

TECHNEQUALITY POLICY BRIEF

Scenarios for the Impact of Intelligent Automation on Work



PROJECT

TECHNEQUALITY

Understanding how technological innovations affect work, education, inequality

Technequality Policy Brief

Scenarios for the Impact of Intelligent Automation on Work

This policy brief is based on the TECHNEQUALITY report: Levels, M., Somers, M., & Fregin, M-C. (2019). Scenarios for the impact of intelligent automation on work. Maastricht: Maastricht University Research Centre for Education and the Labour Market. The full report can be found here: <https://technequality-project.eu/research>.

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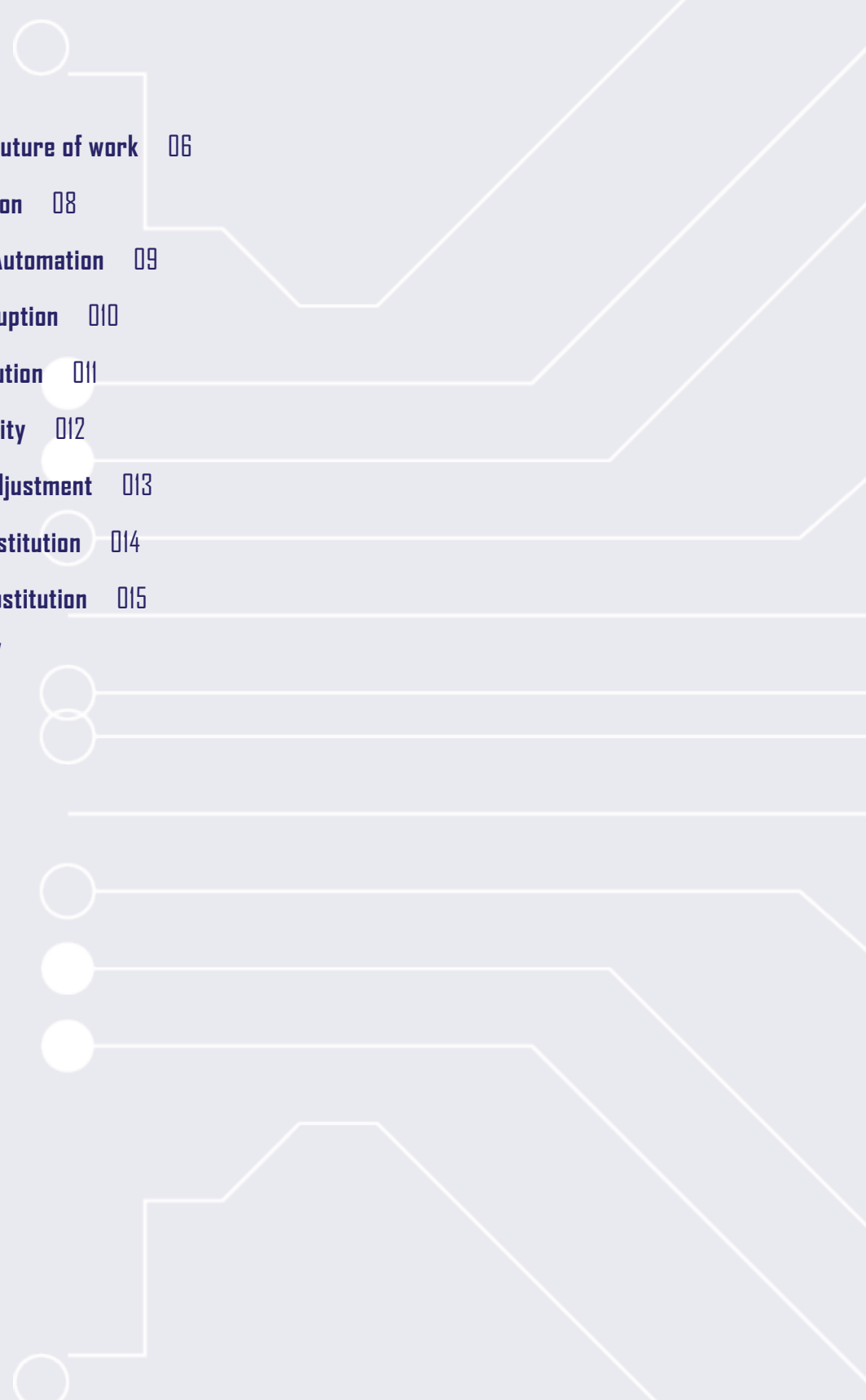
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 TECHNEQUALITY has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 822330



