HOW ARTIFICIAL INTELLIGENCE IS CHALLENGING ACCOUNTING PROFESSION

Eleonora P. Stancheva-Todorova

Faculty of Economics and Business Administration, Sofia University "St. Kliment Ohridski",
125 Tzarigradsko Shose Blvd. block 3, Sofia 1113, Bulgaria

Abstract

Recent developments in robotics and artificial intelligence and their applications have started to reshape our world, bringing it closer to what famous futurologists as Jules Verne and Isaac Asimov have predicted some decades ago. Many aspects of our lives are changing due to technological innovations. Businesses are now exploring new opportunities for raising profitability and return on capital ratio through revenue increase, cost reduction and new sources of value creation, trying to overcome the negative long-lasting effects of the World Financial Turmoil from 2007 - 2008 and aiming to become more competitive and sustainable.

The "artificial vs. human intelligence" dilemma widely debated among academics and practitioners, encompasses many controversial issues related to the future prospects of some occupations, the required new skill set and competences, the way humans and machines could work efficiently and effectively together.

Accounting profession is on its way to make a great change of the role it plays in the organization and the functions it currently performs. The proponents of artificial intelligence revolution view this development as a step-ahead and embrace the challenges of the future. The opponents, on the other hand, consider it a step-back as many accountants will fail to adapt to this new business environment and will drop behind.

This paper is aiming to discuss few of the challenges facing the accounting profession nowadays and to shed light on some possible trends of its future development in the artificial intelligence context. Some conclusions related to accounting education will be drawn from the perspective of the new intelligent technologies and their business applications.

Keywords: *artificial intelligence, challenges, accounting profession, accounting education*

1. INTRODUCTION

Nowadays we can hardly imagine our lives without artificial intelligence (AI) solutions. The self-driving vehicles have become real. Our smartphones can understand speech, complete words while text writing and provide advice in spoken language (Makridakis 2017). In fact due to the tireless efforts of computer scientists AI has seen tremendous progress. From Deep Blue, through Watson computer to AlphaGo and DeepMind, AI is improving due to deep learning algorithms and big data science. These last generation computers can teach themselves based on a "software writing software" principle (Parloff 2016, p. 3). Actually the AI concept dates back to the 1950s but many of the technological breakthroughs occurred later on in the 1980s and 1990s. As a term, AI is applied to any technique enabling computers to mimic human intelligence and encompasses machine learning and deep learning, being its subset (Parloff 2016).

The history of AI applications in the accounting domain could be traced back to the 1980s. An extensive research was conducted by academics and practitioners on AI application in auditing, taxation, financial accounting, management accounting and personal financial planning. The development and use of expert systems (ESs) in the accounting discipline is probably the most studied area (Baldwin, Brown & Trinkle 2006). ESs, considered as software programmes attempting to replicate human experts' behaviour and expertise, store human knowledge and experience and transform it into rules thus trying to solve accounting problems and perform some accounting tasks (Suton, Holt & Arnold 2016). Some ESs have been developed for analysis of accounting-based decision processes (O'Leary 1987). O'Leary

(2003) argues that early ESs have not lived up to their potential probably because their common feature was that they were based on logic, if-then rules and decision trees. They could make the same mistakes over and over again (Makridakis 2017) being incapable of learning. Beside these early, even quite primitive attempts for automation, stands accountants' everlasting willingness to improve efficiency and effectiveness of their work and deliver more value to businesses. The recent technological breakthroughs in AI are now opening a new page in accounting discipline refocusing the research from ESs applications to some new perspectives towards accounting practitioners: how could accountants benefit from the use of AI capabilities, what is the long-term vision for AI and accountancy, how will AI change accounting roles in the organisation (ICAEW 2017). This new generation of machine learning systems have great impact on economics and business but they are also bringing new life style and sociological side effects. The increase of unemployment is considered as one of the clear impacts (Dirican 2015) and accountants should be prepared for all the challenges of AI revolution.

2. HYPOTHESIS

AI systems will substitute accountants in some of their more routine functions as they can perform them faster and are more accurate than humans. Being a real thread from unemployment perspective, still there is a minimal risk of raising unemployment ratio among the profession, if accountants develop new skill set and competences related to their changing role in the organisation. The successful strategy will be to embrace the technological challenges and to adapt to the new business environment and management requirements. Humans and machines can work efficiently and effectively together and AI will never substitute human intelligence especially in the more creative work tasks. Education will play a key role for preparing accountants for this new accounting realm.

3. ARTIFICIAL INTELLIGENCE IMPACTS ON EMPLOYMENT

3.1 Will AI emerging industry uphold Isaac Asimov's Three Laws of Robotics?

It seems as if we have never doubted that despite the science fiction origin of the Three Laws of Robotics, they will always protect us from being destroyed by our clever creations. Their guiding principles robots never to harm humans and disobey their orders have been wildly accepted as an axiom, as a guarantee for the future of the human race. We can find many examples in the movie industry for scenarios with robots rising against men and Ridley Scott's Prometheus is probably a good one. David caught audience attention with his unscrupulous android nature. Our admirations for his AI were quickly replaced by perplexity. It seemed so easy for a robot to cross the red line despite these protective laws. Currently we are moving between our fears and futurologists' visions, trying to assess the risks of exponential growth of intelligence systems applications (Faggella 2016).

Stephen Hawking, Elon Musk and Bill Gates are probably the most cited distinguished men nowadays with their arguments against the risks inherited in AI technologies. We can hardly overpass their warnings about the end of humanity. Some of their advocates argue that the existential threat is real and it is possible humans to be superseded by robots in the near future. They will make better decisions, faster and free of bias. It seems that "singularity", the moment when AI will match human intelligence, stands for the moment when the grim ending of the mankind will begin (Kontzer 2015).

The esteemed British theoretical physicist Stephen Hawking warned us in an interview for BBC that "The development of full AI could spell the end of the human race". His message that "Humans, who are limited by slow biological evolution, couldn't compete and would be superseded" sounds like prophesy and echoes in many subsequent arguments and discussions (Cellan-Jones 2014). The basic point in Hawking's appeal is actually the AI great impact on unemployment.

