequality range within states, and even more between states.

For a reasonable future, for a balanced future, we need high worldwide growth over a long time. This is the position of the OECD and this is also the Club of Rome position on that issue. A reasonable future needs a considerable average growth over the next 40-50 years. This is needed for two reasons: One is growth of world population, which will increase from 7 to maybe 10 billion people. All these additional people come with basic requirements and individual aspirations. On top, the poorer parts of the world aspire, for good reasons, a much higher living-standard than they have today. So, sustainability has to be achieved under this constraint.

The role of leap-frogging for development

Therefore, we need growth and development, most of it in the developing world, and this growth must allow closing the gap, must allow developing countries to catch up and come closer to the living standard of the OECD countries. This is generally a topic that falls under the concept of leap-frogging. Leap-frogging means that countries in development, when they take over technologies, methodologies and innovations already in place in the developed world have a huge potential for growth. To achieve this and to make use of their options, they have to adjust available tools and technologies for their needs and also tailor their education systems and infrastructures accordingly. If they care for the right kind of regulation of their markets and if they can attract capital from all over the world,

they have a good chance to repeat the development the OECD world already went through.

Usually, such processes in poor countries start from becoming assembly lines for companies from abroad, as was e. g. characteristic for the rapid and most impressive development in China over the last decades. The Chinese experience powerful proves what is possible in this direction – however, with three specifics that should be taken into account in today's China: (1) a gigantic environmental problem, (2) a strongly building-up demographic problem and, as a quite unique feature of China's situation, (3) having the world's largest population and an outstanding cultural heritage with some thousand years of history.

If we want to achieve the mentioned goals, which are also goals of the OECD and which correlate positively with the Better Life Index, and if we take into account what we understand about globalization and the forces that are in place, and if we understand that neo-feudalization is an option as is collapse, if we understand with reference to Piketty's work that slow economic growth will mean that already existing wealth gets higher in importance and those on top of the wealth pyramid will even further add to their property, then it is clear what the world needs: It needs a balanced growth programme of considerable size, but this must be done in a way that, at the same time, the environment is protected, climate change is avoided in the sense of staying within the 2°C limit and that more social inclusion and thus balance is achieved - within states but particularly also between states, where today are the biggest gaps. Our own work with the Club of Rome suggests an average 4 percent growth rate, with a significant part being due to population growth. Most of the 4 percent will come from non-OECD countries because of leap-frogging and the growing population. Of course, companies and investors from OECD countries are massively involved in the process. The pattern reminds of the 1985-2005 period.

Future developments should thus lead to massive leap-frogging, should lead to a huge build-up of jobs and should allow workers in poorer countries to increase their earnings (in relative terms) much faster than the workforce in the rich world (inclusiveness of growth). It still also requires some growth in the OECD (e.g., maybe two percent).

More on balanced income

To put it the other way round, income distributions have to develop towards more balance as part of a good programme towards the future when sustainability is the aim. All this has to go along and can only go along with massive innovation in technology. We need new solutions, we need much better solutions, and these solutions must be much more efficient than our solutions are today. Higher efficiency means that new solutions enable us to do more with less resource input, namely producing more goods and services. This is an essential part of the required green character of such an economy. At the same time, we should also be able to get the "fruits" from these achievements to all people in the sense of a more balanced income distribution, also of a more balanced property distribution and of more inclusion. That is what markets should achieve. Certainly, we do not want the opposite that is more resource problems, more climate problems, higher concentration of capital, and a more unbalanced distribution of income – within countries and between countries. Nicely, BIG DATA and analytics can add to make the earning greener and more inclusive, but only under proper regulations, not with the markets as they work today.

Complete decoupling – a big challenge ahead

If the potential of BIG DATA and analytics can be unlocked, we can do things in less time, with less waste, with less time wasted. In a sense, we have a chance to massively increase the output of goods and services with less resource input and less negative climate effects (Radermacher, 2004; Radermacher/Beyers, 2007). All that could be the basis for a reasonable annual "CO_2-neutral" global economic growth (experiences from

recent years suggest something like four percent a year) that would be really helpful, given the challenges ahead.

