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Work in the age of artificial intelligence

Four perspectives on the economy, employment, skills and ethics

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Abstract

The report Work in the age of artificial intelligence is part of the Artificial Intelligence Programme set up by Minister of Economic Affairs Mika Lintilä. The programme's steering group is chaired by Pekka Ala-Pietilä. A working group on the transformation of work and society, chaired by Osmo Soininvaara, Lic. Pol. Sc., wrote the report.

The report is a collection of four main articles that discuss (1) the effects of artificial intelligence on general economic and employment trends; (2) the transformation of work and the labour market; (3) reforms on education and skills maintenance; and (4) ethics.

Artificial intelligence is a general-purpose technology that changes working life and society extensively. It opens the possibility for rapid productivity growth and for a higher standard of living. To harness the potential of artificial intelligence, society must invest in updating workers' skills, facilitating workforce mobility and generating innovations that complement human labour. The importance of a well-functioning labour market will be even greater.

One of the working group's proposals for further preparation is a lifelong-learning reform where every person of working age would be given a skills account or voucher that they could use to update their skills. Employees, employers and society together would bear responsibility for updating workforce skills. This would create a demand-based market for education and training.

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Rapporten Arbetet under den artificiella intelligensens tidevarv är ett led i programmet för artificiell intelligens, som är tillsatt av näringsminister Mika Lintilä. Programmet har en styrgrupp som Pekka Ala-Pietilä är ordförande för. Rapporten har utarbetats av arbetsgruppen med politices licentiat Osmo Soininvaara som ordförande.

Rapporten består av fyra huvudartiklar, som behandlar (1) den artificiella intelligensens inverkan på den allmänna utvecklingen av ekonomin och sysselsättningen, (2) arbetets förändring, (3) utbildning och upprätthållande av kompetensen, samt (4) etik.

Artificiell intelligens är en genombrottsteknologi som i stor utsträckning omdanar arbetslivet och samhället. Artificiell intelligens möjliggör en snabbare ökning av produktiviteten och därmed en förbättrad levnadsstandard. För att uppnå fördelarna med artificiell intelligens bör samhället investera i att uppdatera arbetskraftens kompetens, att underlätta arbetskraftens rörlighet samt att få fram innovationer som kompletterar det mänskliga arbetet. Vikten av en välfungerande arbetsmarknad accentueras.

För den fortsatta beredningen föreslår arbetsgruppen bland annat en reform för livslångt lärande, där varje människa i arbetsför ålder får ett kompetenskonto eller en kompetenssedel som hen kan använda för att uppdatera sin kompetens. Arbetstagarna, arbetsgivarna och samhället får tillsammans bära ansvaret för att uppdatera arbetskraftens kompetens. Samtidigt uppstår i Finland en utbildningsmarknad.

Olli Koski (arbets- och näringsministeriet / tfn 029 504 7174)

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Tiivistelmä

Tekoälyajan työ -raportti on osa elinkeinoministeri Mika Lintilän asettamaa tekoälyohjelmaa, jonka ohjausryhmän puheenjohtajana toimii Pekka Ala-Pietilä. Raportin on tuottanut ohjelman alaisuudessa toiminut Työn ja yhteiskunnan muutos –työryhmä, jonka puheenjohtajana toimi VTL Osmo Soininvaara.

Raportti koostuu neljästä pääartikkelista, jotka käsittelevät (1) tekoälyn vaikutuksia yleiseen talous- ja työllisyyskehitykseen; (2) työn muutosta ja työmarkkinoita; (3) koulutusta ja osaamisen ylläpitoa; sekä (4) etiikkaa.

Tekoäly on yleiskäyttöinen teknologia, joka muokkaa työelämää ja yhteiskuntaa laajasti. Tekoäly tarjoaa mahdollisuuden tuottavuuden nopeampaan kasvuun ja siten elintason paranemiseen. Hyötyjen saavuttamiseksi yhteiskunnan tulee investoida työvoiman osaamisen päivittämiseen, työvoiman liikkuvuuden helpottamiseen sekä ihmistyötä täydentävien innovaatioiden synnyttämiseen. Työmarkkinoiden hyvä toimivuus on entistä tärkeämpää.

Työryhmä esittää jatkovalmisteluun muun muassa elinikäisen oppimisen reformia, jossa työikäisille luotaisiin osaamistili tai -seteli, jolla voisi päivittää osaamistaan hankkimalla koulutusta palvelujen tarjoajilta. Työntekijät, työnantajat ja yhteiskunta kantaisivat vastuun yhdessä työvoiman osaamisen päivittämisestä. Suomeen syntyisi koulutuskysynnän ylläpitämänä koulutusmarkkinat.

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INTRODUCTION

On 18 May 2017, Minister of Economic Affairs Mika Lintilä appointed a steering group chaired by Pekka Ala-Pietilä to prepare a proposal for a Finnish artificial intelligence programme. According to the appointment decision, "the objective of the artificial intelligence programme is to turn artificial intelligence into a success factor for Finnish companies. Finland's goal is to be a global leader in applying artificial intelligence". Five sub-groups worked under the steering group, one of which was the working group on the Transformation of work and society chaired by Osmo Soininvaara. The working group met nine times. For a list of its members, see Appendix 1.

When participating in the drafting process of the report, the working group members did not represent their background organisations, and these organisations are not committed to the views expressed in the report. Each member contributed to the report independently based on his or her personal expertise. The objective was to invite to the working group members with highly diverse expertise and different viewpoints. The policy recommendations and conclusions of the report do not necessarily represent the group's joint views. While they were not formulated unanimously, they do represent a majority opinion.

The report consists of four chapters on different themes (Chapters 2 to 5). Each chapter is an independent whole prepared by the working group members in different compositions. Rather than aiming for a fully consistent format, the report wished to emphasise the members' personal views.

1 Reflections on work in the age of artificial intelligence

Artificial intelligence (AI) has been compared to electricity. It is a general-purpose technology that will over time make its way to almost every aspect of life. This may bring about significant changes in work and society. As the impacts of artificial intelligence and other aspects of digitalisation are difficult to tell apart, neither did our working group find it necessary to make a clear distinction between them.

Consumers will mainly find artificial intelligence to their advantage as inexpensive or completely free products which make their lives easier or improve their comfort come into the market. In parallel with this optimistic vision, pessimistic views concerning the future of work and development of societal inequalities have been expressed.

Ideas of to what extent and how fast artificial intelligence will do away with current jobs vary greatly. We must be prepared for changes that may take place at a very fast rate. The impacts of artificial intelligence will be smaller in Finland than in such countries as Germany. In 2015, approx. 9% of Finnish jobs were so-calledTaylorised jobs containing routine tasks which lend themselves to automation easily, whereas this figure was approx. 30% in Germany based on the same definition (Makó, Illésy & Borbély, unpublished working paper, 2018).

According to a McKinsey report on Finland, artificial intelligence will destroy some 15% of jobs by 2030 and change the nature of work in a considerably larger proportion of tasks. The estimate recommends that we should be prepared to retrain one million Finnish workers. Similarly, advanced applications of AI will make many completely new products and occupations possible.

While the rate at which jobs will disappear appears fast, it is considerably lower than rates Finland has faced in earlier decades. Previously, however, workers mainly moved from unproductive work to higher-paid jobs. This time around it may be that many workers who lose their occupation will have to settle for a job with lower pay. Artificial intelligence will also affect the work of highly educated professions, including lawyers, physicians and bank managers.

Artificial intelligence may also improve the functioning of the labour market. The efficiency of employment services can be improved immensely as a jobseeker's properties can be mechanically compared to all available jobs at once. A job exchange robot may also look for jobs for those in employment, ensuring that as their skills improve, workers could move on to roles that are a better match with their competence and free up less demanding jobs for the unemployed and those entering the labour market.

Productivity growth and the creative destruction brought about by it slowed down in the 2000s in all industrial countries. If artificial intelligence meets the expectations placed on it, we may see another boost in productivity and creative destruction. This change will reduce certain kinds of jobs and increase the number of others. At the same time, the demand will decrease for certain skills and grow for others. Without corrective actions, this will worsen the labour market mismatch and exacerbate structural unemployment. It is generally predicted that an increasingly high level of education will be required of the labour force. According to McKinsey's prediction, the proportion of highly educated labour will increase from 44% in 2016 to about 51% by 2030. This change will set challenges to the Finnish education system, as the improving trend in the level of education in Finland stagnated in the 1990s.

Artificial intelligence development and introduction as well as the general digitalisation of society will challenge the conventional and siloed practices of political decision-making and central government. More consolidated thinking will be needed to enable the implementation of comprehensive development measures across the boundaries of administrative branches and sectors. In a broader context, this is about the public sector's ability to respond to changes in the operating environment and new ways of doing things together.

Threats associated with artificial intelligence include growing structural unemployment and inequalities in society. In conditions of a political democracy, a situation where the majority of the population would find their position weakened is almost impossible. It is vital to be able to anticipate social problems, or threats of such problems, created by the change.

While the challenges of artificial intelligence do not require any solutions of a completely new type that would not have been suggested already, they will significantly increase the need for certain actions. The change in the labour market will stress the need to protect the most vulnerable groups, while it will exacerbate the obstacles created by labour market rigidities. Responsibility for protecting those in the most vulnerable position must be shifted towards social policy whose costs are paid by the central government. As such, the Nordic welfare state is much better placed to face the change than such countries as the United States, where the safety net is thinner.