Even earlier, the founder, CEO and lead designer at SpaceX and co-founder of Tesla, Elon Musk shared with the students at the Massachusetts Institute of Technology his fears that AI is a real threat for humankind's existence. Some years later, at the World Government Summit in Dubai, he explained one of the threads of AI domination, saying that "Humans have already started losing their jobs to machines"

(Sulleyman 2017) and new roles for those people should be figured out. In his opinion, the real problem is that the process of labour displacement is very quick and disruptive.

Rob Enderle, a well-known Silicon Valley analyst, a member of the Futurist Board and the Social Factors Board of the non-for-profit Lifeboat Foundation supports these AI concerns. According to one of the three scenarios, developed by the Foundation, AI will replace all humans' jobs, "resulting in global economic catastrophe, revolutionary war, famine and the like" (Kontzer 2015). His opponent Jeff Burnstein, president of the Robotic Industries Association, argues that the negative effects in this scenario are considerably exaggerated and they will be compensated to certain extend as the new AI technologies will create or enable new jobs. In fact this is exactly the economists' point of view.

3.2 What is the economic theory explanation about the AI impacts on employment?

According to the postulates of the classical and neoclassical economic theory, the technologies have a positive effect on employment as they increase companies' productivity by changing their work patterns and they create new job opportunities and types of jobs (Mensel & Tholl 2017). But these theories could hardly explain the Great Depression of the 1930s and more precisely its destructive impact on employment. The then-prevailing idea that full employment is automatically provided by the self-balancing mechanisms of the free markets couldn't interpret the worldwide economic collapse. As a response to the inadequateness of the contemporary economic thought, the British economist John Maynard Keynes, considered as the founder of the modern macroeconomics, introduced some revolutionary ideas by asserting that government should interfere through public policies to moderate the economic business cycles for achieving full employment. Keynesians believe that in periods of economic downturns the demand is inadequate because of the decrease in consumer spending due to uncertainty followed by less business investments and long periods of high unemployment. In their model of economic activity wages response to changes in demand and supply is slow resulting in large unemployment fluctuations. The only way to stabilise the economy is through government intervention. Because of the stagflation after the World War II, characterised with both inflation and slow economic growth, Keynesians' ideas were waned as they couldn't explain and offer an adequate measures for overcoming such discrepancies. The Renaissance of Keynesian thought came with the World Financial Turmoil from 2007 - 2008. The Harvard professor N. Gregory Mankiw stated for the New York Times that the only one economist who could help us to understand the current economic problems would doubtlessly be John Maynard Keynes. (Jahan, Mahmud & Papageorgiou 2014). But what about AI and how its effect on the unemployment patterns could be explained as technologies started to replace humans faster compared to what expected?

Nobel prize-winning economist Joe Stiglitz (2014) argued that innovations actually introduce an economic paradox. People who lost their jobs or suffered wage reduction due to technological innovations cannot save money and decrease their spending on goods which causes deflation. Capital owners become less inclined to investments that create new job positions due to the shortened customer demand. The dilemma is actually caused by the following interdependence – the more decrease in the demand side, the more efficiency in the supply side is needed in order to compensate the negative effects of the former (Dirican 2015; Hirst 2014). Companies are more inclined to continue with speeding up the innovations, stimulated by the upward shift in the money supply resulted in low interest rates. As an impact lower skilled workers will be replaced with high skilled employees and according to Stiglitz's survey (2014) the inequality between people and the level of unemployment will go above the socially desirable one.

The so debated economic paradox is not a theoretical idea that burst out from a beautiful academic mind. Innovations and AI in particular, are changing the economic patterns and societal well-being. And these effects have already been observed and investigated by the researchers. It seems that the modern economic thinking should reconsider some tents in the light of AI technologies and their augmented applications.

3.3 How AI will affect the labour markets?

Makridakis (2017) asked a critical question for the role people will play in the near future after AI substitute, supplement and/or amplify the tasks humans currently perform at their working places. He

argues that the future could be caught up by four polarised scenarios presenting four different perceptions about AI impacts on human lives, societal environment and labour patterns. The scenarios are presented in table 1.

Table 1. The four AI scenarios

Scenarios	General implications	AI impacts on employment
Optimistic (utopian)	• An era of nanotechnology, genetics and robotics; • People use to the highest possible extend computers' capacities; • Genetics enables changing of humans genes to avoid diseases and extend humans lives.	• Robots fully substitute humans at their work; • Humans spend their free time on leisure activities and work what they actually want.
Pessimistic	• Machines take control over the most important decisions; • Humans become endangered species; • Complex societal problems occur.	• Humans are reduced to second rate status and are fully substituted by computers; • People are not motivated to work and leave all important decisions to computers; • Full labour displacement by computers.
Pragmatic	• Control over AI technologies and their strict effective regulation; • People manage to stay a step ahead of AI.	• People exploit the power of computers and augment their skills and human decision making.
Doubting	• AI never become threat to humanity; • Computers never achieve human ability to be creative.	• In all tasks requiring creativity humans keep clear priority over the computers.

Source: Makridakis 2017, pp. 50 - 52.

Some ideas behind these four scenarios are quite provocative and probably a result of our fears and imagination. We can hardly assess the probability of their occurrence and test their objectivity but we will refer to some recently performed surveys aiming to shed light on some possible development trends of the labour market in an AI context. Our main concern is the existence or non-existence of a real threat for human labour displacement. Our review encompasses several surveys – "The future of employment: how susceptible are jobs to computerisation?", performed by Frey and Osborne (2013) and extended by Knowles-Cutler, Frey and Osborne (2014), Nesta's project report "Creativity vs. robots: The creativity economy and the future of employment" (2015), "Technology and people: The great job-creating machine", published under the head of Deloitte (2015) and the report "A future that works: automation, employment and productivity" (2017), which is part of the McKinsey Global Institute's research on how technologies influence and change business and societal patterns.