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Technequality Policy Brief

Scenarios for the Impact of Intelligent Automation on Work

Predicting the impact of intelligent automation on labour markets, economies and societies is not straightforward. In fact, it is quite uncertain if, how, and when technologies will affect the demand for labour. However, the current wave of technological innovations has the potential to be disruptive. This challenge demands policy answers under uncertainty. The TECHNEQUALITY scenario study provides eight plausible future scenarios of how the recent wave of technological innovations could affect labour markets in EU countries, outlining implications e.g. for education systems and social policies. With these scenarios, we do not provide predictions. Instead, we take the reader on a thought experiment that can help academics, enterprises, and policy makers to think about potential responses to intelligent automation.

01 Introduction

The performance of many tasks that were considered beyond the potential of computer-assisted technologies are now within the scope of what computers can do. These recent advances in digital technologies and robotics have fed concerns about large-scale technological unemployment. However, historical evidence does generally not support fears of machines substituting for human labour in the past. However, historical technological and economic trends cannot be simply extrapolated into the future. In fact, predicting the impact of intelligent automation on labour markets and inequalities in European societies is not straightforward. It is quite uncertain if, how, and when technologies will affect the demand for labour.

Historical evidence does not support fears of large-scale job loss due to automation. However, historical trends cannot simply be extrapolated into the future. Many factors constrain the adoption and diffusion of technologies.

The adoption and diffusion of technologies is constrained by several factors such as price and access to technology, legislation, availability of training data and also managerial practices and culture.

Existing studies do not provide a sufficient answer to how technologies will affect the world of work with respect to job destruction and job creation but also qualitative changes in work and employment.

Several studies predict the extent to which jobs are susceptible to automation. However, these studies assess to what extent it is technically feasible to *substitute* machines for human labour, but disregard the potential of machines to create jobs and to *complement* workers performing tasks that cannot be automated, thereby ignoring qualitative changes in job tasks. The current wave of technological innovations, and in particular

combinations of “general purpose technologies” (GPT) in the fields of machine learning and robotics have the potential to be disruptive. Although under great uncertainty, these changes demand policy answers.

This report contributes to the understanding of the potential implications of technological change. We develop eight plausible future scenarios of how the recent wave of technological innovations could affect labour markets in EU countries. This study is not an attempt to predict the future, but a thought-experiment. Instead, we explore and describe possible developments and alternative potential implications, given certain crucial variables.

This study is a thought experiment, with which we neither aim nor claim to predict the future. Instead, we use empirical evidence, theoretical modelling and logic to take the reader on a journey into the years 2025 and 2035, describing possible future scenarios and potential outcomes.

The future scenarios serve as thought-provoking tools that can help academics and policy makers to think about potential responses to intelligent automation. To achieve this goal, we journey into the near future, describe possible scenarios from the perspective of the years 2025 and 2035, looking back on what could plausibly have happened between today and 2025 or 2035 respectively. Our thought-experiment is based on the scientific literature and grey literature, as well as transcripts from the TECHNEQUALITY Expert Meeting on the Impact of Automation, organised in April 2019 in Amsterdam¹.

The development of the scenarios is based on following approach: we start with an identification and analysis of the factors that are deemed most crucial in determining the impact of the current wave of innovations on the workforce. We distinguish three key variables. First, the **speed of innovation**. We focus on technological factors

1 Technequality organised an Expert Meeting that took place in April 2019 in Amsterdam. This meeting brought together (1) experts at the forefront of creating disruptive technologies, (2) experts with relevant knowledge of skill requirements in occupations and labour markets, and (3) policy experts from various levels of government. More information can be found in the appendix of the full version of this study.

and discuss the automation potential of key technologies. We also make assumptions about the speed with which innovators are able to overcome bottlenecks in various technological domains. For reasons of simplicity, we distinguish between scenarios that assume a gradual innovation pace from scenarios that assume an innovation boom. Second, the speed of adoption and diffusion of innovations. We make assumptions about the factors that determine the actual adoption and diffusion of technological innovations in organisations. Again, for simplicity, we assume two possible scenarios: one where the adoption and diffusion rate is slow, and one where it is fast. Third, the impact on job tasks. We discuss through what channels technological change can either lead to a displacement of workers or to an increase in the demand for labour. Based on reasonable explorations of possible developments and outcomes, we then develop plausible scenarios for the future world of work and discuss what implications each scenario entails for different groups of workers. In addition, we provide possible policy responses to each scenario.