In the best case, growth would not require to use more resources (von Weizsäcker et al., 2009; von Weizsäcker et al., 2014), it could be the dematerialization in total we want, a complete decoupling, which is an issue very high on the present agenda of the Club of Rome. More on that follows below.

If this could be combined with more people having more decent jobs, then also the social requirements could be met more or less straight forwardly. Hopefully, we could avoid rebound effects concerning social and ecological aspects of the equation studied. In the best of all worlds, we then could also have more inclusion, by machines helping less educated people in dealing with really "smart guys". That could lead to more balance. If these technologies even have a potential for boosting leap-frogging around the globe, then it would also be a tool for closing the gap between rich and poor, between OECD and non-OECD countries. We could thus be today, with the issue at hand, at a cumulation point of intelligent innovations of a technical nature that could move humankind exactly into the direction of a green and inclusive growth that is so urgently required.

Box 13. A huge potential for green and inclusive growth

There is a huge potential in BIG DATA and analytics for a balanced future and sustainable development. However, there is also a new and singular problem. A completely new form of rebound, maybe a singularity. A real challenge.

Big Data and Analytics (BD&A) have a big potential into the direction of green & inclusive growth of GDP

- *massive dematerialization of the production of goods and services seems to be possible with the help of new data-driven innovations and this would be a prerequisite for green growth*
- *everybody could become what could be named a "citizen of the cloud". That means a possible workforce inclusion of nearly 5 bn people in the working age globally today out of approximately 7 bn people in the working age population expected within the next 30 years.*

***BUT** BD&A could have also negative impacts.*

- *One problem to be mentioned is "total transparency".*
- *The problem concerning the impact on employment and equity is the possibility of a technologically induced unemployment.*

Having in mind that currently the number of employed people of the OECD countries is approx. 530 million, this number has to be compared to the possible workforce in the next 30 years of about 7 bn people.

VI. POLICY OBJECTIVES

The challenges described, resulting from new developments concerning BIG DATA and analytics, require a permanent and careful political observation. As green and inclusive growth is the aim, this is the yardstick to orientate politics. Since over the next 20 years job effects will be limited, a smart approach is recommended, dealing with the issues at hand, while preparing society for the future. In this context, a double strategy is particularly helpful that allows to deal with different futures to a considerable extent. Double strategy here means to prepare oneself for two futures simultaneously. While for twenty years, the present way to entitlements via jobs and always better education in the context of "Running with machines" and staying on top in the race between "education and technology" will work, things may be quite different on the long run. So while optimizing our own positions in the economy of today, in parallel we have to look into new forms of entitlement to put in place in later phases, if needed, i.e. in 20-50 years. Also then, we might try to be as close to the present scheme as possible, i.e. aim at higher education, develop creativity, strengthen and train the body and its sensomotoric capabilities, contributing to socially positive activities instead of going for simple financial transfers. So, this section describes also implications concerning required skills for the upcoming "racing against the machines".

What education will be needed from a job and future perspective?

What kind of education will help to be at the front of (1) being able to take over responsibility for proposals or decisions, (2) to have property related rights, (3) to be more attractive to customers than machines, (4) to beat machines, cost-wise, (5) to master excellent sensomotoric skills, (6) to benefit from superior creativity.

Looking into the six areas described in Chapter IV, where humans will be needed for a long time and cannot be replaced for the time being, have their opportunities, we might

draw some ideas, where to put emphasis in future education or where to develop respective offerings. What type of education will develop respective skills and further help to improve them in an ongoing process that involves lifelong learning in the "race between education and technology", as long as entitlements to income are coupled to contributions in jobs in competition with other humans and machines?

Obviously, people will need a broad education as a basis for life-long learning in the race described. A narrow education, trimmed to jobs needed at a particular time, is not the best basis. And to only have a short time to study to get into a job, neither. The issue is broad understanding of many subjects and a deep insight into issues. Understanding history, social and legal systems, legal requirements, humans and, on top, a lot of "hard" theoretical subjects such as mathematics, physics, chemistry, biology, geology, etc. will be required. On top, the power of fantasy and creativity have to be strengthened and trained. Actually, body and brain have to be trained and kept in good shape for decades.