The research of Frey and Osborne (2013) refers to the US labour market and is aiming to examine how susceptible jobs are to computerisation. They defined three bottlenecks to computerisation and managed to link them with nine objective variables, describing the level of perception and manipulation, creativity, and social intelligence required to perform an occupation, as presented in table 2. The

variables were derived from a survey of O*NET – an online service, developed for the US Department of Labour. The unique pattern of the O*NET data, used as one of the survey's primary data sources, is the approach to define the key characteristics of an occupation as standardised and measurable set of variables and provide up-to-date descriptions of the tasks, specific to the occupation. Occupations were ranked according to the knowledge, skills, and abilities, required to perform them and categorised on basis of the involved tasks.

By implementing novel methodology Frey and Osborne estimated the probability to computerisation for 702 detailed occupations, using Gaussian process classifier and distinguished between high, medium and low risk occupations with thresholds at probabilities of 0.7 and 0.3. According to their estimate, 47 per cent of total US employment is in the high risk category to become automatable over a decade or two. Their findings show that substantial share of occupations in services, sales and construction businesses are greatly endangered to be substituted by computers which they considered to be in line with the recent documented technological developments, mainly in machine learning and mobile robotics (Frey & Osborne 2013, pp. 36 - 38). On the contrary, engineering and science occupations are characterised with low susceptibility to computerisation due to the fact that they require high degree of creative intelligence (Frey & Osborne 2013).

Table 2. Computerisation bottlenecks

Computerisation bottlenecks	**O*NET variables**
Perception and Manipulation	Finger Dexterity
	Manual Dexterity
	Cramped Work Space, Awkward Positions
Creative Intelligence	Originality
	Fine Arts
Social Intelligence	Social Perceptiveness
	Negotiation
	Persuasion
	Assisting and Caring for Others

Source: Frey & Osborne 2013, p. 31.

More surprisingly at first sight, the occupations of accountants and auditors are in the risky category as the probability of their computerisation in the near future is 0.94 (p. 69). These findings contrast to the research performed by Baldwin, Brown and Trinkle some years ago (2006). They argue that accounting tasks comprise of variety of structured, semi-structured and unstructured decisions and because of the risky environment and scarce information, auditing and assurance decisions and analysis could be categorised as unstructured. One of their conclusions is that because of the complexity and importance of many of the audit tasks AI applications in auditing are insufficient. The existing gap between business and accounting domains and computer science and AI domains should be bridged by means of more cross disciplinary research.

Further to their primary goal, Frey and Osborne analysed how wages and educational attainment relate to occupation's probability of computerisation. Their findings showed that there is a strong negative relationship between them. The model used in the survey predicted a change in the labour market polarisation trend towards computerisation being limited to low-skill and low-wage occupations only. Creative and social skills would become workers' guarantee for non-susceptibility to computerisation.

The results and trends derived by Frey and Osborne (2013) were reconfirmed by Knowles-Cutler, Frey and Osborne (2014), who extended their study to the UK labour market by using the same approach and methodology. They estimated that 35 per cent of UK jobs are at high risk of computerisation. An interesting conclusion relates to the education of the future and re-training of the current workforce. According to the researchers, the education system needs to adapt to the changing world by building the most appropriate teaching disciplines to service the demand for employees with "creative, innovative and tech-savvy skills" that will enable them to easily switch their jobs (Knowles-Cutler, Frey & Osborne 2014, p. 20). The rapid technological changes challenge the companies and require investments in continuous re-training of their current employees in order to keep pace with the rate of innovation applications.

In this context it is quite logically to raise the question about the future prospects of the accounting and auditing professions, considered in the risky category. For sure they require creative and social intelligence for performing some of the job tasks but there is also a variety of routine tasks that would be computerised due to the vast development of AI technologies. For instance more than 400 individual audit tasks have been identified as a result of a substantial research work. Because some of them are characterised as less structured as they rely on uncertain and incomplete information, they are considered as non-suitable for AI applications (Abdolmohammadi 1991). Accounting tasks also need such detailed analysis in order to distinguish the non-routine from routine ones. One important conclusion is that more AI solutions should be investigated for accounting and audit (Baldwin, Brown & Trinkle 2006) decision-aids in the current risky and uncertain environment. Despite such efforts, due to the complexity of the business world and the importance of accounting information for the management decision process, there is a minimal risk of raising unemployment ratio among the accounting profession because of high level of computerisation of its work tasks. Obviously the strong AI turbulence will bring some changes in the profession's role and functions. The successful strategy will be to embrace the technological challenges and to adapt to the new business and management requirements by developing new skill set and competences. And education system should play a key role in preparing the profession for this fast changing environment.

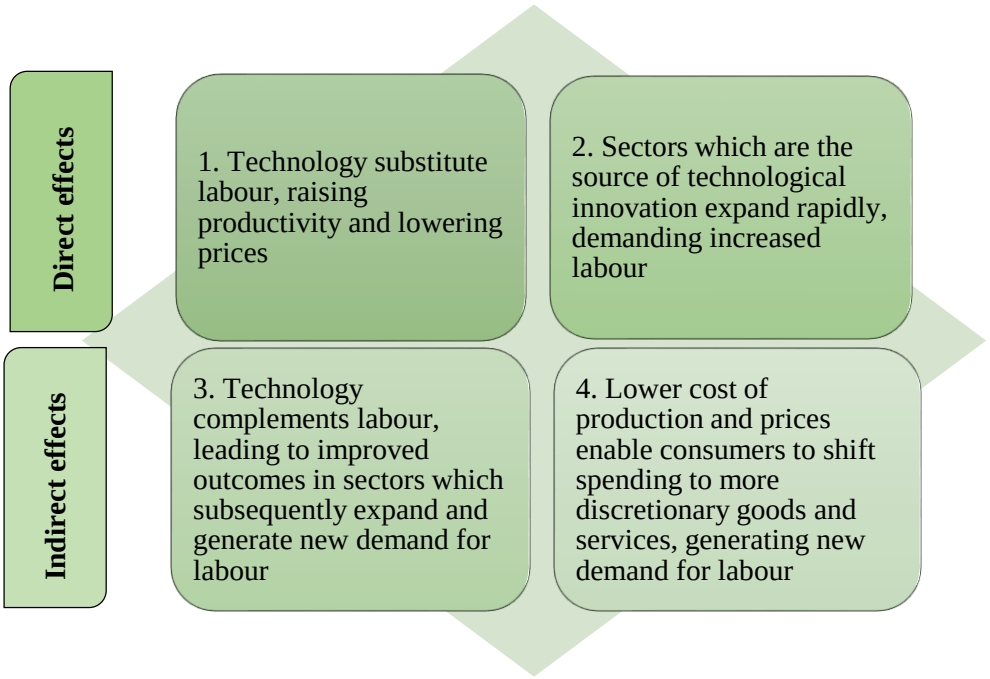
Inspired by the methodology used by Frey and Osborne (2013), Bakhshi, Frey and Osborne (2015) published the research paper "Creativity vs. robots: The creativity economy and the future of employment" as part of a project, conducted by the UK charity Nesta. Its aiming was to study the potential impact of augmented automation on creative occupations, categorised on basis of whether they require the use of imagination or original ideas to create something. Probably it is worth mentioning that the question whether AI could be creative was raised in the beginning of our century by computer scientists who proposed the Lovelace test, a variant of Alan Turing's Imitation Game (later referred as to the Turing test). After a decade, an Associate Professor of Computing at Georgia Institute of Technology Mark Riedl presented Lovelace 2.0 test, designed to challenge the premise that a computational system can originate a creative artefact like a story, poem, paining, etc. (Riedl 2014).