Making proposals related to social policy was not part of our working group's mandate. However, we can note that the need to make accepting work worthwhile is stressed, as is the need to reduce equilibrium unemployment through pay subsidies or income transfers complementing earned incomes.

The requirement of lifelong learning is also not new, but the need for it will increase strongly. In order to turn it into reality, the question of who will pay for the education and training must be resolved. The working group proposes setting up a skills account for each Finnish person, in which funds entitling the holder to training will be accumulated. The costs could be paid for by the central government together with employers and employees. Entrepreneurs should have equal rights to upskilling. This would also create a training market maintained by the demand in Finland.

Osmo Soininvaara
Working group chairperson

2 Impacts of artificial intelligence on growth and employment[1]

2.1 Digitalisation and artificial intelligence as a technological leap

So far, digitalisation has already revolutionised the modes of production and work in many occupations and different fields. It has also made away with old tasks and created new ones. Key manifestations of digitalisation in recent years include the wider use of mobile internet, cloud services and big data and increased computing power. However, the greatest impacts on the world of work of artificial intelligence, machine learning and applications associated with these technologies, including advanced interactive robotics and autonomous transport, quite obviously are yet to come (see Appendix 2 to the report).

In the context of digitalisation and artificial intelligence, we can talk about a revolution of technological development created by them. This leap in the advancement of technology influenced by many different factors will change entire society. Ultimately, it is about a new relationship between humans and machines in productive activities. In the era of the steam engine and electrification, machines mainly replaced physical effort and complemented human work (the so-called first machine age). As technologies advanced further and the second machine age dawned, machines could already be used to direct physical work, and cognitive tasks that lent themselves to simple coding could be transferred to them.

1 The authors of this Chapter are working group members Anu Järvensivu, Seija Ilmakunnas and Ville Kyrki.

In some occupations, machines could replace human work completely, and such occupations of dwindling work have often been found around the middle of the distribution of earnings.

The job descriptions of diminishing jobs are characterised by routine tasks and repetition, which computers can manage more efficiently. Examples of this include non-executive office occupations (routine information occupations) and industrial assembly occupations (routine manual occupations). At the same, occupations with few routines at both the bottom and top end of the distribution of incomes have increased their relative shares.

Their relative position has been improved by the requirement of a personal approach, flexibility, problem-solving ability or creativity associated with the work (which is more difficult to digitalise). These changes associated with the development of information technology and globalisation have been discussed in a number of studies on labour market polarisation.

In the second wave of the second machine age, rather than only operating on the basis of pre-programmed inference rules, machines themselves are learning to use neural networks and large datasets. This has added to the possibilities of utilising automation in many new applications associated with such fields as translating languages, pattern recognition, diagnosing illnesses and self-driving modes of transport. These new application areas mean that the impacts on employment will also touch many information occupations with few routines which, in the light of earlier polarisation studies, were believed to increase rather than lose their share.

The identification of society's points of transition is always open to interpretations – at least in beforehand. The development rate of the actual technology is fraught with uncertainties, and it is unlikely that the changes in employment will be as rapid as indicated by technological advancement. The impacts of technological development on society will be filtered through many factors. First of all, companies may be unwilling to take up new technologies if this requires major reorganisation. Legislation incompatible with new circumstances and ethical issues awaiting solution may at least slow down the development.

However, the interpretation pointing to a fundamental change is supported by a number of factors, including the fact that artificial intelligence as a general-purpose technology already enables even radical product and process innovations in many different sectors. The changes may take place rapidly and make existing physical and intellectual capital unproductive at an unpredictable rate. The advancement of information technology has also meant that more and more products have a global market, reproducing digital products is often almost free, and major economies of scale are available in production. This makes for rapid changes in the market, and a 'winner(s) take(s) it all' phenomenon is typical of many markets. A very small group of companies may corner a major share of profits and markets. The possibility of exploiting a monopoly position and lack of competition are apt to exacerbate the risk of uneven income distribution. The possibility that the benefits of the new technological leap will be divided less evenly than the benefits of earlier similar leaps can be considered a threat.

In national economy statistics, the impacts of digitalisation development on economic growth have been more moderate than anticipated (Itkonen 2017). An observation of poor productivity development coinciding with digitalisation leads to an inconsistency that calls for explanation. On the one hand, the background factors to this include the difficulty of measuring the economic significance of digital goods. Completely new goods, free services, changes in quality and global intellectual capital have proven a challenge to measuring digitalisation. Improvement in ICT devices and services is a factor whose impacts on price development have been difficult to estimate. In practice, the price development has been overestimated, among other things because the quality improvement in ICT products has only been taken into account partly, and the better quality has incorrectly been manifested as higher prices. This means that economic growth, or GDP development in constant prices, has been similarly underestimated. As a conclusion, we can say that the impacts of digitalisation on improving the standard of living have not been fully reflected in economic statistics.

Another explanation is that large-scale productivity growth will only take place when innovations complementing human work have been developed and introduced comprehensively, including new ways of organising work. This, on the other hand, will require investments in intellectual capital, such as education and research, at the level of both society and companies. Even if artificial intelligence

technology already enables many types of profitable technologies today, visions will not be turned into reality unless people invent and develop innovations required to complement them. While some of these will be technological in nature, a significant share will be social or socio-technological (Brynjolfsson et al. 2017).

It is also possible to interpret the current situation more fundamentally as a type of regression in the innovation concept and a return to technological determinism. The innovation concept based on technological determinism means a model where technologies developed through research are expected to spread to companies and have a linear impact on growth, employment and the modes and practices of work. This model was challenged decades ago, however, and co-operative innovation models including 'open innovation' or 'quadruple helix' were proposed to replace it. In these models, policy-makers and government, business life, researchers and citizens work together to create the future and to implement structural changes (Kopp et al. 2017; Arnkil et al. 2010.).

2.2 Employment impacts in the light of research

The current discussion about the impacts of artificial intelligence on the world of work can be divided into two main streams. The first stream concerns itself with employment impacts: a) will sufficient quantities of new jobs be created to replace disappearing jobs or tasks, or will the number of those without work and income grow; and b) which occupations are the most at risk and what types of new tasks will be generated (e.g. Frey & Osborne 2013; Pajarinen & Rouvinen 2014; McKinsey 2017; Linturi & Kuusi 2018). The second one focuses on qualitative changes in working life: what types of changes will take place within tasks and modes of work, including employment relationship models or the times, places and organisation of work, and whether the entire set of concepts relevant to work and the world of work should be re-thought (Järvensivu 2010; Gratton 2011; Dufva et al. 2017; Antila et al. 2018). The emphasis of this report is on the employment impacts of artificial intelligence.

The impacts of automation on employment have been discussed since the early days of the industrial society. The latest debate on the employment impacts of

technologies and their scale began with an article written by Frey and Osborne (2013), who classified occupations according to how likely they are to lend themselves to automation. Occupations were placed in high, medium and low risk categories. The results indicate that in the USA, up to 47% of employment will be automated with a 70% likelihood within 20 years. A similar analysis on Finland showed that one third of employment is exposed to the threat of automation (Pajarinen & Rouvinen 2014).

Occupations consist of many types of tasks, and the likelihood of these tasks being automated varies significantly. Using the OECD's international PIAAC data, this analysis can be focused on tasks. Studies drawing on these data published by the OECD have concluded that the aforementioned predictions have probably overestimated the impacts of automation. A study published in 2016 covered 21 member states, and task-level analyses indicated that only approx. 9% of the employment could be automated. Differences between countries turned out to be significant; in Finland, for instance, it was estimated that only less than 7% of the jobs would lend themselves to automation (Arntz et al. 2016).

In the most recent OECD study, the group of countries examined was extended to 32. Its results show that 14% of jobs are exposed to a high risk of automation (Nedelkoska & Quintini 2018). In addition, the risk of automation is 50–70% in one third of jobs. In other words, these jobs also contain a considerable share of tasks that can be automated, which significantly increases the pressure to change the skill requirements of persons working in them. According to the results concerning Finland, approx. one third of jobs are affected by either a high (over 70%) or medium (50–70%) risk of automation. This figure is the third lowest after Norway and New Zealand.

The latest OECD study strives to also describe employment exposed to the greatest risk of change based on the population groups most affected by the change. According to the report, the changes would affect low skills level employment the most, and there would be a linear reduction in the risk of automation as the education and skills level increases. Young people, who often work in labour market entry level occupations with a high risk of automation, are exposed to the greatest risk.

Major international management consultancy firms have contributed to the discussion on the employment impacts of technology. The level of analysis selected for the McKinsey report (2017), which has received some attention in publicity, is functions and capabilities needed for performing them. According to the report, approximately one half of the functions could be automated using modern technologies, whereas only 5% of occupations could be fully automated. However, up to 60% of occupations contain functions that could be automated.

Looking at various studies, we can see that there are great variations between the predictions. Different levels and periods of analysis and dissimilar sets of concepts are used in them. The big picture of disappearing jobs is difficult to perceive, and the situation is not made any easier by the fact that the impacts of artificial intelligence are hard to pinpoint among the impacts of other technologies. As a conclusion we can note, however, that while automation is not likely to completely make away with many occupations, it will replace some of the human work in many tasks (Koski 2018). At the same time, it will change job descriptions. The fact that new tasks and occupations will also be created means that the prediction is associated with major uncertainty (Linturi & Kuusi 2018).