Sensomotoric skills will become always more important. In this area, we will for a long time outperform machines. It is interesting to note that humans, given the impressive manifestations of intelligence of machines, are re-discovering their bodies. For a long time, abstract abilities were our way to distinguish from other animals. Now our bodies are the way to distinguish from intelligent machines. For the time being, we are still the best "combination" of abstract abilities and impressive sensomotoric skills living on this earth. For how long this will be the case is another issue.

We certainly should also be smart in social relations. Learning for life and for life-long learning is important. Certainly, family work, social activities to help others might become important, allow to develop global empathy, help society and might eventually also lead to entitlements, if today's kinds of jobs loose in relevance for humans (as they can be done by machines) and, possibly, working time in these fields will be massively reduced, while

requiring more participation in other fields, including family related “work”, mostly not paid today.

Data-related skills needed

For the foreseeable future, given the obvious importance and potential of data-related skills, and given the shortage of trained workforce, there is an interesting, though limited, field of job availability to be addressed.

Considering the needed permanent improvements of our data-related skills and the generation of employment opportunities in a world with a high demand for data-analytic contributions and insufficient supply, the following considerations might be helpful: Major issues concern the ability of modelling of subject areas, all kind of statistics and time series as tools to draw conclusions. Experts in the field have to know all about statistical tests and the role of stochastic dependence and independence, different behaviour of symmetric and skewed distributions, all kind of limit behaviour of distributions, random walks, correlation and fake correlations. Here, a broad education is needed and of help. However, maybe certain elements of personality also seem to play a crucial role. Consequently, though these job opportunities seem not to be open to all.

Studies to the issue of Big Data skills

Several studies have looked into the issue of the demand for Big Data skills (Forfás 2014, European Commission 2012, IDC 2012, BARC 2014, MGI 2011). MGI uses a reasonable differentiation that also has been adapted by Forfás (2014). They distinct categories of skills and competencies in three areas:

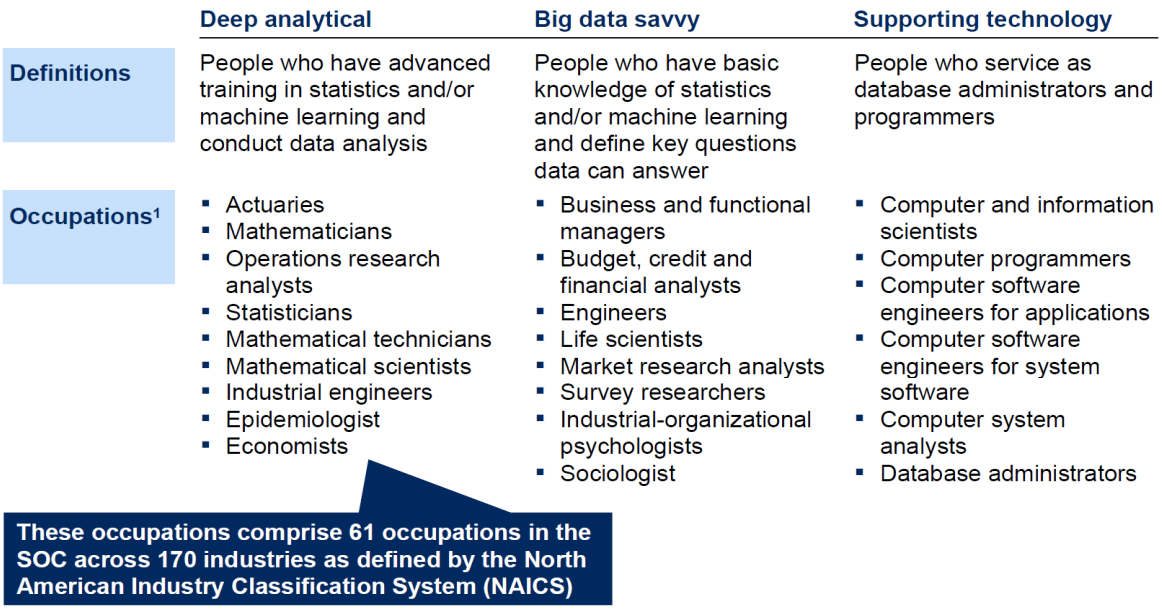

Fig. 5: *Big data talent grouped into deep analytical, big data savvy, and supporting technology (MGI, 2011, p. 134)*