Bakhshi, Frey and Osborne (2015) managed to examine 702 different occupational categories in the US and 366 in the UK using several data sources. Their growing concern about the future of employment stems from the recent technological achievements in machine learning and mobile robotics, allowing computers to substitute humans in performing a broad spectrum of non-routine job tasks, both manual and cognitive. They brought our attention to the point in time, not so far ahead, when jobs, currently considered as creative, may not be so. According to their estimates, 21 per cent of the US employment and 24 per cent of the UK workforce are highly creative and a great share of the occupations behind these percentages (86 per cent in the US and 87 per cent in the UK) is at low or even at no risk of automation. One disturbing finding relates to accountants and auditors. Their creative probability is calculated to be 3.4 and the estimated probability of computerisation is 77.4. The former is too low and the latter is considerably high. Keeping in mind that creative skills will become more important with the expansion of technological innovations, as concluded by Bakhshi, Frey and Osborne (2015), it is crucial for the future of the accounting profession to keep its competitive advantages. As stated earlier, some leading professional organisations start asking the right questions: how accountants could benefit from the use of AI capabilities and increasingly improve the quality of their work, what will be their new roles in the organisation and the required new skills to perform them. Many of the current job tasks and

decisions will be automated but still accountants can be equipped with powerful new capabilities to take on all the challenges and opportunities of the future (ICAEW 2017).

Stewart, De & Cole (2015) present different and more optimistic perspective in their paper "Technology and people: The great job-creating machine", published by Deloitte LLP. The economists identified four mechanisms through which technological innovations affect employment, shown in figure 1. They focused on the job-creating not job-destroying effects, the latter prevailing in the current discussions, as technology debate is skewed towards destruction.

Figure 1. Four mechanisms through which technology affects employment



Source: Stewart, De & Cole 2015, p. 1.

Though chaotic and unpredictable, the analysis of the creative effects give a different aspect of the interaction between humans and machines and deserve our attention. The researchers were inspired by some lessons of history and examined two data sources: census records on employment in England and Wales for every decade year since 1871 and Labour Force Survey data from 1992 (Stewart, De & Cole 2015). For instance, one of their findings showed a dominant trend of rapidly growing employment in the caring, creative, technology and business services sectors prevailing over the agriculture and manufacturing contracting employment since 1992. Another interesting conclusion relates to the effect of technology by nature of the occupations. The data used in their survey revealed that both manual and cognitive routine jobs, like bank and post office clerks and metal making and treating operators, suffered significant substitution from technology innovations since 1992. On the contrary, technology is highly complementary to non-routine occupations like management consultants, business analysts, care workers and home carers where a strong employment growth effect has been observed. In fact technology creates jobs in new sectors like the technology sector, a positive trend captured by the second direct effect, presented in figure 1. But we also have to keep in mind one lesson gleaned from history – technologies become obsolete in time and are displaced by improved or new ones, thus shrinking employment in certain occupations like telephone and telegraph operators.

Let focus our attention on one of indirect mechanisms, depicted by Stewart, De & Cole. Even less obvious, it reflects the way in which the growth in some technology intensive sectors leads to a combination of productivity and employment expansion over time. It is worth mentioning that these

effects caused a raise in the demand for certain specialist services, helping customers to benefit from technological innovation and to deal with the increased complexity of the business environment. Accountants served as a good example as their numbers in England and Wales have risen tremendously in the last 140 years. An interesting phenomena was captured by the second indirect mechanism for affecting employment. The increased consumer purchase power and spending, a side-effect of the first direct mechanism, creates new demand and new jobs. For example there was a massive upward shift in employment in bars and personal services.

Stewart, De & Cole are quite optimistic regarding the future of employment despite the faster growth in technological improvements and labour replacements. They predicted that the required working skills will encompass "a bigger share of social interaction and empathy, thought, creativity" in the future (Stewart, De & Cole 2015, p. 10). An important policy challenge is figured out as the rapid technology changes will require high-level education and continuous re-training and these issues will become a focal point for the efforts of policymakers.

Another profound survey on the automation impacts on labour is the report "A future that works: automation, employment and productivity", published by McKinsey Global Institute (2017). It was produced as part of a more comprehensive research on how data and analytics, automation, robotics and AI will change the workforce patterns and the global economy. The performed analysis is focused on work activities rather than whole occupations, which distinguishes it from the other reviewed studies and in our opinion makes its conclusions about the future of human labour more accurate. Every occupation comprises of a set of activities, each having different potential for automation. By using data from the US Department of Labour, technical automation potential of more than 2,000 work activities in more than 800 occupations was assessed. Some of the key findings are summarised and presented in table 3.