It is also good to note that artificial intelligence will not have the same effects on the work and employment of all people. The introduction of new technologies will also have impacts on income distribution. Artificial intelligence may bring about even more such impacts, as it is expected to affect not only routine but also high expertise tasks. The risks of polarisation and increasing inequalities are real (Korinek & Stiglitz 2017), as are the possibilities of social and political disorder, especially over the short term (Eurofound 2018). Consequently, development of societal and economic institutions will be needed. In this development, the criticism levelled at technological determinism should be addressed, and practices that extensively allow and support the participation of different actors, which are easily enabled by digital tools, should be used.

2.3 Policy recommendations

1. National action plans on artificial intelligence should focus on innovations that complement human work, a significant share of which are social and socio-technical. Productivity will only grow extensively once artificial intelligence technology is complemented by changes in the modes and organisation of work that support the take-up of AI.
2. In education contents, the need for combining technological and interaction skills should be addressed, as artificial intelligence will shape the task contents of most occupations. While the proportion of employment that can be automated in full is relatively small, a considerable share of jobs contain tasks that will be automated. This means workers will face changing skill requirements.
3. Technological development is associated with a so-called skills mismatch, also in the context of artificial intelligence: there is a shortage of experts, while those with a lower education level cannot find jobs. To ensure a sufficiently high level of employment and reduce the risk of exclusion, ensuring that everyone has adequate learning skills and that the number of those with no education after comprehensive school is as small as possible is crucial.
4. The scaling of AI technology makes the creation of monopolies possible. Any abuses of dominant market power should be intervened through smart regulation and competition oversight.
5. Labour mobility should be supported to move workers on to tasks that are a better match with their skills, for example by improving employment services. The use of non-competition obligations should be restricted.

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3 Labour market dynamics in a technological revolution[2]

3.1 Economic growth stems from productivity, but productivity growth has stalled

Economic growth measured by gross domestic product (GDP) increases the average happiness[3] and wellbeing[4] of citizens, also in developed national economies. Economic growth is the sum total of growth in employment and labour productivity. A stalling of economic growth has been observed in developed countries everywhere in this millennium. This slowing down cannot be explained by problems of measurement.[5] While no full consensus concerning the explanations for this has been reached by economists, it appears that the most significant productivity potential offered by the previous technological leap has been mostly used up for the time being. The dynamics of business and jobs has stagnated in developed countries.

The long-term growth in labour productivity is ultimately based on technological development, which can be conceived as a multiplication of ideas. This

2 The authors of this Chapter are working group members Mika Maliranta, Niilo Hakonen, Juha Antila, Mika Kuismanen and Susanna Siitonen.

3 Stevenson, B. and Wolfers, J. (2013). Subjective well-being and income: Is there any evidence of satiation? The American Economic Review: Papers & Proceedings, 103(3), 598-604.

4 Jones, C. I. and Klenow, P. J. (2016). Beyond GDP? Welfare across countries and time. The American Economic Review, 106(9), 2426-2457.

5 See e.g. Byrne, D. M., Fernald, J. G. and Reinsdorf, M. B. (2016). Does the United States have a productivity slowdown or a measurement problem? Brookings Papers on Economic Activity, 2016(1), 109-182 and Syverson, C. (2017). Challenges to mismeasurement explanations for the US productivity slowdown. Journal of Economic Perspectives, 31(2), 165-186.

multiplication, for its part, depends on 1) how many people are developing new ideas, and 2) what the level of productivity of the people developing these ideas is, in other words what the level of productivity of research is. Recent analyses have shown that the number of researchers has increased strongly in the last few decades, while the productivity of research has declined: more and more researchers are needed to come up with a new idea. This can be seen in many sectors and in many ways[6].

Information and communication technologies have had a major impact on productivity growth since the mid-1990s. However, this effect dwindled in the first years of the 2000s. Research findings pointing to this phenomenon mainly originate in the United States. As technology development is global, similar trends are likely to also affect other developed countries, although they can sometimes be masked by other country-specific factors. Artificial intelligence is such a new issue that it has not had time to make a major impact on productivity at the level of national economies.

In other words, the advancement of wellbeing still depends to a significant degree on the growth of employment and, above all, labour productivity in the national economy. These growth rates, on the other hand, are greatly dependent on the effectiveness of the labour market: how high an employment rate can be reached? How smoothly is the labour force transitioning from low-productivity work to higher-productivity jobs, or how well is the creative destruction working? In other words, economic growth is undermined by people being unable to find work, or being struck with jobs where their skills cannot be used. If a large number of workers were forced to take on less productive jobs with lower pay, this would also have negative consequences in terms of economic growth.

Not only economic growth measured by GDP but also technological advancement, including artificial intelligence, influence production taking place outside the market in a manner that improves welfare. According to researchers' estimates, however, these benefits are not sufficient to balance out the slowing down of

6 1Bloom, N., Jones, C. I., Van Reenen, J. and Webb, M. (2017/2018). Are ideas getting harder to find? NBER, Working Paper No. 23782.

productivity growth in the market.[7] Such free services as Google searches and Wikipedia make citizens' everyday lives easier, which is not reflected in GDP growth, but when these tools are used as free intermediate products in companies, their productivity is increased, and the need for such employees as informaticians is reduced. In this respect, technology development is measured in the national economy level productivity statistics.

A significant consumer surplus is often generated in the market. This means that many consumers would be prepared to pay a price higher than the market price for a product. To illustrate this point, we could imagine what level of monetary compensation the average consumer would require for being unable to use an electric light or indoor toilet, watch television, surf the net or read and update the Facebook for a year. All these aspects of life are clearly more valuable for the consumer than indicated by the price paid for them, which increases the GDP[8]. In digital products, the proportion between the consumer surplus and the price sometimes is particularly great, as the products can be reproduced in almost unlimited quantities, and their marginal production costs are thus low. Consequently, we can expect artificial intelligence to improve citizens' well-being in the future more than what the official GDP metrics show. On the other hand, it is important to remember that earlier key innovations, such as sewage pipe systems, electric light and washing machines, generated immense consumer surplus that we still continue to enjoy.[9]

When interpreting economic growth, we should thus consider how the relationship between consumer surplus and GDP has changed over time. This issue is more hotly disputed than the idea of a significant and drawn-out slowdown in productivity growth.

7 Syverson, C. (2017). Challenges to mismeasurement explanations for the US productivity slowdown. Journal of Economic Perspectives, 31(2), 165-186.

8 Brynjolfsson, E., Eggers, F. and Gannamaneni, A. (2018). Using massive online choice experiments to measure changes in well-being. National Bureau of Economic Research.

9 Gordon, R. J. (2018). Why has economic growth slowed when innovation appears to be accelerating? : National Bureau of Economic Research.

3.2 Digitalisation and productivity growth

Digitalisation has been deemed to offer important potential for improving productivity.[10] Information and communication technologies enhanced labour productivity in the United States in the mid-1990s in those sectors in which they were used significantly. This growth became more sluggish in the early years of the 2000s, affecting mostly the sectors which had earlier seen the most rapid productivity growth.[11] Digitalisation could also be expected to improve the productivity of research and thus accelerate technology development and the growth in national economy productivity. An article about research productivity notes, however, that an increasing number of researchers are needed to create a new invention or innovation[12]. This may mean that the fruit on the lower branches have already been picked — in many sectors, the ideas that were the easiest to invent have already been discovered, only leaving the trickier ones. On the other hand, a new scientific breakthrough may generate an entire wave of innovations.

The creation and destruction of jobs at a rapid pace is part of the productivity growth generated by technology development.[13] However, it appears that the micro-level dynamics of jobs has slowed down rather than accelerated both in Finland and the United States[14].

A technological revolution is often associated with growing productivity gaps between companies. Companies that have been successful in applying new technologies increase their productivity, while others are treading water. In

10 Pohjola, M. (2006). ICT, productivity and economic growth: What will be the next wave? In P. Heikkinen and K. Korhonen (ed.), Technology-driven efficiencies in financial markets (pp. 9-33). Helsinki: Expository studies A:110, Bank of Finland.

11 Fernald, J. (2014). Productivity and potential output before, during, and after the great recession. In Nber macroeconomics annual 2014, volume 29. University of Chicago Press.

12 Bloom, N., Jones, C. I., Van Reenen, J. and Webb, M. (2018). Are ideas getting harder to find? : NBER, Working Paper No. 23782.

13 Aghion, P., Akcigit, U. and Howitt, P. (2013). What do we learn from schumpeterian growth theory? : NBER, Working Paper No. 18824; Comin, D. and Mulani, S. (2009). A theory of growth and volatility at the aggregate and firm level. Journal of Monetary Economics, 56(8), 1023-1042.

14 Kauhanen, A., Maliranta, M., Rouvinen, P. and Vihriälä, V. (2015). Työn murros – riittääkö dynamiikka? Etla b 269. Helsinki: Taloustieto Oy; Molloy, R., Trezzi, R., Smith, C. L. and Wozniak, A. (2016). Understanding declining fluidity in the US Labor market. Brookings Papers on Economic Activity(1), 183-259.

this respect, the findings are somewhat inconsistent. The dispersion of labour productivity between companies within industrial sectors in Finland increased from the early 2000s until 2010, after which year it has decreased slightly. A very similar trend has been observed in Sweden. The dispersion of labour costs also increased slightly in Finland in that period, however clearly less than in Sweden. On the other hand, productivity differences between companies in service sectors have grown in Sweden but not in Finland, which indicates a difference in innovativeness. However, this growth has also declined in the Swedish service sectors in the 2010s. All in all, while dispersion of productivity and pay has increased, the development appears to have stagnated in the 2010s.[15]. This issue is interesting and important, as analyses produced in the United States show that pay gaps between individuals are to a significant degree caused by increasing pay and productivity differences between companies.