For the US, MGI estimates 140,000-190,000 more deep analytical talent positions and 1.5 million more data savvy managers needed to take full advantage of Big Data in the United States until 2018. Based on statistics and the assumption of future continuity, for example with respect to replacements and new opportunities, they calculate these numbers for job opportunities exceeding the prospective national supply of adequately skilled personnel. The results estimate the need as a percentage of total employment as around 0.2 percent jobs requiring deep analytical talent, around 1.4-1.8 percent for savvy roles and around 0.4 percent for supporting technological professionals. An important point in the MGI study is that the high-paid job opportunities require talent, especially a mathematical talent (MGI, 2011, p. 104) *"developing deep analytical skills requires an intrinsic aptitude in mathematics for starters and then takes years of training"*. EC 2013 provides a very detailed analysis of skill requirements for different Big Data roles and projects a growing need for developers with very specific programming skills.

A recent OECD document about ´ICT, jobs and skills – Proposals for a Research Agenda´ (OECD, 2014c) figures out very similar findings in such a way that it is up to reasonable and timely political action against the "increasing concern that this process of creative destruction (Schumpeter) may have become unbalanced […]. This raises the issue of what policies, if any, should be implemented to correct this potential imbalance or, at least, reduce its toll on employment." (OECD, 2014c, p. 2). The findings in this detailed analysis confirm our view that ICT in general, with BIG DATA and analytics being part of it, "tends to be biased against low-skill workers and towards high-skill labour." (OECD, 2014c, p. 3), resulting in something that is called there "polarisation". For ICT in general, this report sees the middle-educated workers to be mostly affected by automation. We have described this with special emphasis on BIG DATA and analytics. Overall, this is an important topic that requires more specific analysis about the future impact of BIG DATA and analytics and data-driven innovation, especially with respect to the discussion of possible political reactions.

Unconditional basic income versus negative income tax

The following chapter deals with the situation that millions of high-level jobs may be lost due to technical obsolescence. If there are not enough opportunities for employment in value-added processes providing a fair share in participation through reasonable wages and due to natural limitations the question is whether employment could resist as a main basis of a social welfare system. What could society do in this case? Some authors argue in the direction which also the Club of Rome and the FAW/n take.

The mechanics of the economic system then has to be changed, so that people have access to a decent income, even if there is no (full) job for them, as we know it today. The one alternative would be to shorten work time considerably, but staying with decent incomes, essentially coming from taxing machines doing the work and taxing the use of resources. Of course, taxing humans and/or machines and/or resources has to take place in an

intelligent way with the aim to maximize growth (properly measured), while, at the same time, staying green and inclusive, that is to go for sustainability. There are many aspects to be considered. We argued above to stay in the present regime to the extent possible, whatever the future is to come. We might put emphasis on a broader education, developing additional abilities in creativity, train the body, be socially helpful, do more (paid) family work etc.

Concerning transfer of money, different proposals how this issue might be addressed are around, in particular unconditional basic income versus a negative income tax, all tuned in the right way. The following description goes more into detail.

As mentioned, the innovations and further developments in the field of Big Data and analytics might have severe impacts to employment and employability. Knowledge-based capital has a huge potential to substitute workforce. In addition, the potential to develop and supply new goods and services to the variety of value-added is constraint by ecological limitations and resource efficiency. Immense innovations are necessary if a growing GDP should not lead to a further overexploitation of natural resources.

Largely up to now, advances in technology have always significantly increased productivity. This means that the production of goods and services could be performed in large quantities with increasingly less labour. Yet, in the countries of OECD where the most production and consumption of the total gross domestic product takes place, unemployment is already a major problem. The amount of potential employees will grow for several reasons; including the number of women due to the success of efforts for gender-equality and advances in health care leading to longer life.

Both of which meaning more people must be employed longer as long as the fundamental basis for potential and fair shares in value-added for consumption is employment. There is in consequence the challenge to guarantee a fair participation for the future through the necessary social innovations. An option for future fair participation would be a basic income as it is already discussed since decades with different approaches. One approach is

via a so-called negative income tax as proposed also by Milton Friedman (Friedman, 1962). One could see the earned income tax credit in the United States as an implementation going into this direction. The problematic with a negative income tax is that employers could unintendedly misuse it by lowering wages. Another problematic is when only those employed are granted or the amount is set low to force people into employment, because many people then are not included. The latter aspect has to be reflected in light of the argument of technological unemployment as a consequence of further innovations.