Table 3. Automation technologies and their potential effects

Effects	Description
Cognitive capabilities	Robots and computers increase their capabilities to accomplish activities, including cognitive capabilities as making tacit judgments, sensing emotion and driving.
Productivity growth	• At a microeconomic level – labour cost reductions, increased throughput, higher quality, and decreased downtime; • At a macroeconomic level – an annual raise between 0.8 and 1.4 per cent.
Automation potential	• Only few occupations could be fully automated based on the currently demonstrated technologies; • About half of the world's workforce paid activities could potentially be automated by adapting existing technological innovations.
Pace, extent of automation and impact on workers	• Would vary across different activities, occupations, and wage and skill levels; • Disproportion effects on low-, middle- and high-skill workers caused by automation could be reduced.
Effects across countries and sectors	• A wide range of effects depending on country's stage of development; • The sector mix and the mix of activities within sector are the key factors for revealing automation potential.

Key factors influencing the pace and extent of automation	• Technical feasibility; • The cost of developing and deploying automation solutions; • Labour market dynamics; • Economic benefits; • Regulatory and social acceptance.
Effects on employment	• Changes in the nature of work; • Human labour will become complementary to the work of the machine; • Changes in companies' organisation, industries' competition patterns and business models.
Issues for policymakers	• Encourage investments to stimulate technological progress and innovations through appropriate policy; • Develop policies that help workers and institutions to adapt to the impact of automation on employment.

Source: McKinsey Global Institute 2017.

According to the McKinsey Global Institute's survey, every distinct work activity requires a combination of 18 performance capabilities, grouped into five categories: sensory perception, cognitive capabilities, natural language processing, social and emotional capabilities and physical capabilities. For instance, among the cognitive capabilities are: retrieving information, optimisation and planning, creativity, and problem solving (McKinsey Global Institute 2017). By adapting currently demonstrated technology, more than 50 per cent of the paid work activities could be automated. From the occupations point of view, less than 5 per cent have the potential of full automation and about 60 per cent have at least 30 per cent of activities that could be performed or even outperformed by the machines. Among the activities less susceptible to automation are: interfacing with stakeholders, managing and developing people, applying expertise to decision making, planning, and creative tasks. These findings reconfirm our conclusion drawn earlier that similar approach could be applied for detailed listing of the activities performed by accountants in order to assess more precisely which job tasks have high potential for automation. The question brings another important issue to the fore: what new functions accounting professionals could perform for realising their full working potential and creating more value to organisations. The use of AI capabilities brings some challenges as accountants will work alongside intelligent systems and need to be relevantly equipped with a proper skill set to benefit from the recent technology advances.

4. SOME FUTURE PERSPECTIVES TOWARDS ACCOUNTING PROFESSION

It is really a disturbing fact that accounting profession has been estimated as having high probability for automation in some well accepted among academics and practitioner empirical studies. But we have to neglect such dark prophecies as the profession is far away from its inglorious ending. AI should be considered as a beginning of its renewal and will once again prove its potential to adapt to the recent changes in business environment and the shift in management requirements (figure 2). In fact accountants can benefit from the intelligent systems as by using their capabilities they will be able to solve three broad problems (ICAEW 2017, p. 8):

- support decision-making by providing better and cheaper data;
- provide more profound analysis of data and give new insights on business;
- focus on more valuable tasks after freeing up working time due to AI applications.

4.1 What is the potential for displacement of accounting job tasks due to AI applications?

As stated earlier, the right approach for assessing the potential for job displacement is to analyse the task content of the accounting work. Undoubtedly some tasks can and probably will be substituted by the smart systems and the right question is when and to what extent. The current research and implementation projects are insufficient in light of the recent AI advances and AI capabilities for solving real-world accounting problems. We will give some insights on recent accomplishments based on ICAEW IT faculty study on AI and the future of accountancy (ICAEW 2017).

Bookkeeping is the most routine, time consuming and unquestionably susceptible to automation part of the accounting work. The logic behind double entry system enables the specific coding of accounting entries. Complex business transaction are easily disaggregated, described in accounting terms and recorded into the ledgers. The process can be fully automated by using the machine learning technologies. The accuracy of accounting data will be improved as well as the timing of recording.

Figure 2. Areas of AI impact on accounting profession

Fraud prevention and detection is another area where AI applications are possible and desirable. Machines cannot be tempted with money or power as they are driven by predetermined rules and act straightforwardly. There are many examples of deliberate human decisions and actions that are damaging to companies. Asset theft, tax avoidance, skimming of cash and cash larceny, financial statement falsification are only few from many common examples. Fraudulent activities are predictable and identifiable due to the easy machine learning modelling of "normal" activities.

Another job task where AI is likely to be beneficial is the *revenues forecasting* (ICAEW 2017). In time of uncertainty, information asymmetry and inherent risks, forecasting is not an easy work activity despite currently applied models and techniques. The accuracy of the revenues forecast is crucial for an operations budget and all other budgets derived from it. The use of predictive models, based on machine learning algorithms, can improve quality of the forecast data and consequently the processes of budgeting and strategic management. On the other hand, accountants must pay special attention to the quality of the data set being used for the forecasting and planning purposes because of the risk of inherent biases. They have to exercise due care when providing the data for the models (Shimamoto 2018).

Financial accounting and reporting is another area with great potential for automation. It is worth mentioning that even in 1980s and 1990s some expert systems were in use, mainly for cash flow evaluation, analysis of business combinations, accounting treatment for leases and analysis of financial reports for regulatory purposes (Yang & Vasarhelyi 1995). In the early research financial statements were represented as sets of interrelated cross sectional equations and ESs technologies were applied. As stated by Yang & Vasarhelyi, ESs were suitable for supporting the financial accounting domain as they "can greatly enrich this axiom and provide the basis for many types of metaphors" (1995). A practical challenge is the increasing number of regulations that need to be transformed into if-then rules and decision trees suitable for AI algorithms.

Analysis of large amounts of unstructured data comprising emails, contracts, graphs, videos, blogs, etc. can be substantially improved by application of deep learning models. Big data sets could provide new insights on businesses leading to better decision-making and strategic business solutions. Because of their diverse and complex nature and large volume, they require special technologies but also new job skills for big data analytics. Accounting professionals are challenged to build such skills through proper education and training. The lifelong learning concept is the key for successful adaptation to the constantly changing competence requirements.