In terms of economic growth, the crucial question is whether digitalisation will be able to accelerate productivity growth in the years to come. Promises of this are offered by robotisation and, above all, artificial intelligence. If (and when) they begin to shape the content of work, eliminate tasks and create new ones at an accelerating rate, there will be potential for faster productivity growth. This will have many types of effects on economic structures and dynamics. The best tool for examining the economic impacts of automation in economics currently is the framework proposed by Acemoglun and Restrepon (forthcoming)[16]. It can be used to anticipate future trends but also assess the need for government measures.

Artificial intelligence will have a significant *substitution effect*, thanks to which the same output can be produced with a smaller work input. This will result in elimination of tasks, while also making it possible to channel the freed work input to higher added value tasks, or complete existing tasks better through artificial intelligence.

15 Maliranta, M. (2016). Reaalisten yksikkötyökustannusten kehitys ja siihen vaikuttavat tekijät Suomessa ja Ruotsissa. Kansantaloudellinen aikakausikirja, 112(1), 22-46.

16 Acemoglu, D. and Restrepo, P. (Forthcoming). The race between machine and man: Implications of technology for growth, factor shares and employment. American Economic Review.

At the same time, mechanisms that increase demand for labour are at work in the economy. Due to the *productivity effect*, production costs and thus product prices will decrease and households' purchasing power will grow, driving the demand for labour in the economy. Due to automation development, a machine can be used to perform tasks that could previously only be completed by human work. This creates the aforementioned *substitution effect*. Automation also contributes to improving the efficiency of machines that replaced human work. This generates a similar productivity effect as the one described above. This is about the *deepening of automation*, which will improve capital efficiency and increase the demand for labour using such capitals.

The framework outlined above helps to structure what happens in the economy when automation picks up speed. It can be used to examine what the new balance will be like and how the transition into it will take place. The model can also naturally be used for considering policy measures. It indicates that more automation will take place in a free market than what is optimal for welfare. Without taking the negative effects of doing so into account, companies will substitute labour for machines as much as this is appropriate for the company. Distortions of capital taxation and shortcomings in the labour market will exacerbate the gap between the actual and ideal situation. Labour market rigidities and other ineffectiveness will further increase the tendency to substitute machines for labour in excess of what is rational. Capital taxation distortions will also have a similar effect. While inequalities will also grow during a transition period, the self-correcting mechanism of the economy described above will keep the long-term effects in check. From earlier episodes in history, including industrialisation in the 19th century, we know that the adaptation period may be rather drawn out. In other words, the economy may be afflicted by labour market disruptions, slow pay development and increased income gaps for an extended period. The development thus also contains the risk of long-term increases in inequalities.

Acemoglu and Restrepo's framework also offers a tool for seeking the reasons for the slowing of productivity growth described above. Lack of skills will become a barrier, but this will be about specific types of skills rather than general skills levels. Competence that was previously valued highly may become outdated very quickly. The demand for some capabilities will increase, will other skills will be less in demand. The labour market value of some workers' skills will decline, as many types

of skills gaps will be created. The education system will not necessarily be able to respond rapidly to such changes in demand.

As automation increases productivity, the same production can be achieved with a smaller labour input. The demand for labour will remain at the same level if production is stepped up. A saturation point in the demand for labour may be reached, however, even if product prices go down. On the other hand, technological advancement will enable the development of totally new products, and the labour force may transfer to producing them.

Policy measures and labour market institutions will influence not only the rate of automation but also the form it will take: to what extent it will be about replacing old tasks with machines, and to what extent about the type of automation that enables the creation of new tasks. The aim of innovation policy should not be speeding up automation. Instead, the priority of public measures should be research and development aiming to complement automation in order to speed up the creation of new and new types of tasks in the economy. Acemoglu and Restrepo highlight the importance of academic and applied research and stress the need to understand the societal factors associated with artificial intelligence development. They warn that due to political pressure, policy solutions may end up hindering technological progress and thus the development of welfare, unless the impacts on income distribution related to automation are taken seriously enough.[17]

It is extremely important to ensure that the transition will treat citizens fairly and reasonably. Failing to do so will result in eroding societal trust, which in recent years has been seen as societal protests both outside the political system and within it in elections and referendums.

The Nordic welfare society is clearly better placed to face the social risks brought about by the transformation of work than, for example, the United States. In Finland, this has been underpinned by both the government's social policy and labour market practices and by legislation that protects the weaker party. On the other hand, the obstacles created by various degrees of rigidities in the labour

17 Acemoglu, D. and Restrepo, P. (2018). Artificial intelligence, automation and work. National Bureau of Economic Research.

market will be highlighted in the conditions of a technological revolution, and the idea of transferring the focus on social policy and redistribution of income should thus be favoured. In this case, however, care must be taken to ensure that this will not become a factor slowing down adjustment to the change.

3.3 Digitalisation, the platform economy and the labour market

The most rapidly growing manifestation of the digital economy that mounts the greatest challenge to conventional business thinking is web-based trading venues, or platforms. The platform economy will create plenty of economic efficiency benefits and diversify the labour market through new modes of work. Similarly to trading venues, platforms also enable the meeting of demand and supply in an organised fashion and with low trading costs, and they thus are a tool for the efficient targeting of economic resources. On a platform, funding providers, product ideas and innovations can meet, enabling crowd financing and small investments in developing new ideas. Platforms today also offer a meeting place for jobseekers and employers, and they can be used to offer and find small on-call jobs. Platforms can be used to offer goods for those who need them, which enables not only the selling of second-hand items but also the shared use of many things.

The success of platforms is based on the network effect: each new user makes the platform more attractive. Digitality ensures that the network effects spread rapidly, increasing the scaling potential of platforms. In other words, digitality offers good preconditions for a productivity-enhancing change in company and workplace structures, or creative destruction. A prerequisite for this is that the other requirements for creative destruction, including competition between companies and smooth mobility of labour, are in place.[18]

As the platforms are digital, data is accumulated from all platform activities, offering a significant added value factor for the commercialisation or development of the

18 Maliranta, M. (2017). Tieto- ja viestintäteknologia, tuottavuus ja "luova tuho". In M. Lehti and M. Rossi (ed.), Digitaalinen suomi 2017 (s. 567-581). Vantaa: ERWEKO Oy.

actual platform or the building of third-party applications linked to it. Data is the capital of the platform economy, which cannot be used up; on the contrary, as it is used, it accumulates and is processed further. In addition to consumers, platforms are making their way to the B2B market.

As part of the platform economy, goods in private use, including houses and cars, can be integrated in the sharing economy. This creates a policy challenge: how should the rules on consumer protection, terms and conditions of work and insurance, taxation etc. be formulated to provide a level playing field in the markets between conventional activities and the platform economy? However, the more efficient use of resources that sharing results in cannot be considered a distortion. The platform economy is also associated with a significant risk of monopolisation. In that case, competition authorities and regulators must be up to their tasks. A level playing field is a key precondition for reaping the benefits generated by creative destruction.

3.4 Digitalisation and entrepreneurship

Digitality offers significant new opportunities for updating business models and improving competitiveness. This is why entrepreneurship policy must support the generation of new, innovative entrepreneurship on the one hand and create preconditions and incentives for the renewal of established companies on the other.

According to Statistics Finland, there were approx. 152,000 self-employed people aged 15–64 in the labour market in 2013. In 2000–2013, this figure increased by approx. 32,000. The greatest growth has been recorded in the number of sole traders (excluding farmers) and freelancers. In the last few years, the number of sole traders has increased by some 4,000–5,000 a year. The proportion of sole traders compared to employees grew in the aftermath of the financial crisis in 2008–2016, in particular. It should be noted that not all sole traders operate on a full-time basis. While the number of the self-employed has increased somewhat, it remains relatively small when the structure of the labour market is examined as a whole.

This group's total proportion of the employed aged 15–64 was some 6% in 2013, showing an increase of slightly over one percentage point since 2000.

Self-employment through enterprising is especially compatible with the platform economy and digitalisation development. Firstly, the platform economy enables non-hierarchic activity, even without an employer organisation. Platforms also make it possible for demand and supply to meet in an organised fashion and with low trading costs, and they thus are a tool for the efficient targeting of economic resources. Secondly, self-employment as an entrepreneur often is an efficient way of seeking operative flexibility and thus productivity growth.

Over the years, numerous working groups have considered the possibilities of creating a new category of so-called light entrepreneurs between employees and entrepreneurs. This category already exists in such countries as the Netherlands. In Finland, however, these efforts have proven fruitless. Risk-taking is part and parcel of entrepreneurship. Should the category of so-called light entrepreneurs be created, who would enjoy the security of employees and the possibilities of entrepreneurs, this could distort competition in the same way as if small companies were exempted from value-added tax. The line between employees and entrepreneurs is sometimes blurred, but replacing one boundary with three others would not necessary make things any easier.

Previously, a similar debate about the line between an employee and an entrepreneur was had in the context of agency workers. In the early 1990s, temporary agency work emerged in public discussion as a new phenomenon, and at that time, concerns were also expressed over the manner in which the new mode of working would be integrated in the labour market. The role of agency employers gradually changed to comprise legal activities in which the modes of having work performed and contractual rules became accepted. In the early phase, these activities were marked by questionable and even illegal features. The willingness of large operators who remained in the sector to shape its image as respectable and normal activity gradually resulted in a situation where the operation of the temporary agency work market is acceptable in terms of competition and respectable regarding terms of employment. The change of culture in the sector eliminated pressures to create a separate status for people engaged in temporary agency work and specific statutes on companies in this

sector. The current discussion about the so-called third category needed for work performed on platforms, or devising a new category between employees and entrepreneurs, reflects the poor level of development in the operating culture of platform economy work. As in temporary agency work, it is also possible to build legal business on the basis of the current classifications. While there is an obvious need for updates and adjustments in individual issues related to social security, it is hardly necessary to set up a whole new category.