The goal of scenario studies is to analyse future developments by exploring and describing alternative potential outcomes. Three variables are of key concern: (1) the speed of innovation, (2) the speed of adoption and diffusion, and (3) the impact on job tasks.

To make assumptions, we use existing theoretical models where applicable, and build on existing empirical evidence where it is possible. The rest is a logical exploration of

what could happen, given reasonable assumptions, and not what will happen. By combining the potential outcomes of the three variables, we arrive at **eight scenarios** for the impact of innovations on future work.

Note that it is not expected that the future will unfold precisely following either of these scenarios; rather, these scenarios will probably occur concomitantly. The future of work will most likely be characterized by a *combination* of various possible scenarios that unfold simultaneously, with some scenarios being more plausible in certain economic sectors and countries, and less in others. The strength of a scenario study is that it allows some insights for how to think in a structured way about the future, in cases where extrapolating existing trends is not feasible. This allows us to present and discuss a wider range of potentially interesting policy and business dilemmas that follow from intelligent automation.

In all scenarios, labour market efficiency is only achieved when education systems succeed in endowing school-leavers with the skills demanded on the labour market.

In almost all scenarios, the consequences for human work are considerable. Under the assumption that innovations would primarily have a labour-saving effect, reduced demand for labour and rising unemployment (either short term or long-term) is a distinct possibility. Even if technology augments human productivity, it seems a rise in frictional unemployment is likely. In such scenarios, reskilling of the labour force is essential.

02 Eight scenarios for the future of work

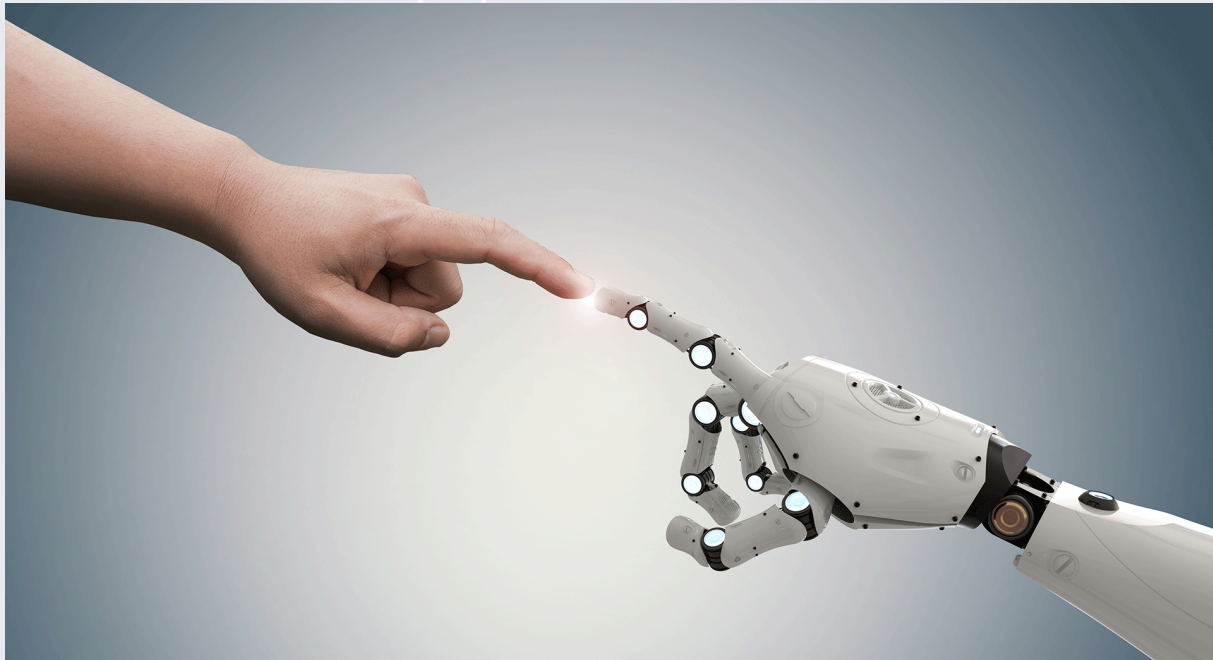
In this section we describe eight scenarios for the future of work.² Although logic dictates that some of the potential outcomes are similar in alternative but comparable scenarios, we chose to emphasize different potential developments in different outcome scenarios. This allows us to present and discuss a wider range of potentially interesting policy and business dilemmas that follow from intelligent automation. We describe these scenarios from the perspective of the years 2025 or 2035, looking back on possible developments between today and then. Using this thought experiment, we describe possible outcomes that would come along with the different “types of future”. These scenarios serve to underline that the future is not fixed, but the way the future unfolds will (partly) depend on these important variables.

