Today is the future of yesterday; what is the future of today?

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Abstract - In the educational context, understanding the future is important for two reasons. First, we are educating people for future tasks, which need skills that are useful in the future. Secondly, educators have to be able to select the most promising tools and technologies to apply in their work. The problem is that there is no clear way to weigh the importance of the alternatives — what the real importance of a certain technology will be in the near future and especially in the long term. In our paper, we focus on analyzing selected technologies. Our approach applies the framework developed by the authors. The promising technologies are reviewed by a systematic literature study, focusing on and restricted to the information and communication technology (ICT) sector. The findings are classified according to their importance and the time span of their effectiveness. The question we answer is "What should every educator know about changes in technology?"

I. INTRODUCTION

Technological changes and progress in technology are enablers and accelerators for wider changes in our society and economy. Ultimately, the consequences are seen not only in products, but also in processes, business models, and common behavioral patterns. It is justified to say that now one of the biggest change factors is information and communication technology (ICT). We do not wish to underrate other fields of technology, but in everyday life, the changes made possible by ICT in particular can be perceived the clearest. Forecasting is the highest level of being prepared for the future — especially if the prognoses are accurate. Having forecasts provides us with the means to be proactive — prepared in advance for situations that happen, or also preactive — having the means to affect in advance the alternatives that may happen.

For educators, understanding the future is important because they are educating people for future tasks (the "product" we are producing), and because they have to be able to select the most promising tools and technologies to be applied in their work (the optimal process and environment to "produce our product"). Both of these aspects are changing just as fast as the surrounding society.

The aim of the paper is to build a synthesis — not complete (which is actually not possible at all) but a list of a variety of technological changes that are worth recognizing now. The research question handled by our paper is "What should every educator know about changes in technology?" Our approach applies the principles of the Technology Change Analysis and Categorization (TCAC) framework introduced by Jaakkola et al. in [1]. The material used in the analysis covers the publicly available technological forecasting sources that are the best-known and most referred to. In spite of the fact that the material covers a limited scope of sources, we consider the picture it gives to be relatively reliable.

We have approached this study topic with two papers (Figure 1). The principles of the analysis method were introduced in Paper I [1]. The aim of the present paper (Figure II in Fig. 1) is to apply the method in ICT-related technologies and to give a synthesis — a list of the technological changes that are worth recognizing now (ICT Change Analysis and Categorization — ICA).

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Figure 1. Structure of the problem solving — two interconnected papers.

The research question handled by our paper is "What should every educator know about changes in technology?" The time span of our analysis covers mainly the next five years, but related aspects with a longer time span are also discussed. We selected this split approach to separate method development and its application from each other and provide the means for a deeper discussion than only one paper allows. We urge the reader to study both of these papers.

Figure 2 introduces the principles of the TCAC framework. It also reflects the structure of our paper. The method is based on Paper I [1]; the details can be found there.
II. WHAT WILL OUR NEAR FUTURE BE LIKE?

The main purpose of writing this paper is to make a review of the ICT-related technological changes that are relevant today. We specified the research problem to be discussed as “What should every educator know about publishers as the dimensions. Every topic area is analyzed by the ICT technologies for 2017; this search is published and visualized in mind map format. This step allows the researcher to separate the hype effect from the changes in technology discussed as “relevant today. We specified the research problem to be a systematic literature review. Section 6 concludes the paper.

The starting point is data collected on the study context (in our case ICT-related changes) — Step 1. Two methods are used to analyze the data: hype cycle based analysis of pre-embryonic technologies to understand the delay of their commercial appearance, and life cycle model based analysis to understand the life cycle and renewal power of the technology analyzed — Step 2. There is also an arrow between the hype cycle curve and life cycle curve. Since the hype cycle represents the pre-embryonic phases of the phenomena analyzed, it ultimately feeds the embryonic phase of the life cycle analysis; pre-embryonic becomes embryonic provided that the exit (not valid for mass and commercial use) has not been realized before it. Finally, the changes are classified according to their importance in four categories — Step 3. This phase also includes “fine-tuning” the interpretations of the importance and effectiveness classes, i.e., to give them exact semantics. The result is the classification of the selected technologies (Publishing — Step 4).