4.2 What are the new skills required of accountants to benefit from deployment of AI technologies and create more value to the businesses?

The analysis of job-tasks displacement shall be accompanied by corresponding study of practical challenges facing the accounting profession and more precisely the new required skill set for performing activities in the rapidly changing environment fuelled by digital technology and increasing information processing power (Chan 2013). The fast transformation in the business landscape due to AI applications resulted in situations where new smart technologies were integrated into business and accounting software and many accountants encountered them without realising their logic, capabilities and full potential (ICAEW 2017).

One of the most required skills is the *technical expertise in machine learning* and the depth of knowledge depends on the organisation's size, investment policy and innovation strategy. Despite these factors, it is important for accountants to understand the significance of quality of the used data. Machine learning implies recognition and application of patterns based on existing data points or examples, deriving own algorithms and refining them in time (Shimamoto 2018). "Teaching" the computer by using data sets requires special attention to their quality as mentioned earlier. Internal control procedures should be implemented to mitigate the risk associated with the inherent biases and other limitations of AI applications.

Among the technical skills are *the big data analytical skills* as "there is an increasing focus on Big Data for the accounting profession" (Gamage 2016, p. 590). As stated by Ellis King, the manager of a global professional services recruitment company, Morgan McKinley, there is a big shift in the required skills for entering the labour market and big data analytics plays a central role. Even young and less-experienced accountants are expected to be creative with data and produce useful analysis thus contributing by forecasting potential growth, new markets or competition (King 2014). According to some recent research estimates, 77 per cent of companies, which exploit the benefits of data analytics, achieve better financial performance (see Gamage 2016, p. 592). Moreover, decision-making driven by data leads to 5-6 per cent efficiency gains depending on sector specifics (Tene & Polonetski 2013). Machine learning "also benefits from having very large data sets – the more data points there are, the more times the model can run, learn and test the accuracy of its results" (ICAEW 2014, p. 4). The report published by the Association of Chartered Certified Accountants (ACCA) and the Institute of Management Accountants (IMA) (2013) acknowledges that there are three important contribution areas: valuation of data assets, use of big data in decision-making and use of big data in the management of risk and accountants must be well trained to gather and analyse structured and unstructured data in order to "seize the opportunity to become champions of big data as a source of evidence to support decision-making – and help to redefine how business is done" (CGMA 2013, p. 22). In its report "Big Data and analytics – what's new?" ICAEW affirms that accounting professionals can enhance their contribution to businesses by making use of big data and analytics, such as: "using predictive models and other

sources of data to improve budgeting and forecasting; using more sophisticated outlier and exception analysis to improve internal control and risk management; improving the efficiency and quality of audit activities through analysis of whole data sets" (ICAEW 2014, p. 11). Because of their natural prudence and scepticism they can also contribute by testing and improving the quality of data. However, they need to be equipped with sufficient theoretical knowledge and practical skills in statistics to communicate professionally with the other parts of the business.

In addition, *communication skills* and *critical thinking* will become increasingly important in the AI age (ICAEW 2017). According to Jazaie, among the 10 most important communication skills for accountants are: presentation skills (storytelling), credibility, confidence, friendliness, eye contact, understanding people's point of view and ability to give and receive feedback (Jazaie 2017). On the other hand, critical thinking skills have been "widely accepted as a key requirement for success in most practical and professional spheres, not just accounting", since at least the 1980s (Sin, Jones &, Wang 2015, p. 432). The ability to think critically was even then considered as a prerequisite for a successful transition from the classroom to the professional workplace. The development of critical thinking needs to become a main objective in the accounting education.

Leadership skills will become more important with the changes of accounting roles. As the professionals increase their participation in company's strategic management and collaboration and partnership with other parts of the organisation, certain types of leadership will become indispensable. Among them are: strategic and organizational leadership; coaching and mentorship; a strong sense of ethics and cross-functional leadership.

4.3 What are the new accounting roles and tasks across organisational boundaries?

As noted by Gamage, accountants will become more than preparers of historical financial data (Gamage, 2016). One of the shifts in accountants' roles is a response to their intensive work with data analytics. Complemented by business awareness and understanding, and strong numeracy skills, accountants' capabilities are well placing the profession across organisation boundaries. Moreover, AI is accelerating this trend.

Some of the existing accounting roles will expand due to the increase in collaboration and partnership with other parts of the organisation. Accountants' competences in machine learning and data analytics will be valuable as they can provide support to other employees in understanding the complex models and deriving the right meaning of data (ICAEW 2017).

In addition to changes in some of the current accounting roles, new job tasks will arise. For instance, the research carried out by ICAEW highlights that "accountants will ned to be involved in training or testing models, or auditing algorithms, …in projects to help frame the problems and integrate results into business processes, ….in managing the inputs or outputs, such as exception-handling or preparing data" (ICAEW 2017, p. 10).

Gamage affirms that due to their data analytical skills and financial modelling skills, accountants can play more strategic and proactive roles in their organisations (Gamage 2016). An interesting conclusion was drawn by ACCA and IMA in their joint report (ACCA & IMA 2013). The two professional bodies predict that in the future accounting profession will be transformed into some kind of professional hybrid, as shown in figure 3, due to the interaction of finance, technology and information skills and competences.

Accountants can increase their participation in the decision-making process, strategic management and problem solving. Their contribution as internal consultants giving advices to company's management will be valuable as well as their increased social role of building and strengthening relationships in the organisation (ICAEW 2017).

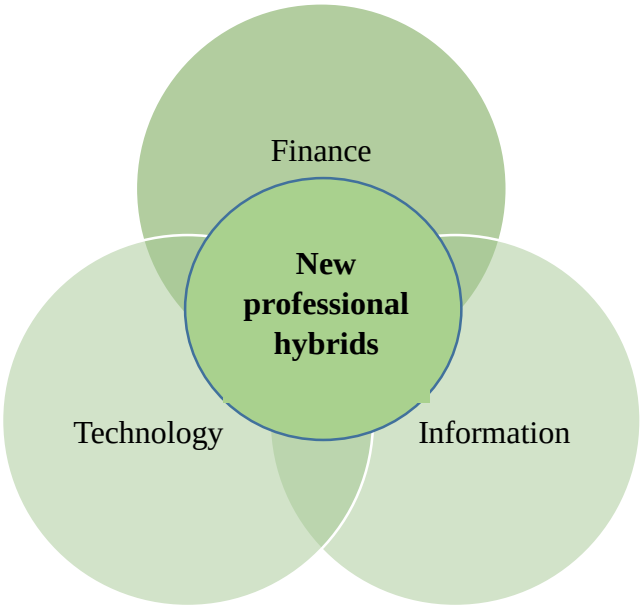
4.4 Are accounting educators ready for the AI challenge?