In drafting these scenarios, we also make a number of assumptions on other important variables, including the following:

1. Current demographic trends in most European countries (e.g. population aging, declining fertility rates, net migration rates) can be extrapolated into the future.
2. Sociological trends (e.g. educational expansion, increasing social homogeneity, rising social inequalities) continue into the future.
3. Governments are not passive actors but are able to respond proactively to expected trends.

Following current policy debates, we assume they will mostly do so by reforming (a) labour market policies, (b) social welfare programmes, and (c) education and training systems. Of course, large cross-national differences in policy responses will occur, but we reason that all countries will reform policies along these dimensions.

Scenario studies describe how the world could be, given reasonable assumptions, and not how the world will be



² More detailed information about the assumptions underlying the scenarios can be found in the Technequality Report Scenarios for the impact of intelligent automation on work. .



Scenario I

Acute disruption

Innovation: boom


Adoption: fast

Impact on work: mostly substitution

In this scenario, the main engineering bottlenecks of crucial technologies (AI, computing, and/or robotics) were overcome by 2025, and as a result, machines were able to perform both routine and non-routine job tasks. Concomitant to these developments, companies jumped on the technological bandwagon, sped up the adoption of key technologies to keep up with the competition, succeeded in overcoming the main organisational and cultural roadblocks to technology implementation, and adopted HR policies that facilitate those implementations in their value chains.

As a result, the companies who implemented these technologies created new job roles to achieve smooth integration of technologies into work processes. To fill in the new roles demanded by technological developments, companies initially repositioned and retrained their staff wherever that was required, possible, and cost-efficient. At first, these roles were geared toward programming and implementing AI and digitalization of internal processes, and generating training data based on a successful re-design. However, as AI's became trained better in more processes, intelligent automation was increasingly able to perform routine and non-routine tasks.

At this point, the demand for workers dropped, and companies started to lay off human workers whose skill sets no longer matched the skills required in the new organisation. A large number of jobs disappeared and many became unemployed. The wages of workers with demanded skills rose precipitously, but on average, wages steeply dropped. Inequalities soared. Because this happened in a relatively short period of time, the labour market did not have time to adjust. As a result, large groups of workers became unemployed for a long period of time. Education systems were not yet capable of supplying the labour market with required skills, because it long remained unclear what skills would be in demand in the new economy. By the time new jobs became available, however, new cohorts of school-leavers were educated to be proficient in skills demanded to be productive. The supply of young, agile, trained and cheap labour further hampered reintegration of the technologically unemployed.



Scenario II Incremental Automation

Innovation: boom
Adoption: slow
Impact on work: mostly substitution

In this future, the main engineering bottlenecks of AI, computing, and/or robotics were overcome by 2025, and the potential of these technologies became clear. However, market diffusion took a much longer trajectory, because of organisational, regulatory and cultural barriers, and because of practical issues such as lagged process digitalization and a delay in the spread of paperless offices. As a consequence, companies prepared for the implementation of intelligent automation early on. Investments in HR strategies were made in time and cultural barriers were eventually overcome by specifically designed policies. As a result, the companies who implemented these technologies were able to mould job profiles to the demands of the new technologies and thus created new roles and functions to guarantee smooth integration of technologies into work processes. However, all of that took much time.

Governments had ample time to reform education systems to ensure that children were learning the required skills. The stock of well-skilled school-leavers was too low to meet the initial demand, so reskilling of workers became essential as well. Companies invested

and retrained staff where needed and when considered cost-efficient. They mainly selected the most talented from their own rank and file for retraining or hired workers that already possessed the required skills. Wages of workers with demanded skills increased considerably as companies competed for skilled workers. These workers had increasingly interesting jobs that relied heavily on creativity, problem solving, and complex communication.

However, the declining demand for labour led to a slowly but steadily growing surplus of workers on labour markets. The labour market partly adjusted for this, as lower-skilled service jobs increased in numbers and new jobs were created. After a period of job seeking, some workers thus found new careers, mostly in jobs that intelligent machines cannot perform. The share of over-educated workers increased, and some crowding out of lower educated workers took place. Workers that could not find new jobs eventually became inactive on the labour market. On average, incomes steeply dropped, and more people became dependent on income from other sources than labour. Older workers retired early.