The paper is structured in the following way. Section 2 covers the first step of the analysis method — collecting the material for further analysis and classification according to the principles of the systematic literature review. The findings are organized in table format, having topic areas and publishers as the dimensions. Every topic area is handled in detail in Section 3, which is divided into sub-sections according to the topics. Section 4 covers a summary of the classification of the findings. The results are published and visualized in mind map format. This section also validates our analysis method in a practical situation. Section 5 reflects the findings in terms of the education sector and gives answer(s) to our original research question. Section 6 concludes the paper.
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III. HELPFUL HINTS

A. General findings

A common finding in all the reports analyzed is the rising importance of artificial intelligence (AI) – either as it is but mainly embedded in a wide variety of products and processes (robotics, intelligent analysis, intelligent sensors, networks, etc.). Embedded intelligence is seen no longer as a support, but as an alternative for human work. AI beats human intelligence because of its ability to manage masses of information and repeat the same routines carefully time after time. AI also has an unlimited memory capacity that can be retrieved quickly in decision making, as well as the capability to store large masses of information either directly or by remote access.

B. Artificial intelligence and its Applications

Cognitive computing provides the means for “human kind of thinking” and machine learning (deep learning) for “human kind of learning” and adaption in new situations. virtual assistants (software based chatbots; conversational systems) are used in the role of service robots and advisors (Apple (Siri), Google (Now), Amazon (Alexa) and Microsoft (Cortana) are examples of such tools). The real electromechanical ro ots help or replace people in a variety of (simple) human tasks. Voice activated speakers (also called Smart Speaker Hubs, Voice Activated Speakers) are Internet connected virtual assistants that use conversational systems as a user interface to activate demanded services. Such speakers are available e.g. from Amazon (Echo), Google (Now), LG, Harman Kardon, Lenovo and Sonos. When the opportunity to use more versatile communication than before provided by the new user interfaces (speech, haptic control, augmented reality (AR)) is connected here, a robot (soft or hard) becomes a part of ordinary processes, both in business and in private life. In robotics, such sub-areas as wearable intelligence (intelligent materials), wearable robots (e.g., to support the disabled in their daily life), the use of avatars and surrogates to replace humans (digital twins; physical-digital integration) in certain situations, are recognized in the reviewed analysis. One of the special areas in robotics, which has a promising future, is microrobotics. This is based on nano particles (zero size intelligence) that are small in size and possible to use, e.g., in medical care, to provide (non-destructive) access to such parts of the human body that are unreachable in traditional human hand touch-based medicine. Appearance of artificial heart is also reported related to the field of medicine.

C. Data and Analysis

One key technology area of today is big data. Quantumrun reports on a study by IBM: Every single day human beings create 2.5 quintillion (10**18) bytes of data. Individual human-related data is produced in a variety of ways: cellphone signals, social media, on-line shopping, credit card usage, web usage, service usage, health wearables are all examples. The data may be open (providing open access) or closed (access restricted and controlled). Individual-related data has in principle a closed characteristic, but in increasing amounts is kept open by the agreements defined by the “data owners” (e.g., most of the social media services). Big data technologies are used to manage and handle large amounts of data, centralized and distributed, closed and open. An increasing amount of data is signal data (audio, video, mixed format) that provide an important source for data analytics – to an increasing extent in real time.

Several analysts have pointed out the importance of big data technologies to support medical care – a good example of this is the Watson medical diagnostics system. Their reports are also worried about data usage ethics and ownership of data. The terms digital ethics, digital cannibalism, digital feudalism, security attacks are found in the reports analyzed. All of these focus on questions of privacy and data security and the use of data (access permitted or not permitted). Adaptive security architectures (based on intelligent, scalable architectures or platforms) are seen as a solution. One specific area of data analysis was handled in the report of IEEE [18] – face recognition. This technology provides enormous opportunities for recognizing peoples face from raw data, both in live stream and especially in stored data. In turn it further increases privacy related problems; technology itself starts to be reasonable mature for mass use.

D. ordscape

“Robots and AI will take our jobs.” It is estimated that between 35 and 50 percent of jobs that exist today are at risk of being lost to automation. Repetitive, blue-collar type jobs might be first, but even professionals — including paralegals, diagnosticians, and customer service representatives — will be at risk. The problem is that the jobs that will remain will require high levels of education and creativity, and there will be fewer of them to go around. We need to start thinking about what kinds of jobs the rest of the population will be doing – those that are no longer employable in their traditional jobs. Life-long learning and transfer to new jobs is not an answer to this societal problem.