In platform work, the algorithm used by the platform and changes made in it will affect the terms of work, whether you are in the position of an entrepreneur or a wage-earner. In other respects, working through platforms is associated with similar questions of taxation, social security and labour market position as in the case of any wage-earners, self-employed persons, sole traders, the unemployed or students who are thinking about accepting or giving up work. It is good to remember that in different stages of his or her life, the same person may have a number of different roles, some of them even simultaneously.

Clear rules, smoother transitions between different roles, and predictable decisions and outcomes concerning such aspects as social security, pensions and the net income are on people's wish list. These are goals that society should also aim for. They will be particularly important if working through platforms becomes a route to work, the labour market or entrepreneurship for an increasing number of citizens.

3.5 Digitality and well-being at work

Digitality already is a cross-cutting phenomenon in the Finnish world of work – not something that is on the horizon. For example, most members of the trade unions affiliated to the Central Organisation of Finnish Trade Unions - SAK also use other digital technology in their work apart from communication devices, or a mobile phone and e-mail[19]. Digitality has an even bigger impact on work in white-collar occupations. Additionally, many people have already become accustomed to

19 Miten uusi teknologia muuttaa palkansaajien työtä? SAK:n työolobarometri 2018.

effective digital services at home and at school and also expect to have them in the workplace to support their work.

The message from a number of different indicators is rather consistent: the level of well-being at work is on average higher than before in Finland, and higher than in our competitor countries. Well-being at work correlates positively with the quality

of leadership.[20] The average quality of Finnish leadership is also relatively good by many standards and by international comparison, but as has been observed in every country, there are great variations between companies.[21]

The impacts of digitality on well-being at work depend on leadership practices. Digitality increases the need to see to the employees' upskilling. Taking older employees into account when introducing new technologies is especially important. It has been observed that most older people in the position of employees are struggling to use technology, and they also are less motivated to learn to use new hardware and software than their younger colleagues. Unless sufficient attention is paid to this issue, the goal of extending careers is at risk.

Digitality makes it possible to improve the meaningfulness of the employees' work, but this strongly depends on the possibilities the employees have of influencing the purchases and uses of new technologies. In the language of the labour market, this is about employee participation. Successful employee participation is a precondition for the personnel seeing changes as meaningful and being motivated to use new technology in a way that improves productivity. The majority of workplaces have not succeeded in using technology optimally[22]. Smooth employee

20 Bloom, N., Kretschmer, T. and Van Reenan, J. (2009). Work-life balance, management practices and productivity. In International differences in the business practices and productivity of firms (pp. 15-54). University of Chicago Press.

21 See e.g. Maliranta, M. (2017). Johtamisen laatu, talouden uudistuminen ja tuottavuus: Arvioita Suomen tilasta. Työpoliittinen Aikakauskirja, 60(2), 33-49; Maliranta, M. and Ohlsbom, R. (2017). Suomen tehdasteollisuuden johtamiskäytäntöjen laatu. Research Institute of the Finnish Economy, ETLA raportit No. 73. Jokinen, J., Sieppi, A. and Maliranta, M. (2018). Johtamiskäytäntöjen laatu suomen ammatillisessa peruskoulutuksessa. Kansantaloudellinen aikakausikirja, 114(2).

22 SAK:n luottamushenkilöpaneeli, kevät 2018.

participation has close links with the workplace culture, in which leadership plays a crucial role.

It is natural to think that the quality of leadership is accentuated at the time of a technological revolution, as companies have more urgent needs to renew themselves. Good leadership is a factor that improves both productivity and welfare, thus creating a positive correlation between productivity and well-being at work. In a competitive environment companies have incentives to develop leadership, as it improves productivity and profitability. Good productivity also requires a skilled and motivated workforce, and in a competitive environment it is thus economically profitable for companies to invest in well-being at work.[23].

The possibility of using digitality in all sectors and almost all workplaces is a positive trend. Workplace practices and culture form a filter through which technology is implemented. Leadership and well-functioning work communities play a crucial role in this. From the public policy perspective, work communities should be supported, as deficient technology implementation will undermine working life quality and the potential of digitalisation.

3.6 Policy recommendations

The starting point of the recommendations is that technology does nothing by itself; things are done by people, individually and together. Rather than what is technologically possible, the essential point is what is also expected to be profitable and desirable. The use of artificial intelligence and digitalisation enables a productivity leap, but this leap can and should be taken without impoverishment in society.

23 Maliranta, M., Jokinen, J. and Sieppi, A. (2018). Johtamiskäytäntöjen tutkimus: Havaintoja suomen ammatillisen peruskoulutuksen oppilaitoksista ja teollisuuden toimipaikoilta. Labour Institute for Economic Research, Talous & Yhteiskunta 2/2018.

An effective labour market will be more important than ever

1. When new technologies are introduced, an effective labour market will be more important than ever. Measures are needed to promote the transition of those who are employed to tasks and jobs that are a better match with their skills and more productive, in a manner experienced as secure. Change should appear more attractive than preserving status quo. This way, the nation's skills can be used better, and vacancies will also become available for new entrants in the labour market. In order to promote labour mobility, employment services should also be offered to the employed. Concrete measures could include a notification service of suitable vacancies implemented using artificial intelligence and directing employment services to not only the unemployed but also those already in employment. Complementary income transfers or pay subsidies could also be used more, as is done in Sweden.
2. In an era of a technological revolution and transformation of work, the harmful effects of an ineffective labour market are exacerbated. On the other hand, employees' need for security and fair treatment is increased rather than reduced. If the current means for achieving this become more costly, it would be justified to consider new means for ensuring security. The security offered for employees by labour market rigidities can be made up for by strengthening the social security and education systems. From workers' perspective, secure transitions between jobs enable the requisite labour market dynamics.

Public support should not lead to market distortion

3. In the reconciliation of earned incomes and social security, solutions should be avoided that put sole traders in a better position than SMEs competing with them, for instance, or otherwise distort the market function, hampering

productivity-enhancing change in business and job structures, or creative destruction.

4. The positive impacts on productivity of such revolutionary technologies as artificial intelligence are born from creative destruction with which the government should not interfere. Some companies will not be able to take up the possibilities offered by the technological revolution. While public policy may promote the preconditions for taking up technologies, public funds should not otherwise be spent on subsidising such companies.

No need for a regulated new category between entrepreneurs and wage-earners

5. Setting up new categories in between entrepreneurs and employees is not recommended, as they could easily blur the roles of these actors vital for the national economy in a manner that would distort entrepreneurship. New categories can also easily create new marginalised groups. Instead, the current social security system should be improved, providing for smoother transitions with more predictable consequences between different roles in the labour market, including studies and unemployment.

A workplace development plan to promote complementary artificial intelligence innovations

6. In years to come, the greatest impacts of the transformation of work and technology will be seen in the workplaces, and they should thus be at the core of development and the measures that support it. It has been estimated that when new technologies and ways of organising work are used, work content, practices and the required skills and leadership will be gradually renewed in all sectors and work communities and all types of tasks. Programme-based and long-term working life development should thus be continued in Finland, and it should be linked to innovation

policy with the aim of promoting artificial intelligence innovations that complement human work.

Back to basics in innovation policy

7. It is recommended that rather than accelerating automation development, innovation funding should increasingly be targeted at innovations that generate new types of production, as they create new tasks and jobs. For example, organisational and social innovations needed for the successful utilisation of new technologies should be supported.
8. The central government should encourage multidisciplinary and versatile research with closer links to basic research which also builds up cooperation between universities, companies and public organisations. Eligibility for support should depend on the level of ambition and viability of the innovation, not such criteria as company size. The level of research and innovation funding should be increased, and Finland's R&D investments should reach 4% of the GDP by 2030 as recommended by the Research and Innovation Council.
9. The universities' performance guidance and incentive scheme should be updated to create clear incentives for participating in cooperation and network projects and commercialisation of research. Experience has shown that R&D funding should be increased gradually through a multiannual programme requiring commitment.

4 Learning and skills in a transition[24]

4.1 Impacts of artificial intelligence on skills

The utilisation of general-purpose technologies based on artificial intelligence in society will change the world of work and the skills needed in it extensively. Issues related to competence and learning will then unavoidably emerge. General-purpose technologies have also had diverse impacts in earlier times: while they have been used to develop working methods and efficiency, they have also created new markets and services.

In addition to skill requirements, these impacts extend to learning itself. This can be illustrated by imagining a situation where no electricity would be used in the learning environment. The use of electricity was introduced gradually: first came lighting, which naturally had an important effect. The other impacts really only became visible when the use of audiovisual materials or computers in teaching began. Major impacts have only become apparent now as we transition to digital learning environments.

It is good to realise how late electricity, for instance, started having more in-depth significance in learning situations. This example shows how long it may take before new general-purpose technologies have a more significant effect on human activities, such as learning. The impacts of technology have been felt radically faster in work and skill requirements than in learning. In the case of artificial intelligence, the impacts may materials at an equal rate in the economy and the labour market

24 The authors of this Chapter are working group members Vesa Vuorenkoski, Anita Lehikoinen, Tuulia Hakola-Uusitalo and Penna Urrila.

as in learning, as artificial intelligence is particularly useful in terms of learning (Brynjolfsson, Rock & Syverson 2017).