Scenario III

Delayed Disruption

Innovation: gradual

Adoption: fast

Impact on work: mostly substitution

Engineers struggled to overcome the main bottlenecks of AI, computing, and/or robotics for over a decade. Slowly increasing data availability in many processes hampered training AI for many processes. The slow innovation pace gave companies ample time to deal with organisational and cultural roadblocks for the implementation of technology in their value chains. Because most new technologies did not yet reach their potential, many companies were implementing technologies that could not yet fulfil all the expectations. Some companies got disappointed and lost interest in investing in new technologies. Those that remained interested had overcome organisational and cultural barriers once the main engineering bottlenecks were solved, and were ready to adopt new technologies fast and relatively smoothly. This allowed them to gain significant early competitive advantages over those companies that did not. The following competition exponentially increased the pace of technology adoption.

At first, wages for workers with demanded skills steeply increased as companies competed for tech talent. By the time intelligent automation technologies reached their full potential, the early adopters had geared

their organisations towards smooth integration of technologies that were already able to perform many routine and non-routine tasks. The demand for workers with skills that machines were also proficient in, steeply dropped in a short period of time. Organisations started to save on human wage costs, either by letting off redundant personnel or by suppressing wages. Unemployment peaked and quickly turned into long-term inactivity.

The relatively slow pace of technology diffusion implied that governments had sufficient time to understand the capabilities of technologies and prepare their education systems for the future. New cohorts of school-leavers were more likely to be equipped with skills that were in demand on the labour market. However, with less work to be done for humans, non-standard work forms (temporary work, part-time work, mini-jobs) became increasingly common. Increasing numbers of people, both workers, unemployed, and inactive, became dependent on support income from other sources than work.

Scenario IV

Slow Substitution

Innovation: gradual
Adoption: slow
Impact on work: mostly substitution

In this scenario, innovation of key technologies took at least until 2035, and the diffusion of these technologies was also very slowly paced. By the time intelligent automation reached its full potential and diffusion in the labour market reached saturation, many older workers had retired and were no longer active on the labour market. Consequently, the supply of skilled labour had significantly decreased and the ratio of workers to retirees had gradually dropped in many European countries.

The pressure on social support systems was exacerbated by the consequences of slowly but steadily advancing automation of jobs performed by younger, lower skilled workers. The slow pace of innovation meant that companies had ample time to prepare their organisations for the implementation of intelligent automation. Job moulding and limited reskilling ensured

that the most skilled workers remained employed for a long time. As the demand for human labour gradually declined with increasing machine capabilities, companies incrementally let go of human workers with obsolete skills. These workers mostly did not find new employment, and increasingly relied on social support for their livelihood. Pension systems and social welfare systems were increasingly costly, and the average income of people dependent on support, dropped. Education systems also were gradually reformed, and labour market arrangements had been put in place to ensure labour markets could adjust gradually.



Scenario V Abrupt Volatility

Innovation: boom

Adoption: fast


Impact on work: mostly augmenting

The innovation crucial to intelligent automation progressed fast and reached its zenith around 2025, when most important engineering bottlenecks had been solved. Ever since, intelligent machines had been capable of performing both routine and non-routine job tasks. Companies had rapidly adopted these technologies and were able to overcome the most important organisational and cultural bottlenecks.

Some jobs disappeared, but most jobs were moulded in such a way that the potential productivity gains from intelligent automation were maximized. Consequentially, the demand for workers with skills that were complementary to machines increased rapidly. However, these skills were not readily in supply, as many workers were educated for jobs that did not yet rely on intelligent automation.

In response, four developments ensued. First, companies competed heavily for workers with the desired skills, whose wages increased rapidly. Second, international and intra-national migration of skilled workers rose sharply, as a response to this competitiveness. Third, large numbers of workers found that their skills had become

obsolete and engaged in reskilling. The most talented workers followed retraining programmes with their employers, but many others lost their jobs. Those for whom retraining was an option relied on government-sponsored training programmes or invested in their own training. Others found employment in lower-paid jobs, and others still became inactive. Fourth, in response to changing skill demands, governments were prompted to reform their state education systems to ensure that school-leavers had the skills required. In order to ensure competitiveness in global markets, governments rolled out study programmes that enabled school-leavers to contribute to technological innovation. In vocationally oriented education systems, programmes that allowed school-leavers to effectively work with intelligent automation, or endowed them with skills that machines did not yet have, were increasingly implemented. In general education systems, the emphasis would remain on teaching active learning techniques that would allow school-leavers to be flexible.