. User Interfaces

One sector widely referred to in the reports relates to new user interfaces. Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) are seen to be at the breakthrough point for the mass market and applications. Promising use of these is seen in entertainment, therapy, usage as a digital interface, integrated in a variety of daily life and business applications, teaching and training. Glaseless AR – 3D imagery, based on the Magic Leap AR technology (https://www.magicleap.com/) is also reported to be close to the embryonic phase. The use of audio-based interaction and natural language are a rising trend. This covers audio control, conversational systems, and real-time speech-to-speech language translation. Fold-up flexible screens start to be available for display purposes. Gesture-based and open-air haptic interfaces are mentioned as new interfacing technologies, as well as the rising importance of digital streaming as a replacement for traditional media distribution. The term “neurohacking” describes the technologies that are used to pay attention to the technologies that are used to identify the “inner signals” of the object – e.g., the signals from a human brain; the signals are retrieved from the brain connected sensors or
remotely by retrieving the electromagnetic signals produced by human body. It can be seen as a first step towards the computer – brain interface that can be found in the “innovation trigger” phase of the Gartner hype cycle (see details below in this paper).

. **Device innovations**

In the category of device innovations, the reports mention that autonomous interacting vehicles are close to being ready for mass use; these cover autonomous cars, robotaxis, and also fly robotics. Most of the reports also recognize the fast growth of electricity as the power source of cars. It is also expected that in ten years autonomous buses managing 3D driving will be reality – at least in restricted usage. 3D printing is seen as an ordinary, but fast improving application. Transfer towards application areas that are more versatile than at present is going on: printing of complete systems, bioprinting (printable bio materials), and printing of transforming objects (4D printing based on materials adapting in time and situation). The IoT (Internet of Things) is in its emerging phase and mature for early stage applications. Intelligent home and adapting space are based on improved (Wifi) networked sensors (as an application area of IoT) and the analytics of the data produced by them. However, it is seen to suffer from the *lack of seamless solutions* (standardized interfaces and commonly accepted development platforms). Drones (UAVs – Unmanned Aerial Vehicles) show a lot of promise. A wide variety of application areas cover assistance of human work, surveillance tasks, supervision tasks, distribution tasks, and a variety of commercial tasks. A new sector of flight traffic control is also needed to control and guide the drone traffic.

. **Eye Technologies**

The reports list several key technologies. The fast growth of the *internet* – both its use and its transmission capacity – is maybe the most important of these. The trend towards *mobile* (mobilization of the 4th billion of the world population) and wide coverage (Internet everywhere) relates to this issue. Fast transfer towards *cloud* architectures will continue; cloud-based ICT infrastructure is becoming mainstream in companies. Simplifying (standardized) cloud platforms are awaited. In the data management area, the transfer toward NoSQL (non-structured) data handling provides opportunities for new data-oriented applications, as well as *local* chain technology. In addition to digital currency, application areas related to the latter cover wide opportunities in distributed trust creation (smart contracts, distributed ledgers).

. **Process and Business landscape**

The benefit of technology innovation is ultimately achieved only if it is adopted in *daily actions* and in *business processes*. Many of the reports point out the important role of the *user and consumer*: Customer satisfaction, customer experience, fast time to market, on-demand based services, customization, digital services, and combining virtual and physical experience are the factors mentioned in the reports. People live in a *hyperconnected world*, in which social presence and *experience sharing* play an important role. The transition from face-to-face communication to the use of virtual communication channels is accelerating. New phenomena appear (AR-based games like Pokemon Go), new jobs are created (bloggers for example), and massive messaging – an increasing amount based on video – are an essential part of the current lifestyle. Everything can be shared almost in real time; nothing remains a secret (if so desired, sometimes even when that is not the case). *Characteristics of business* are changed by the opportunities provided by technology. New businesses are born and some exiting ones disappear. The IoT is seen as changing business processes. Future companies are a part of an *intelligent digital mesh* which implements the idea of Connected Intelligence Everywhere. It applies data science technologies and allows the creation of intelligent physical and software-based systems that collaborate as a member of the digital mesh (a term introduced by Gartner). The use of AI in operations and big data in management increases productivity. The concept of product is changing: digitally enhanced products and services provide new experiences for customers, increasing their satisfaction and diversifying their experience.