4.2 About skill requirements

Technologies based on artificial intelligence frequently improve the efficiency of tasks performed by humans and thus productivity. Machine learning and artificial intelligence are particularly useful in tasks in which analysing big data and pattern recognition are required. While artificial intelligence facilitates and may even replace individual tasks, it probably cannot be a substitute for entire occupations or persons carrying out the work on a particularly rapid schedule. AI-based technologies have so far only replaced routine, highly structured and repetitive tasks (Brynjolfsson & Mitchell 2017).

Workforce skill requirements are influenced by changes in the demand for labour in the labour market. In the future, we can expect the demand for labour to reduce first in occupations where a large proportion of tasks can be performed by AI-based technologies. On the other hand, the demand will grow most strongly in tasks focused on developing artificial intelligence or its applications. In terms of the overall impact, the number of meaningful occupations generated in which human work and artificial intelligence complement each other will also be important. These new occupations will require new combinations of skills. The changes occurring in skill requirements have been approached in at least four different ways. (Acemoglu & Restrepo 2018, Brynjolfsson & Mitchell 2017)

Firstly, skills related to tasks that will be replaced by artificial intelligence will become useless for humans, at least in practice if not necessarily at the theoretical level. This is associated with the question of which skills will be difficult to replace by AI-based technologies and which tasks artificial intelligence will perform better than humans. We should work on not only people's preparedness for change and learning but also companies' preparedness to renew themselves and to support the upskilling of their employees. Society's formal education system should also support continuous development of skills and lifelong learning.

Secondly, the skill requirements associated with artificial intelligence will change as AI use increases. If and when artificial intelligence is used extensively to replace and complement human work, employees must still understand what tasks AI is performing on their behalf, and they must learn to use the artificial intelligence that performs the tasks in question. In order to use learning systems, we may also have to teach them. Even if teaching an AI-based system were not necessary, its operation and efficient use requires an understanding of its operating principles, as is the case with any tool.

Thirdly, work improved by artificial intelligence may provide the person performing it with an opportunity to achieve something else with the work input replaced by artificial intelligence. Workers will have an opportunity and a need to improve their skills in order to produce new added value. This means that the tasks contained in occupations will be diversified and developed. Companies should be able to adapt their employees' job descriptions in cooperation with the employees. Regulation related to occupations should also be examined from the perspective of this development.

Fourthly, artificial intelligence will also change the skill requirements more directly. The wider spread of artificial intelligence will certainly create a great number of jobs that we cannot anticipate yet. This has happened before as a consequence of general-purpose technologies. New occupations with new and as yet unknown skill requirements will be created. The best way of responding to a change of this type is ensuring the sufficient flexibility and ability to respond of systems related to developing society and skills. Learning is possible if citizens have a good level of basic skills and a broad knowledge base.

It is not likely that artificial intelligence will replace humans in tasks that require versatile communication, expressing emotions, drawing on intuition or creativity, or understanding culture and human actions. Applying artificial intelligence is also difficult when the operational situation requires extensive application of general knowledge or background information. Teaching machines or artificial intelligence has so far also been a task for humans. As machine learning advances, the tasks based on skills listed above will no longer necessarily be completed outside the realm of AI application. The launch of large-scale AI use will only take a little longer in the case of these skills. (Brynjolfsson & Mitchell 2017)

Understanding the way in which the nature of skill requirements will change is important because the new requirements brought about by artificial intelligence will at least to some extent be incompatible with the current skills of the workforce. It has been suggested that this incompatibility will slow down the growth in demand for labour, increase inequalities and reduce productivity growth. (Acemoglu & Restrepo 2018)

The incompatibility of the workforce's current knowledge and skills with the demand will lead to an increased need for labour mobility. Different legal barriers and obstacles related to social security and skills for moving between jobs should be dismantled and replaced by bridges that facilitate doing so, and security should be improved. In terms of skills, this means that education programmes strictly producing specialised competence in a specific field must be cut back. In addition to highly specialised competence, education should also offer capabilities for learning new things.

In the midst of major structural changes of the economy, great alterations often take place in the value of competence, or human capital. Many skills that a moment ago were a guarantee of good pay and appreciation may even become completely useless as a result of technological development. Economic history can provide numerous examples of this. Individuals themselves in many cases have the best understanding of their skills. Employers, on the other hand, have the best knowledge of changes in skill requirements. Consequently, we should consider how power over and responsibility for maintaining human capital could be decentralised in a sustainable and acceptable manner. A more effective education market should be devised for the purposes of lifelong learning.

4.3 Learning is changing

It is likely that artificial intelligence will also change the ways in which we learn. It will help to address individual differences in learning better and assist learning (Acemoglu & Restrepo 2018). Artificial intelligence and digitalisation will make it possible to offer individualised teaching of a good standard to a larger group of people at a lower cost.

In learning support, AI-based technologies offer possibilities against which it would be difficult to compete with conventional methods. Similarly to the digital systems that have now been introduced in teaching, AI-based systems will be used to support learning in the future. Those education systems that can apply artificial intelligence the most productively to supporting learning will be successful.

4.4 The Finnish education system and artificial intelligence

Renewal at different levels of the public education system is slow, for justified reasons. Consequently, the ways in which the education system can be updated to respond to the challenges created by increased artificial intelligence use should be addressed at an early stage.

While artificial intelligence and automation will replace skills in the tasks of all workers, lower education level tasks are still expected to be the most severely affected by the change. The education system must be modified, both vocational education and training and higher education. Additionally, more investments should be made in updating the skills of workers already in the labour market, and the lifelong learning system should be reformed. (Ministry of Education and Culture 2018)

More funding alone is not a sufficient response to renewing the education system in the face of the requirements brought about by artificial intelligence. The diversity of education programmes should be increased, adding to them modules that enable the use of new technologies and artificial intelligence and the complementary use of AI.

More emphasis should be placed on skills of the AI era, including communication and social skills as well as cognitive skills that require creativity. In addition, as AI technologies are being developed, the education system should offer studies that develop mathematical skills comprehensively and, in particular, encourage not only boys but also girls to pursue studies in mathematical and technical fields.

Increased flexibility will be needed in the education system to ensure that the offer of teaching can respond faster to the new and changing demand in the labour market. Education must be reformed by offering programmes that support students' freedom of choice and mobility, in which AI technologies are used to support learning. It should be possible to complete studies as modules, from which students could select the ones most useful for them. Ensuring broad access to higher education studies both for young people and those already in the labour market will be especially vital.

Vocational education and training should be changed dramatically by integrating new skills in it, facilitating the possibilities of those pursuing vocational studies of also studying in higher education programmes, increasing freedom of choice and flexibility in terms of content, enabling student mobility between education programmes, and encouraging workplace contacts. (Haapakorpi 2018). While major changes are needed in vocational education and training contents, teaching methods should also be updated.

Additionally, higher education programmes should be modified to respond to the changing skill requirements described above. Young people starting in higher education in 2020 who have completed their matriculation examination in a digital format may still be at working age and able to work in the 2070s. By that time, a number of current occupations will have changed so radically that workers fulfilling today's skill requirements will no longer be able to cope.

Funding for higher education institutions will be developed by expanding the funding basis. It must also be possible to lower costs through AI technology use. The emphasis of resources use should be shifted from premises to offering teaching of a new type, technology use and research.

It has been estimated that in the future, up to one million people in the Finnish labour market should receive continuing training or re-training. The education system should thus offer the working-age population modular opportunities for lifelong learning that are much more flexible, efficient and of a higher quality than today. When developing lifelong learning, we should take into account the fact that young people completing their basic education today may have gaps in their knowledge and skills and that a large proportion of adults have insufficient basic

skills for lifelong learning. Reforms at multiple levels will thus be needed to develop lifelong learning.

4.5 Employers' investments in upskilling

A major share of people's skills are based on on-the-job learning. Artificial intelligence will first be utilised in employers' activities, and employers together with employees will discover the incompatibility between the currents skills and the new skill requirements.

Employers' responsibility for upskilling will grow as, in the context of AI utilisation and specification of the skill requirements related to it, employers are best placed to assess the exact needs for new skills. In this connection, we should note that it is in an individual company's interest to train employees based on their own needs, and companies' training investments are as such insufficient to meet the workforce's training needs. On the other hand, the advancement of technology will lead to more and more new technological and service standards that will enable improved comparability of workforce skills in the labour market.

Successful companies will have made skills development a key part of their strategic management. A precondition for this is higher awareness of changing markets and the potential for new technologies based on artificial intelligence. In terms of digitalisation, it has been observed that excluding start-ups, SMEs are slow to take up new technologies.

4.6 Humans and learning

The wider spread of AI technologies will render some of the tasks performed by humans today unnecessary and, in some cases, these technologies may even fully replace humans in certain jobs. The working-age population will experience a need to update their skills if they intend to stay in the labour market. The great question thus is how to motivate people to continue learning throughout their lives. In the

current political debate, initiatives have been proposed to extend compulsory education to the secondary level. Should we then launch a debate on compulsory lifelong learning?

In any case, learning will become a key coping skill for humans that will increase their likelihood of remaining in the world of work. When creating education systems of the future, methods that stress the themes of responsibility, self-regulation and willingness to learn should be emphasised.