Scenario VI

Controlled Adjustment

Innovation: boom
Adoption: slow
Impact on work: mostly augmenting

In 2025, most important engineering bottlenecks had been overcome and machines could perform both routine and non-routine job tasks. However, companies had difficulties overcoming the organisational and cultural bottlenecks that hampered integration of these technologies into their value chains. As a result, the implementation of intelligent automation took a long time.

This gave governments enough time to prepare education systems to meet the skill demands. Education systems were delivering cohorts of skilled school-leavers to the labour market to meet the demand. As a result, macro inefficiencies in the labour market for school-leavers were limited. The long diffusion time of intelligent technology also gave companies the opportunity to gradually invest in the development of skills. They also incrementally let go of workers whose skills were obsolete and who could not efficiently be retrained.

Middle income jobs required upskilling or disappeared, and the number of jobs requiring high-level skills increased. Lower income jobs requiring craftsmanship and personal socioemotional intelligence were too expensive to automate and also did not decline in number. To make the transition to a new job, informal education and adult education were essential for workers' productivity and long-term employability. Workers who had no access to retraining or who could not retrain successfully for upskilling, took jobs below their level of formal education. In some countries, the responsibility for retraining was regarded a responsibility of employers. Here, relatively highly skilled staff more had better access to retraining, which increased productivity but also inequality. In other countries, adult informal learning was sponsored by state programmes. Here, inequalities were smaller.