. **Managing System Complexity**

As business is to an increasing extent based on networking, even the systems used to support business implement the same idea. Instead of large monolithic information systems, the future is for solutions that provide *open interfaces, modular structure, and versatile interoperability*. These can be called *complete systems of systems*. The role of widely accepted and applied frameworks – *development platforms* – is growing. These are used to structure and *layer* the complexity following generally accepted principles. They also guide development experts to use the right architectural components in system implementation. The practical implementation of system components partially remains the responsibility of end-users (casual programmers). Expert work focuses more on conceptualization and structuring (new skill profile).

. **Mobile Data and Internet Traffic**

The future of the telecommunication landscape can be envisaged based on two reports by Cisco [5; 6]. These reports provide a wide detailed view of the progress during the next five years. In this paper we provide a very general synthesis and encourage the reader to study the reference reports in detail. There will be a rapid transfer from traditional (wired) Internet traffic to *mobile*.

Global *mobile data traffic* in 2015 reached 3.7 exabytes \((10^{15})\) per month; in 2020 it is expected to be 30.6 exabytes. The *traffic* has grown 4,000-fold over the past 10 years and almost 400-million-fold over the past 15 years. More than half a billion mobile devices were added in 2015; *smartphones* accounted for most of that growth. The total number of smartphones will be nearly 50 percent of global mobile devices and connections by 2020 and will transmit four-fifths of mobile data traffic. Global mobile devices and connections in 2015 grew to 7.9 billion and are projected to grow to 11.6 billion by 2020 (exceeding the world’s projected population for that time of 7.8 billion). By 2020, aggregate smartphone traffic will be 8.8 times greater than...
it is today, with a CAGR (Compound Annual Growth Rate) of 54 percent. Annual global IP traffic (wired and wireless) will surpass the 1 ZB (zetta, 10**21) threshold in 2016, and reach 2.3 ZB by 2020. Its CAGR is calculated to be 22 percent from 2015 to 2020. *Traffic will exceed C traffic* by 2020. Smartphones will account for 30 percent of total IP traffic in 2020, up from 8 percent in 2015. In general, traffic from wireless and mobile devices will account for two-thirds of total IP traffic by 2020, wired devices 34 percent. There will be 3.4 networked devices per capita by 2020. Globally, IP video traffic will be 82 percent of all consumer Internet traffic by 2020. Virtual reality traffic in 2015 was 17.9 PB (10**15) per month; it will increase 61-fold between 2015 and 2020, a CAGR of 127 percent. The recent issue of IEEE Spectrum [18] reports a study of a daily usage profile of selected applications in one day period (July 11th, 2016): 33.4% Pokemon Go (AR), 22.1% Facebook, 18.1% Snapchat, 17.9% Twitter an average Iphone user spent; this confirms the fast growth of AR traffic also in real life.

Summarizing the numbers above indicates exponential growth both in total IP traffic and especially in mobile traffic. The transfer toward more intelligent and mobile devices is clear (more it isation), and the exponentially growing amount of users and increasing complexity of the data format (video, AR) is also clear. Network operators are responding to this by providing faster transmission technologies. The figures also confirm the findings discussed above in the forecast analysis part of this paper.

. The Appearance and Speed of Changes

Gartner publishes an annual technology forecast in the form of “The Hype Cycle of Emerging Technologies.” It provides a good overview of the expected changes in the time span from two to over 10 years; innovations are classified in five categories according to the delay in reaching the “Plateau of Productivity.” The Hype Cycle 2016 is given in Fig. 3 [15].

Figure 3. Gartner Hype Cycle of Emerging Technologies 2016 [15].

The Hype Cycle distills insights from more than 2,000 technologies into a succinct set of must-know emerging technologies and trends that will have the single greatest impact on strategic planning. These technologies show promise in delivering a high degree of competitive advantage to organizations over the next five to 10 years. The technologies included in the hype cycle also summarize (partially) the earlier analysis given in this paper, and put some of the findings in the right position in the time span. Since the same analysis is published annually, comparisons between years also provide valuable information for the reader about the progress and changes identified. One good example of radical changes in the analysis relates to “big data,” which was located on the 2014 cycle in the “Trough of Disillusionment” with a time span of 5-10 years. In the 2015 Cycle, it had disappeared with the comment “Big Data is out, Machine Learning is in.” Instead of total disappearance, the phrase indicates the importance of AI as part of analytics, rather than the data itself, which is seen as an ordinary part of a variety of technologies.