Provision of incentives for learning cannot be limited to the education system, however. The social security system will also play a key role in encouraging learning, and this system must also be geared to supporting, encouraging and enabling lifelong learning.

4.7 Policy recommendations

Elementary skills in preparation for the artificial intelligence era for everyone

1. Artificial intelligence will change the content of occupations and jobs. A risk of exclusion of those with a lower level of education and an increase in structural unemployment is always inherent in structural changes. In order to prepare for the changes, it should be ensured that young people completing their basic education have general knowledge and skills which give them eligibility for further studies and promote lifelong learning. In order to combat high structural unemployment in the future, a competence programme will be drawn up, which will ensure in practice that everyone will have at least a secondary level qualification. In addition to providing more places in education and training, compulsory education will be extended to the secondary level.

High-quality vocational education and training

2. Artificial intelligence will have extensive impacts on occupations, and the quality of vocational education and training should also be improved to respond to the new requirements. In vocational education and training, mobility between education programmes and participation in third-level studies will be enabled for students. Contacts between workplaces and vocational education and training will be promoted by enabling overlaps in vocational teaching and work, also using apprenticeship contracts.
3. More extensive knowledge and skills will facilitate adaptation to changes in occupations. Opportunities for expanding qualification contents will be integrated in education programmes. The aim is to avoid highly specialised competence in an excessively narrow field. AI era competences will be included in the education programmes of different fields, including communication and social skills.

Higher education

4. Education and research programmes for developing and applying AI technologies will be set up.
5. Taking studies structured around modules should be enabled, thus providing more flexibility and freedom of choice for students. Additionally, a comprehensive range of studies that improve mathematical skills should be offered, encouraging especially girls to pursue studies in mathematical and technical fields more often.

All levels of education

6. Use of technology in education should be promoted at all levels with the aim of offering more individualised education content of a higher quality in a cost-effective manner. Incentives for using artificial intelligence to support learning could be created for education providers.

Reform of lifelong learning

7. Finland may be facing an immense education and training challenge as the skills and competence of an estimated one million working-age adults must be updated along with changing occupational structures. In order to respond to this challenge, a lifelong learning reform has to be planned, with the aim of reforming the education system and offering working-age adults diverse, flexible and faster opportunities for lifelong learning.
8. To promote lifelong learning, a skills account or voucher could be created for all working-age people, which they can use to update their skills and purchase the training they need from training service providers. Employees, employers and society have shared responsibility for upskilling the workforce. At the beginning of 2019, the Unemployment Insurance Fund and the Education Fund will merge to form the Employment Fund. The administration of skills accounts or vouchers and tasks related to developing the market for lifelong learning might be assigned to the Employment Fund, while also ensuring that the unemployed and working-age people excluded from the labour market have the right to upskilling. The details of the system would be worked out appropriately as part of the reform. Entrepreneurs should also have equal rights to upskilling.

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5 Good application of artificial intelligence technology and ethics[25]

In its most unassuming form, good application of technology means being aware of the potential negative impacts or problems associated with it and applying the technology accordingly. The most ambitious definition also includes a conscious attempt to use technology to promote certain societal goals regarded as valuable. We start out discussion with the more ambitious goal.

We look at the criteria based on which good application of technologies can be assessed and the ethical perspectives which are associated with technology application in more general terms. The primary object of our scrutiny is AI technology that can be considered to have features of a so-called artificial agent. This concept refers to software, systems, machines and devices as well as the technologies underpinning them that possess autonomous intelligence, or an ability to act and learn through experience and interaction, also without the direct intervention of humans or other actors. Examples of artificial agents are learning algorithms that make decisions, intelligent robots, autonomous modes of transport and many other learning machines and devices featuring advanced automation. In particular, we look at viewpoints which concern the good application of AI technology in the workplace.

25 The authors of this chapter are working group members Tuomo Alasoini, Antti Koivula and Leila Kurki.

5.1 Why do we need debate on good application and ethics?

"Ultimately the question is not only what computers can do. It's what computers should do."

Brad Smith & Harry Shum, in "The Future Computed: Artificial Intelligence and its role in society", 2018. Microsoft Corporation, Washington.

Artificial intelligence technology is disruptive: it revolutionises older practices. It is used to create new solutions which render old technologies and methods unnecessary and change the markets, earning models and modes of leadership, organisation and work based on them. We are living through a revolution where AI-based applications are becoming more common at an accelerating rate. Today's solutions point the direction in ways that may well have highly significant economic, social, political and cultural impacts on the development of societies extending well into the future. These impacts are multiple and, due to their dynamic nature, difficult to anticipate.

Crucial questions include the extent to which this will take place on a commercial basis and driven by companies' business logic, and the extent to which the government will attempt and be able to influence the development. The ways in which the government exerts influence may include education, research, working on attitudes, public procurement or even more direct interventions. The government's possibilities of influencing the way in which technology will be taken up and applied and the rate at which this is happening will, among other things, depend on whether or not a societal vision steering this development can be achieved. The vision should have sufficient political weight and extensive political endorsement. This vision of a good artificial intelligence society should contain values that inform technology use and application, and principles, rules and practices derived from the values.

The issue of a good artificial intelligence society has been touched upon in many reports on AI application. As far as we know, however, none of them has directly attempted to put together a strategy or an action plan aiming for a comprehensive good artificial intelligence society. The reports have often highlighted transparency, responsibility and extensive societal benefits as the values of a good artificial intelligence society. However, detailed definitions of what these mean in practice

and as measures from the perspective of different actors and regulation systems have rarely been put forward in the debate.

5.2 Values of a good artificial intelligence society

In the following sections we analyse what the aforementioned three values could mean in practice in terms of the good application of artificial intelligence in the Finnish world of work.

Transparency

Among other things, transparency refers to openness regarding 1) what data are collected and for what purpose (to underpin decision-making based on artificial intelligence), and 2) what the aim of the algorithms supporting and making decisions is. The employees of work organisations using artificial intelligence in decision-making should also be aware of this. In terms of the transparency of decisions made in a work organisation, it makes no difference in principle if the decisions are made purely by humans, by an algorithm, or by some combination of these two. The importance of transparency of algorithms is accentuated in a very special way in the decision-making of public organisations, where the decisions in many cases concern citizens' statutory rights and obligations.

Another crucial feature associated with transparency is the possibility of tracing the purity and integrity of the data underpinning decision-making based on artificial intelligence and the grounds for making decisions. This is vital for a number of reasons, which include potential errors or structural biases contained in data or the decision-making process, legal protection of those the decisions concern, clarification of responsibility issues, principles of transparency contained in democratic decision-making, safety-related perspectives (for example, the possibility of humans to intervene in the operation of autonomous learning technology), and building up technology developers' expertise regarding the logic of the operation and learning of intelligent machines. The requirement of traceability is highlighted as the functions become more security critical. Particularly accurate traceability should be required in functions directly concerned

with human health and safety. These applications of artificial intelligence are found especially in healthcare, transport, energy production and national defence.

A machine is not a normative learner in the same sense as a human. It is not directed by an idea of learning that is morally correct, or the importance of absolute truth over statistical truth. As deep neural networks and in-depth learning develop, it will be more difficult to get at the grounds of individual decisions made by a machine due to the non-linearities generated in the system. In this case, rather than the grounds of decisions made by individual algorithms, the requirement of traceability focuses on comprehensive understanding of the operation of the entire neural network system.

The problem of traceability can partly be responded to by clarifying the rules of when a machine makes the actual decision and when only a prediction that supports final decision-making by a human. The more security critical the activity and the more difficult to trace the decision, the higher the threshold should be for a machine making independently a decision on the basis of which action is initiated. However, the point of departure in all cases is that humans assume ultimate legal and moral responsibility for the decisions.

Responsibility

Among other things, responsibility means that decision-making based on artificial intelligence does not pose a threat to anyone's health or safety. This requirement applies to an individual's physical and psychological health as well as data protection and protection of privacy. The requirement of responsibility also means that decision-making may not exacerbate structural inequalities found in society or otherwise do injustice or damage or cause suffering to individuals or groups of people. One way of influencing this is promoting the diversity of artificial intelligence developers and other experts. Without sufficiently strong guarantees of responsible decision-making based on artificial intelligence, it is difficult to imagine that the citizens would support the government's attempts to promote the introduction and application of AI technology and innovations based on it.

Responsibility can also be examined from a broader perspective. In situations where society's resources are used to promote AI solutions, society should also

assume a particular responsibility for any resulting job losses. In a market economy, creative destruction brought about by new technological solutions is a normal, and to some extent even desirable, phenomenon as such. If society wishes to consciously promote breakthroughs and solutions based on artificial intelligence, however, it is not fair that people who are affected negatively by these solutions are left without society's special support – after all, they have funded the promotion of these solutions through their taxes.

Extensive societal benefits

Extensive societal benefits mean that AI-based solutions benefit all groups in society. This value should be a key guideline informing all government support for the development of AI technology and applications based on it. The threat to social cohesion caused by an uneven distribution of benefits, which manifests itself as growing income and wealth gaps, is a significant cause for concern. A happy medium should be found in regulation exercised by society and the promotion of extensive distribution of the benefits where excessive restrictions will not reduce incentives for innovation provided for companies and researchers. At the same time, it should be possible to ensure citizens' approval and support for government measures aiming to promote AI technology through income transfers or other mechanisms of sharing the benefits.