Scenario VII

Delayed Substitution

Innovation: gradual

Adoption: fast

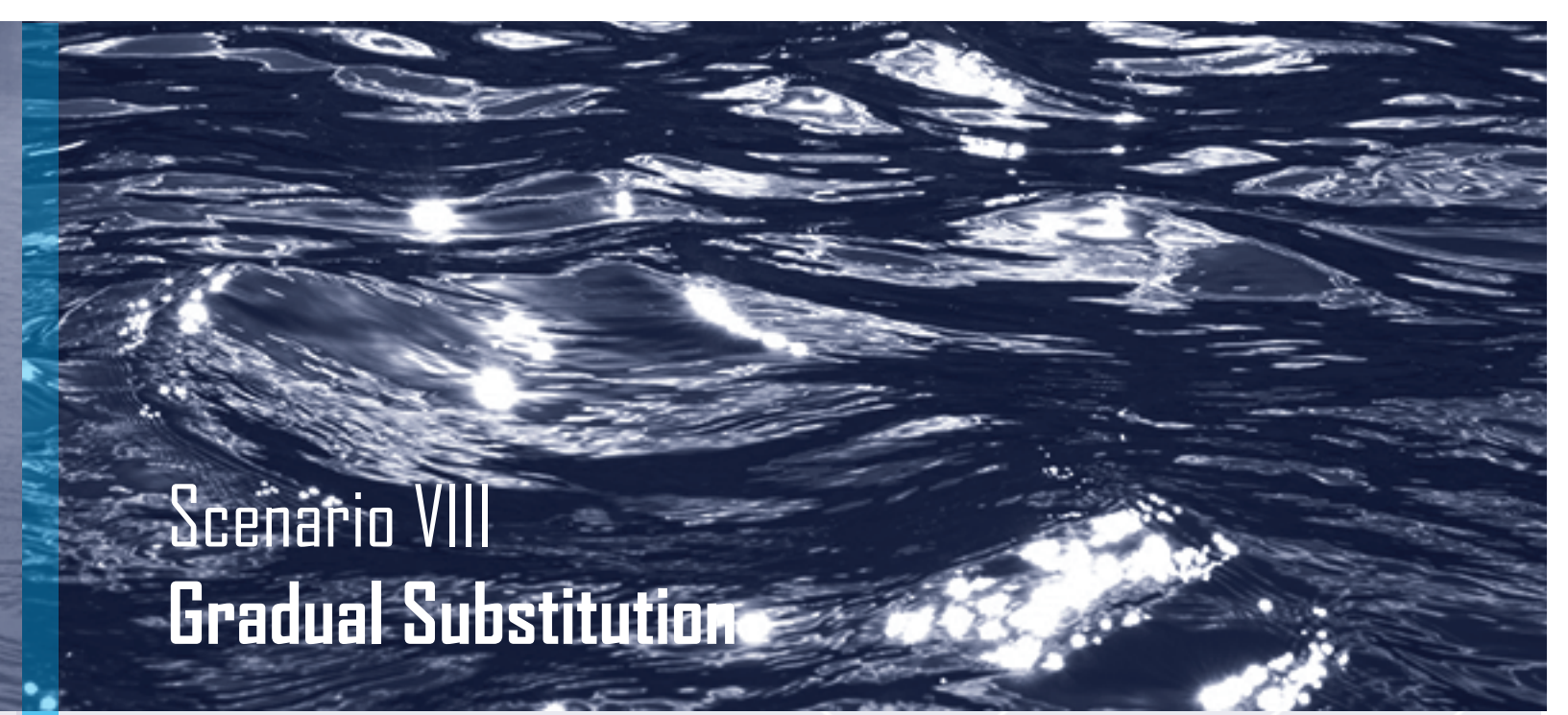
Impact on work: mostly augmenting

In this scenario, innovation of technologies crucial for intelligent automation took at least until 2035. Bottlenecks were only slowly and gradually overcome. By the time they were marketed, companies were ready to adopt technology and integrate them into their value chains. They had incrementally hired and trained staff to help adopt innovations. Few of these were school-leavers, but as the slow and gradual innovation rate made it impossible for governments to sensibly reform education systems, it was long unclear what the potential of new technologies would be, and thus what skills would be in demand. The gradual innovation rate also meant that the need for educational reform was obscured. In many countries, a sense of urgency for such reforms was missing.

When intelligent automation was reaching its peak, many workers still had not been retrained for productivity in the new economy. The number of vacant jobs and unemployment rose, but only temporarily. Many workers actively engaged to find new jobs. The labour gradually polarized, with the number of middle-income jobs decreasing and both lower and higher income jobs surging.

Upskilling programmes became increasingly important for gaining high-income work, for those who were able to do so. People in high-income jobs saw their wages increase.

Those who could not participate in training programmes that would upgrade their skills, had to accept lower-income jobs. As a result, over-education became much more prevalent, and downward social mobility became more common. Wages for low-income jobs did not increase markedly, since higher wages would make these jobs likely candidates for automation. As a result, social inequalities increased. Many new jobs in the low-skilled service sector were created. The increased productivity and availability of workers in high-income jobs resulted in longer work weeks, which in turn implied that more people spent less time on household activities. Their increased income also implied that they could hire personnel to perform household work.



Scenario VIII

Gradual Substitution

Innovation: gradual.

Adoption: slow

Impact on work: mostly augmenting

Innovation of key technologies did not really reach its peak before 2035; the diffusion of intelligent automation technologies also happened incrementally. Eventually, intelligent automation reached its potential, and market adoption picked up speed. At that time, population aging and low birth rates had changed the European population. Mass retirement significantly lowered the worker-to-retiree-ratio and the supply of skilled labour had decreased in many European countries.

As the increasing machine capabilities meant that machines had become more and more able to perform routine and non-routine jobs, the demand for skills had gradually changed. Keeping pace with these developments, companies had replaced workers whose skills were no longer in demand with workers who had the required skills on a piecemeal basis. Retraining programmes helped workers to make the transition to a new job. Formal education reforms ensured that school-leavers were taught the skills needed on the labour market.

Table 1
Scenarios for the Future of Work - Overview

	Variables shaping the impact of automation on work					
	speed of innovation		speed of adoption		impact on job tasks	
	gradual	boom	slow	fast	mostly augmenting	mostly substitution
scenario 1 acute disruption						
scenario 2 incremental automation						
scenario 3 delayed disruption						
scenario 4 slow substitution						
scenario 5 abrupt volatility						
scenario 6 controlled adjustment						
scenario 7 delayed substitution						
scenario 8 gradual substitution						

Potential future scenarios

03 Policy Implications

Governing technological change...

The eight scenarios in this study illustrate that automation of work will almost certainly change the demand for labour and skills, and will likely have consequences for workers in European countries. According to the logic of our scenario studies, the most likely consequences for labour markets are:

- Increased education-to-job mismatches
- Increased skill shortages
- More and longer frictional unemployment
- Increased technological unemployment

These developments are not mutually exclusive; e.g. increased skill shortages may go hand in hand with overeducation. How and when these developments will unfold, and the degree to which they will impact European labour markets and workers depend on the speed of innovation, adaptation and diffusion of key technologies, and the extent to which technologies are augmenting or substituting human workers.

But the economic and social impact arguably also depends on one variable that is not part of our reasoning: government. To design policies that help countries prepare for the future, governments should consider how to curb skill mismatches, reduce skill shortages, and cushion the effects of unemployment.

... requires rethinking education....