Accounting educators are also challenged by AI augmented application. They are experiencing high pressure from the international professional accounting and accrediting bodies to enhance the technological content of accounting courses, including but not limited to machine learning, big data and

analytics (Gamage 2016). Obviously universities have to play an important role in this process as initiators for curricula review and relevant implication tests. The provocative questions of how to adapt curricula and syllabi to the current labour market requirements and employers' expectations from graduates and how to develop the new skill set for the jobs of the future were raised. For example, in regard of the increased focus on big data and analytics for the accounting profession, the Association to Advanced Collegiate Schools of Business (AACSB) states the following in its Accounting Accreditation Standard 7:

"The dynamic nature of IT developments related to data creation, data management and processing, data sharing, data analytics, data mining, data reporting, data security, and storage within and across organizations is critical for the development of emerging professional accountants. The underlying learning experiences for accounting graduates demand an interdisciplinary approach that draws input from professionals and academic scholars with expertise in information systems, statistics, computer science and engineering, ethical issues related to IT and "big data," etc. The focus should not be on "accounting information systems" only, but on information storage, management, and analysis for accounting graduates." (AACSB 2014, p. 5)

Figure 3. New accounting and finance professional hybrids



Source: ACCA & IMA Report 2013, p. 31.

Obviously the interdisciplinary approach should be applied across the curriculum and accounting educators are responsible for the timely response. Knowledge and skills in AI and data science should be considered as a must not as a desirable competitive advantage. For instance, one practical problem is that big data is tied to many disciplines (Gamage 2016).

The ever existing gap between universities and accounting practice has to be overcome in the era of smart technologies. Collaboration and partnership between accounting educators and industry are prerequisites for the successful accounting career of graduates. One of the pioneers among universities, already integrated big data and analytics into the accounting coursework, is the School of Accountancy at the Rawls College of Business, Texas Tech University. The module "Data analytics for accountants" is included in the curricula (http://www.depts.ttu.edu/rawlsbusiness/about/accounting/courses.php).

5. CONCLUSIONS

Beyond a shadow of a doubt AI is reshaping the future of many occupations, and accounting profession is one of the most. Many opportunities for new important roles and jobs emerge when considering the artificial intelligence as a complement to the human intelligence. The threat for labour displacement seems now more as a myth than a future prospect and we are facing a shift from the concerns for automation of accounting tasks towards embracing AI capabilities by the accounting profession for its benefits. Accounting roles are getting closer to company's management functions.

Because AI is impacting and will further impact the role of accountant, there is a call for accounting educators to change their mindset and develop the required skills and competences related to the smart technologies and their augmented business applications. There is a lot of work ahead to review the accounting curricula and prepare graduates for successful career.

Accounting researchers are also challenged by the AI issues in the accounting realm as they have to collaborate with AI specialists and to bridge the existing gap between the accounting domain and AI domain. More complex AI applications can be developed to solve some accounting problems more fully. There are areas in AI technologies as fuzzy logic and neutral networks that might be successfully applied in the accounting context (Baldwin, Brown & Trinkle 2006).

There are also important issues related to accounting regulators and standards setting bodies and the increasing need of their institutional support. Because of the risks associated with AI applications they have to consider the impact of the new technologies on financial reporting standards and transparency of the data outputs, derived by application of machine learning models. One possible and desirable scenario will be regulators to encourage and even push the adoption of intelligent technologies in the accounting practice and their deep understanding of AI and the associated risks needs to be built (ICAEW 2017).

REFERENCES

1. Abdolmohammadi, MJ 1991, 'Factors affecting auditors' perceptions of applicable decision aids for various audit tasks', *Contemporary Accounting Research*, vol. 7, no. 2, pp. 535-548.
2. ACCA & IMA 2013, '*Big data: its power and perils'*, viewed 25 April 2018, <http://www.accaglobal.com/bigdata>
3. Association to Advanced Collegiate Schools of Business (AACSB) 2014, '*International Accounting Accreditation Standard 7: Information Technology Skills and Knowledge for Accounting Graduates: An Interpretation*', White paper.
4. Bakhshi, H, Frey, CB & Osborne, M 2015, '*Creativity vs. robots. The creative economy and the future of employment*', Nesta, viewed 26 February 2018, <http://www.nesta.org.uk/sites/default/files/creativity_vs._robots_wv.pdf>
5. Baldwin, AA, Brown, CE & Trinkle BS 2006, 'Opportunities for artificial intelligence development in the accounting domain: the case for auditing', *Intelligent Systems in Accounting, Finance and management*, vol. 14, pp. 77-86.
6. Cellan-Jones, R 2014, '*Stephen Hawking warns artificial intelligence could end mankind*', BBC News, media release, 2 December, viewed 7 February 2018, <http://www.bbc.com/news/technology-30290540>
7. Chan, D 2013, '*The World is Turning Upside Down'*, viewed 25 April 2018, <https://www.cass.city.ac.uk/faculties-and-research/research/cass-knowledge/2013/november/the-challenges-facing-management-in-a-rapidly-changing-business-environment>