The 2016 report indicates that technology will continue to become more human-centric. It will introduce transparency between people, businesses, and things. The evolution of technology is becoming more adaptive, contextual, and fluid within the workplace, at home, and interacting with businesses and other people. Critical technologies include 4D Printing, Brain-Computer Interface, Human Augmentation, Volumetric Displays, Affective Computing, Connected Home, Nanotube Electronics, Augmented Reality, Virtual Reality, and Gesture Control Devices. *Smart machine technologies* will be the most disruptive class of technologies over the next 10 years. Enablers for this progress are the radical growth of computational power, near-endless amounts of data, and unprecedented advances in deep neural networks. Smart machine technologies harness data in order to adapt to new situations and solve problems that no one has encountered previously. The following technologies are seen to play key roles: Smart Dust, Machine Learning, Virtual Personal Assistants, Cognitive Expert Advisors, Smart Data Discovery, Smart Workspace, Conversational User Interfaces, Smart Robots, Commercial UAVs (Drones), Autonomous Vehicles, Natural-Language Question Answering, Personal Analytics, Enterprise Taxonomy and Ontology Management, Data Broker PaaS (dbrPaaS), and Context Brokering. The shift from technical infrastructure to ecosystem-enabling platforms is laying the foundations for entirely new *business models* which are forming the bridge between humans and technology. Organizations must proactively understand and redefine their strategy to create platform-based business models. The key platform-enabling technologies include Neuromorphic Hardware, Quantum Computing, Blockchain, IoT Platform, Software-Defined Security, and Software-Defined Anything (SDX).

The paragraph above explaining some details related to Fig. 3 is quoted from the original source with minor changes and modifications.

IV. SUMMARY OF CHANGES IN ICT

The purpose of TCAC framework Step 3 is to classify the changes analyzed in four categories: *incremental changes*, *radical changes*, *Changes in technological systems* and *Changes in paradigms* (explained in Paper I; Jaakkola et al. 2017) to enable the publishing of the results (Step 4). Figure 4 summarizes the technology analysis discussion of this paper in the form of the ICT Change Analysis and Categorization (ICAC) framework.
The classification may cause criticism – we accept that. The approach is partially subjective. However, it reflects our experience-based findings. Our aim is first to provide an expert opinion for those that are interested in the topic. Secondly, we want to provide a tool for applied use for those who are ready to do this kind of.

How to benefit from the analysis? This is the subject discussed in the following section.

V. HOW DOES IT AFFECT THE EDUCATION SECTOR?

At the beginning of our paper we promised to answer the question “What should every educator know about changes in technology?” The answer can be divided into two parts – effects on the education process itself, and effects on the goals of education from the content point of view.

The education process part is the easier sub-question to answer. Every educator should recognize the current situation and be prepared to use tools and technologies that support the study goals in the best way and suit the selected pedagogical approach. An additional aspect that must be taken into account is the audience, i.e., students. Education must motivate them and take into consideration their built-in behavioral patterns. At the moment,

- students in higher education start to be members of generation (birth years that range from the mid-1990s to early 2010s; coming of age today); for the details of the generation classification see e.g. [3; 2]. Note: in different sources the year limits are varying a bit.
- the majority to generation (birth from the middle 1960s to the late 1970s; coming of age late 1980s to late 1990s) and
- the oldest to the generation known as $y$ oomers (birth from the late 1940s to the late 1960s).

Recognizing the age profiles is important. Every generation has its own attitudes and values, technical skills, attitude to work, goals in life, interests and basic (professional) skills inherited from their education and adopted through their life experience. The educational methods should follow the needs of generation Z, which can be characterized by the term “digital native.” They are used to the Internet, computers, mobile devices, network-based communication, etc. They are nomads (used to working independently of time and place) and the concept of time differs from that of the older generations. The ICT skills of non-generation Z are not native but learned and variance seems to be wide. Consequently, every educator – either digitally native or learned – should be aware of the opportunities that technology provides for education both now and in the future. Therefore, understanding technological changes is necessary. New media supported learning methods based on distance participation, the blended learning approach (mixture of videos, face-to-face classes, self learning), time independence, and the use of modern technology is worthy of consideration. Answers to the question “What and how to use?” can be supported by the findings of our analysis.