Technological innovations may require that we rethink education systems. Three challenges appear to be important. First, the *challenge to educate adults*. In most countries, education is built on the notion that there is something fundamentally different between foundational schooling (formal education in primary, secondary, or tertiary education) and all other forms of education and learning (e.g. adult education, informal education). The school-to-work transition is still often seen as a formal status change, from being enrolled in foundational education to working. However, learning continues long after people leave school, and continuous education will become increasingly important for labour

market success as technological innovations rapidly and continuously change skill demands. In almost all future scenarios, adult learning is a necessity. The lines between the realm of initial schooling and all other education will therefore blur, and to be successful in answering questions posed by innovations, education systems may have to emphasize continuous learning of key skills more strongly. But reskilling adults is not a panacea, and comes with distinct challenges. Workers for which learning is challenging (like older workers, or illiterate and low-literate workers) may have difficulties to engage in training to learn new skills. They will be more vulnerable. Less talented workers are less-often selected by firms for reskilling. Governments may design policies and systems to ensure that all workers have access to reskilling opportunities, and learn the skills needed to remain productive.

Second, the *challenge to meet changing skill demands*. Machines will increasingly be able to autonomously perform tasks that were long thought to be exclusively reserved for humans, including non-routine tasks, strategizing, and complex decision-making. As a consequence, the content of many jobs will change, even in scenarios that do not assume that machine will mostly substitute human workers. To be employable, future workers have to compete with machines, complement machines, or build machines. The skills that are required in many jobs may differ fundamentally from the skills required right now. The following skills will plausibly become essential for employability in the near future:

- math and numeracy
- information processing
- ict skills
- problem solving skills
- interpersonal skills
- ideation
- complex communication

Whether or not education systems can and should more strongly emphasize these skills is a matter of debate. Many argue that education should more strongly emphasize teaching general skills, like learning

ability. However, how to design education systems so as to be able to respond to the changing demand is a key question that policy makers should address.

Third, and related, the *challenge to rethink vocational education*. Education systems usually clearly distinguish between general and vocational education, both in secondary and in post-secondary and tertiary education. In general academic tracks, the emphasis lies on teaching general academic skills, whereas vocational education emphasizes occupationally specific skills. This strong distinction may become outdated, as changing skill demands may also require more general skills (like creative problem solving and learning ability) in jobs that are still highly occupationally specific, and jobs with a high degree of occupational specificity may disappear. In addition, programs in VET systems that are highly occupationally specific now ensure that school-leavers enjoy a smooth school-to-work transition. But the highly specific skill set may prevent VET educated workers to switch to new jobs, should the changing labour market require them to do so. This implies that the role of VET systems may change.

... social welfare ...

The technological revolution may also require that we *reconceptualise social welfare*. Many European social welfare programs are built on the assumption that social welfare is a temporary safety net and that eventually, unemployed workers can find work. Welfare is a social contract: workers may count on it to soften the consequences of unemployment, under the assumption that they strive to reintegrate into the labour market and become productive whenever they can. The social contract builds on three assumptions about the labour market: (1) the number of jobs approaches the number of workers, (2) workers can be taught skills they need to be productive in these jobs, and (3) workers sell their skills at the market price in competition with other workers. This social model assumes fundamental employability, and as a consequence, reintegration on the labour market is usually heavily incentivized. In some scenarios, higher levels of structural unemployment may be possible. This has three reasons. First, some scenarios predict destruction of jobs and a reduction in labour demand. Technological innovations may thus lead to increased structural unemployment. Second, the equilibrium on the labour market may change: even if jobs remain, labour costs may be lowered, and workers may race to the bottom to sell their skills at a market price until their income is no longer sufficient to pay the bills. Third,

reskilling may not be an option for everyone, or take too long to keep up with rapid technological developments. The possibility of longer and more structural unemployment may call for a reconceptualization of the social contract that underpins social welfare programs, and perhaps a redesign of welfare systems.

... and labour markets

Governments can also directly influence the extent to which labour markets respond to changing skill demands. For example, enforcing or enabling active labour market policies may be used to shorten frictional unemployment. Employment protection regulation is another policy instrument that could be considered. On the one hand, it may reduce employers' flexibility to shape HR policies that enable them to create teams of workers that are adequately skilled to meet the changing skill demands. Deregulation may increase firms' ability to adapt to their changing environment. On the other hand, employment protection may incentivise firms to invest in training, and cushion technological unemployment. Another way to increase the availability of skilled labour may be to attract skilled migrant workers.

These examples serve to underline that the way in which the social challenges that will plausibly be created by the automation of labour are not just policy discussions. They are also political discussions, and the course we take also depends on the interests of the various stakeholders. To prepare European countries for the future of work, governments, employers and employee organisations should engage in an open dialogue and co-create policies that work.