It is vital to make an active effort to grasp the opportunities provided by artificial intelligence to develop the world of work. The automation of individual work functions will create opportunities for thinking, organising and shaping tasks in ways that may be radically different. Technology as such will not determine whether the trend will be towards combining the remaining work functions performed by humans into more demanding, diverse jobs that promote humans' opportunities for learning and developing, or increasing fragmentation and depletion of work content. It is important that this room for manoeuvre contained in the technological revolution for developing task content and the entire world of work will be recognised and discussed at the level of the whole society as well as individual work organisations. Ultimately, this is about whether technology will be assigned the role of serving and empowering humans at work, or vice versa.

Influencing the decisions made by large, international technology companies from Finland is difficult. It is crucial, however, to be able to develop technological and work-related competence in Finland that can be used to influence the decisions made by work organisations operating in this country. In this context, Finland can also strengthen and promote regulative initiatives related to digitalisation and artificial intelligence put forward in Europe.

5.3 Policy recommendations

In addition to its far-reaching social impacts, the ethical viewpoints associated with artificial intelligence should also be taken seriously, as they will directly influence companies' business. The values guiding companies in the development and use of artificial intelligence may in the future become highly important factors affecting companies' brand value. The leading companies in the sector have already understood this. For these reasons, the ethical viewpoints related to AI technology should be an important object of technological, business management and political science research in the future, both in Finland and internationally. Finland should also actively promote international research cooperation concerning the ethical viewpoints of artificial intelligence, information exchanges relevant to this theme and the mainstreaming of good practices as well as serve as a pioneer of ethical discussion in the implementation of the EU's artificial intelligence initiatives.

Due to the complex disruptive societal impacts of AI, rather than leaving the definition of a good artificial intelligence society to companies, experts of the field and policy-makers, ordinary citizens should also be able to play an active part. The best way of supporting extensive participation is building up citizens' understanding of AI technology – its operating principles and potential – as a new civic skill that covers all groups of citizens.

Key policy recommendations:

1. The Finnish artificial intelligence strategy should build on the existing ethical value base of our society, which stresses trust and communality. Monopolistic and state-controlled

practices, for example, should not be adopted. The Finnish model relying on the European democratic tradition could serve as an example of a good practice in the EU and globally. A parliamentary monitoring group should be set up to promote the ethical value base of artificial intelligence more extensively in society, and to monitor and evaluate pilots and technology development associated with the ethical aspects of artificial intelligence. The group should also support the creation of rules and assess practices in the context of defining responsibilities in situations where a machine is making decisions autonomously.

2. The ethical value base associated with artificial intelligence should aim for the common good. In practice, however, the value base will be defined individually for each application area. A key area of AI ethics currently is the secondary use of social welfare and healthcare data, in which ethical rules are being formulated, also for more extensive use. Ethical AI will be piloted in the healthcare ecosystem, for example as part of the health sector growth strategy. The task of testing the ethical use of artificial intelligence in occupational health care will be assigned to the Finnish Institute of Occupational Health.
3. The models for ethical rules currently stem excessively from business models based on social media. B2B cooperation and business are a great opportunity for Finland, and it's a field whose ethical rules have not yet been specified so much. In cooperation with the Ministry of Economic Affairs and Employment and businesses, a group of B2B companies making strong investments in artificial intelligence will be put together to jointly formulate key rules for the B2B sector and to create a foundation for a centre of excellence associated with this task.
4. In the development and use of AI technology, attention should be paid to societal heterogeneity and participation. Diversity should be promoted – including different educational backgrounds, linguistic and ethnic

groups, genders and age groups – among AI developers. It should also be ensured that citizens have capabilities for participating in broad-based discussion on the artificial intelligence society. General understanding of the potential generated and challenges created by artificial intelligence should be built up.

5. Obligations may also be imposed on platforms. The EU General Data Protection Regulation (GDPR), which became valid recently, shows that obligations and prohibitions may also be imposed on major global platforms. The prohibition may also apply to a certain part of an algorithm when it distorts or groundlessly restricts competition or is unreasonable from the perspective of those working through the platform. Platforms could also be required to ensure that the income earned through them is reported to the Tax Administration.
6. Trust, appreciation and cooperation have been keys to the success of our small nation before and may be again when we transition to artificial intelligence use. The impacts of a new technology of this type often are unexpected, at least in part. Consequently, it often makes sense to update regulation concerning new technology only after experiences of using it have been gathered. This has also been done before. In Finland, we have every reason to continue trusting our national institutions and their ability to make the required decisions. Plenty of positive experiences of experimentation policy have been gathered in recent years in different areas of society, and stepping up experiments concerning artificial intelligence would be justified.

Appendix 1. Composition of the working group

Chair:	Osmo Soininvaara	Aalto University
Members:	Tuomo Alasoini	Business Finland, from 1 June Finnish Institute of Occupational Health
	Juha Antila	Central Organisation of Finnish Trade Unions (SAK)
	Merja Fischer	Staria
	Tuulia Hakola-Uusitalo	Ministry of Finance
	Niilo Hakonen	Local government employers
	Lauri Ihalainen	Parliament
	Seija Ilmakunnas	Labour Institute for Economic Research
	Anu Järvensivu	University of Jyväskylä
	Antti Koivula	Finnish Institute of Occupational Health
	Mikko Kosonen	Sitra
	Mika Kuismanen	Federation of Finnish Enterprises
	Taina Kulmala	Prime Minister's Office
	Leila Kurki	The Finnish Confederation of Professionals (STTK)
	Ville Kyrki	Aalto University
	Anita Lehikoinen	Ministry of Education and Culture
	Mika Maliranta	Research Institute of the Finnish Economy
	Susanna Siitonen	Ministry of Economic Affairs and Employment
	Penna Urrila	Confederation of Finnish Industries
	Vesa Vuorenkoski	Confederation of Unions for Professional and Managerial Staff in Finland Akava
Facilitators	Kai Husso	Ministry of Economic Affairs and Employment
	Olli Koski	Ministry of Economic Affairs and Employment

Appendix 2. Definitions of artificial intelligence

A short discussion on the definition of artificial intelligence

In the 1950s, Alan Turing asked if machines can think. His definition of an intelligent machine was acting in a manner no different from a human. Following this definition, intelligence can be defined based on functionality. No single and generally applied definition of artificial intelligence exists, however, but a frequently used one is a system's ability to operate in a goal-oriented fashion and anticipate its environment. In practice, however, this definition is not anywhere near covering all systems termed artificial intelligences. The variety of definitions means that accuracy is needed when interpreting studies, and in many cases, artificial intelligence is used as a synonym for digitalisation.

Artificial intelligence as an enabler of automation

One of the key societal impacts of artificial intelligence is likely to be the automation of tasks and functions it enables. Automation can be divided into the automation of information processes (information work) and physical processes (physical work). In a near future, artificial intelligence (in addition to other digitalisation) will probably have the most powerful impact on information processes, as a number of strongly repetitive physical tasks have already been automated, and the level of the technology will not be sufficiently high for more varied tasks, for instance those of a carpenter, even over the medium term. In sectors seeing a high level of investment, for example in automated vehicles, the technology is likely to mature faster, and a revolution is possible also in physical tasks over the next ten years. It should be noted that automation does not necessarily require artificial intelligence, as automation is facilitated by digitalisation in its different forms.

About AI technology

At the end of the day, artificial intelligence is a computer program. The recent artificial intelligence boom is for the greatest part due to the growth in computing capacity and the volume of data in digital format. These aspects are thus influencing the possibilities of using artificial intelligence in different application areas, and a number of international major companies are currently grabbing both computing capacity and data almost aggressively.

Intelligence in machines, as in humans, is a complex property. The majority of the abilities offered by artificial intelligence can be divided into detection (e.g. pattern or speech recognition), building of internal models (e.g. observing interdependencies), and decision-making. In addition, other more application-specific abilities include processing natural languages (e.g. machine translation), mobility (e.g. robots) and computational creativity.

As we have seen, the current AI systems consist of specialised components for each subproblem. This also applies to such systems as the IBM's Watson, which has different modules for various subproblems. Strong general-purpose artificial intelligence almost reaching the human cognitive level is not within our sights even over the medium term.

Typical decisions that can easily be made by artificial intelligence include those that humans can make quickly and instinctively if enough examples of similar decisions are available. These decisions include many image recognition problems. What artificial intelligence finds particularly difficult are problems where a new solution must be found for a known problem. Problems containing plenty of variation are also difficult, as sufficient example data for machine learning is usually not available.

Work in the age of artificial intelligence -report

The report Work in the age of artificial intelligence is part of the Artificial Intelligence Programme set up by Minister of Economic Affairs Mika Lintilä. The programme's steering group was chaired by Pekka Ala-Pietilä. A working group on the transformation of work and society, chaired by Osmo Soininvaara, Lic. Pol. Sc., wrote the report.

The report is a collection of four main articles that discuss (1) the effects of artificial intelligence on general economic and employment trends; (2) the transformation of work and the functioning of the labour market; (3) reforms on education and skills maintenance; and (4) ethics.

Artificial intelligence is a general-purpose technology that changes working life and society extensively. It opens the possibility for rapid productivity growth across the economy and for a higher standard of living. To harness the potential of artificial intelligence, society must invest in updating workers' skills, facilitating workforce mobility and generating innovations that complement human labour. The importance of a well-functioning labour market will be even greater.

One of the working group's proposals for further preparation is a lifelong-learning reform where every person of working age would be given a skills account or voucher that they could use to update their skills by getting the necessary training from providers of training services. Employees, employers and society together would bear responsibility for updating workforce skills. This would create a demand-based market for education and training.

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