8. Chartered Global Management Accountants Report (CGMA) 2013, '*From insight to impact: unlocking opportunities in Big Data*', viewed 20 February 2018, <https://www.cgma.org/content/dam/cgma/resources/reports/downloadabledocuments/from-insight-to-impact-unlocking-the-opportunities-in-big-data.pdf>
9. Dirican, C 2015, 'The Impacts of Robotics, Artificial Intelligence on Business and Economics', *Procedia – Social and Behavioural Sciences*, vol. 195, pp. 564-573.
10. Faggella, D 2016, '*Exploring the risks of artificial intelligence'*, viewed 15 December 2017, <https://techcrunch.com/2016/03/21/exploring-the-risks-of-artificial-intelligence/>
11. Frey, CB & Osborne, MA 2013, '*The future of employment: How susceptible are jobs to computerisation*', University of Oxford mimeo, viewed 20 December 2017, <https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf>
12. Gamage, P 2016, 'Big Data: are accounting educators ready?', *Accounting and Management Information Systems*, vol. 15, no. 3, pp. 588-604.
13. Hirst, T 2014, '*Does technological innovation increase unemployment?*', World Economic Forum, viewed 10 February 2018, <https://www.weforum.org/agenda/2014/11/does-technological-innovation-increase-unemployment/>
14. Institute of Chartered Accountants in England and Wales (ICAEW) 2014, '*Big Data and analytics – what's new?'*, viewed 10 March 2018, <https://www.icaew.com/-/media/corporate/archive/files/technical/information-technology/technology/what-is-new-about-big-data-v2.ashx>
15. Institute of Chartered Accountants in England and Wales (ICAEW) 2017, '*Artificial intelligence and the future of accountancy'*, viewed 15 March 2018, <https://www.icaew.com/-/media/corporate/files/technical/information-technology/technology/artificial-intelligence-report.ashx?la=en>
16. Jahan, S, Mahmud AS & Papageorgiou, C 2014, 'What Is Keynesian Economics?', *Finance & Development*, vol. 51. no.3, viewed 18 December 2017, <http://www.imf.org/external/pubs/ft/fandd/2014/09/pdf/basics.pdf>
17. Jazaie, R 2017, '*Communication Skills for Accountants: Lessons from GGU's Director of Accounting Programs*', viewed 26 April 2018, <https://ggu-business.com/2017/10/12/communication-skills-for-accounting-presentations/>
18. King, E 2014, '*London jobs: big drive for big data'*, viewed 26 Aprilr 2018, <https://www.icaew.com/en/archive/groups-and-networks/local-groups-and-societies/london-ds/london-accountant/opinion/jun14-morgan>
19. Knowles-Cutler, A, Frey, C. & Osborne, M 2014, *'London Futures Agiletown: the relentless march of technology and London's response*', Deloitte, <https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/uk-futures/london-futures-agiletown.pdf>
20. Kontzer, T 2015, 'Robots Take Over The World!: Not Such A Crazy Fear', *Investor's Business Daily*, viewed 26 January 2018, <https://www.investors.com/news/technology/ai-warnings-from-hawking-musk-gates-taken-to-heart/>
21. McKinsey Global Institute 2017, *'A future that works: automation, employment and productivity'*, viewed 20 December 2017, <https://www.mckinsey.com/~/media/McKinsey/Global%20Themes/Digital%20Disruption/Harnessing%20automation%20for%20a%20future%20that%20works/MGI-A-future-that-works_Full-report.ashx>
22. Makridakis, S 2017, 'The forthcoming Artificial Intelligence (AI) revolution: Its impact on society and firms', *Futures*, vol. 90, pp. 47-60.

23. O'Leary, DE 1987, 'The Use of Artificial Intelligence in Accounting', in BG Silverman (ed.), *Expert Systems for Business*, Addison-Wesley Publishing Company, pp. 83-98.
24. O'Leary, DE 2003, 'Auditor environmental assessments', *International Journal of Accounting Information Systems*, vol. 4, pp. 275-294.
25. Parloff, R 2016, 'Why deep learning is suddenly changing your life', *Fortune*, 28 September, viewed 3 March 2018, <http://fortune.com/ai-artificial-intelligence-deep-machine-learning/>
26. Riedl, M 2014, '*The Lovelace 2.0 Test of Artificial Creativity and Intelligence*', Cornell University Library, viewed 16 April 2018, <https://arxiv.org/pdf/1410.6142.pdf>
27. Mensel, L & Tholl, M 2017, '*Jeremy Rifkin: In New Economy, Social Skills Counts More Than Work Skills*', viewed 1 April 2018, <https://www.huffingtonpost.com/2015/03/02/rifkin-new-economy-social-skills_n_6777646.html>
28. Shimamoto, DC 2018, '*Why Accountants Must Embrace Machine Learning'*, viewed 25 April 2018, <https://www.ifac.org/global-knowledge-gateway/technology/discussion/why-accountants-must-embrace-machine-learning>
29. Sin, S, Jones, A &, Wang Z 2015, 'Critical Thinking in Professional Accounting Practice: Conceptions of Employers and Practitioners' in M Davies & R Barnett (ed.), *The Palgrave Handbook of Critical Thinking in Higher Education*, Palgrave MacMillan, pp. 431-456.
30. Stewart, I, De, D & Cole, A 2015, *Technology and people: The great job-creating machine*', Deloitte LLP publishings, viewed 27 March 2018, <https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/finance/deloitte-uk-technology-and-people.pdf>
31. Stiglitz, JE 2014, '*Unemployment and Innovation'*, Institute for New Economic Thinking, Working Papers, viewed 17 March 2018, <http://beta.ineteconomics.org:8080/uploads/papers/WP1-Stiglitz-Unemployment.pdf>
32. Sulleyman, A 2017, *'Elon Musk: Humans must become cyborgs to avoid AI domination'*, viewed 27 April 2018, <https://www.independent.co.uk/life-style/gadgets-and-tech/news/elon-musk-humans-cyborgs-ai-domination-robots-artificial-intelligence-ex-machina-a7581036.html>
33. Suton, S, Holt, M & Arnold, V 2016, 'The reports of my death are greatly exaggerated – Artificial intelligence research in accounting', *International Journal of Accounting Information Systems*, vol. 22, pp. 60-73.
34. Tene, O & Polonetski, J 2013, 'Big Data for All: Privacy and User Control in the Age of Analytics', *Northwestern Journal of Technology and Intellectual Property*, vol. 11, no. 5, pp. 240-273.
35. Yang, DC & Vasarhelyi, MA 1995, *'The Application of Expert Systems in Accounting'*, unpublished working paper.