An alternative approach would be an unconditional basic income paid to everybody either employed or unemployed. Its amount would reflect a nation's threshold definition not to be categorized as poor. In Europe this threshold is defined as 60 per cent of the median income. Everybody should have a guaranteed purchasing power to access a fair share of added value for consumption even without the force to become employed. From a global perspective, the argumentation could alternatively come from a view point that every human being should have an access right to natural resources as common goods (Solte, 2009). These access rights could translate to a guaranteed share of value-added where its volume could depend on the global resource efficiency of production. This is one way to combine the green with the inclusive side of the economy.

An unconditional basic income seems to be the most appropriate solution to provide a guaranteed participation and it could be implemented with minimal bureaucracy. If its amount is set reasonable and fair, it could replace all other kinds of social benefit systems. The job markets would remain attractive for those, employable and striving for a higher participation level. This is because higher incomes give more options in life and because the jobs themselves might be rewarding, as is the case with many jobs today.

VII. POLICY RISKS AND OPTIONS

What can we, what may we expect from the future?

When OECD looks into the Big Data and analytics topic, a major question is how these technologies might influence our future. Asking this, we might also ask what futures are ahead, what should we be prepared for and how is the influence of Big Data and analytics on the future outcome? The authors, for a long time, are dealing with these issues in the context of globalization, sustainability and future (Radermacher, 2004; Radermacher/ Beyers, 2007/2011; Herlyn, 2012; Solte, 2001, 2009; Kämpke/Radermacher, 2014). This work is closely related with the debates within the Information Society Forum of the EU some 15 years ago (ISF 1998, 2000) and also linked with the work of the Club of Rome since 1972. Concerning the future, there is in particular the issue what will happen if we don't make it with a balanced world, if we don't make it with a green and inclusive economy? What are the alternatives to look at? Essentially, there seem to be two alternatives (Mesarovic et al., 2003; Randers, 2012; Piketty, 2014).

Ecological collapse

One issue is whether we will end up in an ecological collapse or not, probably as a consequence of massive climate change. The ecological collapse is, apart from wars, a global pandemia or other "horror scenarios", one of the most nasty futures imaginable. If it happens, it will put the world under enormous stress in trying to cope with the consequences of e.g. climate change. Hundreds of millions of people might get into substantial, if not existential problems, many people will die before their time has come, the world will essentially be occupied dealing with disasters. In the end, such an ecological catastrophe may lead up to civil war and failing states. It will have a global social catastrophe as a consequence.

A possible neo-feudal future

To avoid an ecological collapse, an option would be to exclude people from the use of critical or scarce resources, to make it impossible for people to add further strain to the environment, to make it impossible to add to the climate problems. Those with access to the scarce resources could stay at their high level of consumption. If there is no route to balance, this is essentially a route in which the ecological problems are solved to a great extent by social degradation. This kind of future is called a global two-class society or a neo-feudal society, which comes along gradually, starting with precarization. Actually, we are already on this route (Piketty 2014, Randers 2012). Of course, this is a very unpleasant future. But it has a considerable probability. This future is neo-feudal with respect to the whole world, leading to a global two-classes-society, a completely new phenomenon. This is because the social issue, up to now, has always been an issue within states, not a global one.

A global two-class society will mean massive draw-backs for the middle-classes of the OECD states. The OECD will be “on fire” if this is the route that humankind will follow. Still, there is a considerable probability that this will be the future. The issue at hand is at the heart of contributions by the authors since 20 years or more. We mention here the publications by Radermacher (2004), Radermacher/Beyers (2007) as well as Solte (2007), but also Gabriel Zucman’s work concerning “Tax havens and the hiding of property” (Zucman, 2013). The recent financial crisis added to this pattern, contributing to a shift of the world in-come and capital distribution to always higher concentration levels, i.e. towards a less balanced distribution (Piketty, 2014).

Obviously, the risks described have to be managed by an open market society that is green and inclusive. This should not be too difficult given the many positive effects of such a direction as discussed in international fora, among them also the OECD.