The content of education is a slightly more complicated aspect. The perspective in education is partially on today and partially on the future. The time span from studies to work varies between education levels. In vocational education the time span is close to today; the objective is to provide skills and readiness for immediate utilization. In contrast, in higher education, the utilization span is longer but forgetting the ability for short-term applicability is not
wise. We (university lecturers) are teaching the professionals of the future based on the knowledge and understanding of today. At all educational levels it is important to remember that even the skills for today must be adaptable to serve future needs. It means that education must provide permanent skills and knowledge that are independent of the changes in tools and technologies – skills that are renewable. In addition to practical skills, we have to be concerned especially about their theoretical foundations. As noticed in our technology analysis, human work will be replaced by robots. Intelligent chatbots, service robots and physical robots will be more productive and skilled in a variety of routine work – even in the work that needs “imitated” human intelligence. Current industrial automation has been the first step in replacing humans in assembly kind of work. Human-type robots, like Sony’s upper robot, are already in use, e.g., in some restaurants and hospitals in assistance work. Telepresence can be implemented by a surrogate robot (i.e., a digital twin) in situations where an interactive presence is needed to fulfill the goals of interactive work. A wide variety of robots are available on the commercial market (VGO, Giraff, Double, Kubi, AMY, TeleMe2; see e.g. https://telepresencerobots.com; https://telepresencerobots.com/comparison).

In the education sector, the key question is “What professions will we really need in the future?” New professions are born, old ones are disappearing, and the rest are changing as they adapt to changes in the environment. Now we have a high demand for data analysts. This demand is reflected in education: many universities have included the study topic in their curricula. Fortunately, many of these are focusing on developing analysis algorithms and tools, and providing expertise in development work of intelligent systems; this work will remain. Pure analyst work is disappearing; according to Gartner, 40% of the work of analysts is disappearing and moving to substance-area experts (citizen data scientists). The same goes for routine software development. Casual programming – programming work done by the end-users – is increasing. Routine software development work can be conducted by software robots, as a lot of other routine work in the software engineering area (testing automation is a good example, service support transferred to virtual assistants, etc.). In banking, customer advisory work is conducive to robots, as is investment advisory work. Fact and rulebook management is much more suitable for (software) robots than for humans. The whole banking branch is in the transitional stage. Slow, non-adaptable processes are being replaced by flexible intelligent automated processes that are available on a 24/7 basis, providing better (routine) services and freeing people up for more demanding work.

VI. CONCLUSIONS

The purpose of our paper is to analyze the changes caused by ICT-related technologies. We have followed the principles of our TCAC framework and reviewed a wide variety of technological forecast reports, analyzed their contents, classified the findings, and finally published the results in the form of a mindmap (ICAC). The aim is to act as guidance for educators in developing the content and structures of their courses and curricula.

The problem with technological forecasting is that finally, when we have found a good solution for everything, something unexpected happens: everything is sensitive to radical changes in our environment – the climate, political situation, etc., belong to factors outside our sphere of influence. Forecasting the future is no easy task; there is also a saying that neither is the forecasting of the past (what would have happened if we had selected an alternative path from the past to today; what would be our today then). One thing at least is sure; computerization in all its forms is continuing rapidly. A lot of tasks are done better and faster by computers: mathematical tasks, data management, combining information chunks to form knowledge, management of detailed data, understanding foreign languages, etc. It has been predicted that the computer-brain interface will become reality in around 10 years (still in the hype phase, however). We already have trials to transfer brain signal data for analysis by computers and interpretation as human feelings. This would be the first step.

What will be the kernel of human skills be in the future? Detail management and fast calculations are no longer so important. The world and systems are becoming more and more complex. We have to be able to manage the whole - modularization and interfacing the pieces to collaborate. It is good to finish the paper with the saying of Larry Page (CEO of Google): “The main reason why companies fail is that they missed the future”. So – be very worried!

REFERENCES