Conclusion

The emerging revolution of Big Data, analytics and eventually machine intelligence depicts one of the greatest breakthroughs in the history of innovation. While we successfully managed power, physical strength, energy and mechanics and outperformed human abilities by several orders of magnitude, similar phenomena might come up in the future in the field of intelligence, including in the field of robotics. In general, such an evolution has a great potential to improve the situation of humankind and support the way to a balanced and wealthy world with 10 billion people living sustainably by producing more goods and services with less resource use, eventually realized in an environmentally friendly and climate neutral way.

There is consensus in the OECD that a green and inclusive growth and a green and inclusive economy is to be aimed for. The principal question for OECD would be how to assure that the benefits which data-driven innovation and Big Data and analytics could have in that direction could lead to a balanced world. What are the most important political challenges that besides the fostering of the technological innovations have to be tackled right now to prevent a path into a two-class society?

In order to profit from the positive potential of data-driven innovation, we would, however, require a modified global market economy, which is green and inclusive. This is the position of the OECD, but it has to be implemented. This is missing up to now. At the moment, the major drivers, particularly the power and capital concentration will probably lead us into another direction. We might lose hundreds of millions of well-paid jobs due to technical obsolescence and not have alternative entitlements in place. A consequence will be greater social imbalance, an even higher concentration of capital and the gradual elimination of the middle class, due to disappropriation via technical progress / technical obsolescence. This time, for reasons we discussed in this document, new and better jobs in big enough numbers might not follow, particularly when looking beyond a 20-year

horizon. The race between education and technology might then be lost in this sense – which need not be a disadvantage, could even be advantageous, but only if politics is able to modify entitlement structures.

If things cannot be managed properly, this may add to a “neo-feudalization” of the world, a process already discussed from another angle in previous contributions of the authors, in the work of the Club of Rome and in the recent publication of Thomas Piketty “Capital in the Twenty-First Century” (2014).

Looking into the future of the BIG DATA issue, yes, there is a big potential for the kind of growth we need, inclusive (also in the global sense) and green (with extremely improved resource productivity). But societies have to be very careful in seeing what the effects of this technology are for employment and participation, freedom, individual data privacy rights, leap-frogging etc., particularly when looking more than twenty years ahead. Technology-induced massive losses of jobs might become an issue. This might be related to what is called “singularity”, but even staying somewhat below this level might already totally change the job situation. Policy then has to act to ensure a green and inclusive market economy. This is also the challenge today. Reasons for change would then be extended, because problems may grow – however, that can also be part of solutions, because politics needs great challenges to deal with it supranationally, as it recently happened with financial regulation, taxation and tax havens.

So, it may well be, that looking into history this time does not really help to understand what is coming when looking 20-50 years ahead, because we approach a tipping and turning point. There is a fundamental change ahead. For the first time in history machine intelligence may massively outperform humans in fields, relevant for having or not having job opportunities of analytical character. This change may require unconventional political measures if the aim is to keep the middle class in the OECD alive, to keep a certain social balance, to avoid a neo-feudal structure, a plutocracy, a society of oligarchs, controlling the rest.

All this is no argument, in principal, for not following the route to more use of BIG DATA and analytics. Because this route has so many obvious advantages that it is hard to argue against it. The point is to have risks ahead clear in mind and be prepared to modify the basic mechanisms of our economy system, if needed, and gradually. Eventually, the interest of the owners of capital may have to be synchronized with the needs of the 99 percent. If this should no longer be possible via the job market, other mechanisms are required. However, in a double strategy, we can stay for the job and education oriented system for quite some time to come, and even in the new paradigms envisioned. The instruments to be used would be a much broader education, more education in art and creativity, more emphasis on health and the body. Entitlements would be connected to education, less working time of the type we have today, instead more family type of work, work related to social concerns and to free creativity. And, maybe, more peace, less stress and more time to develop the soul and peace.

The key policy challenge would, figuratively spoken, be: we globally need a set of mandatory tournament rules, we globally need an adequate musical arrangement to effectively “run/dance with machines” in sustainable harmony!

All in all, we could add much to a better future under very different scenarios, but in any case, we have politically to be attentive and courageous, if needed. The aim is the future – green and inclusive – and technology, powerful as it may develop always more, is only a tool, not the issue itself.

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