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Scenarios for the

Impact of Automation on Work in Europe

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Key message

The current wave of technological innovations (AI, robotics) has the potential to disrupt labour markets and increase societal inequalities. This challenge demands policy answers under uncertainty. Predicting if, how, and when technologies will affect the demand for labour, and the impact of automation on labour markets, economies and societies is not straightforward.

In two TECHNEQUALITY scenario studies, we discuss future scenarios of how intelligent machines could change labour markets in EU countries. The extent of the penetration of automation in industries and occupations and the speed at which automation will be adopted in the economy are the key variables in our scenarios.

In plausible scenarios, we quantify the expected effects on jobs by 2030 and outline implications for education systems and social policies. We estimate that the number of jobs destroyed ranges from 12.5 million to 106.6 million, depending on the scenario considered. This corresponds to 5% and 44% of the total employment in the baseline, respectively. These are the estimated direct job destruction effects of automation but do not account for the indirect (compensatory) effects of automation on job creation.

We also show that the impact of automation on work crucially depends on government interventions and policies.

Speed of innovation and adoption affect the impact on work[1]

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, predicting the future is a risky business; particularly because these technologies are so disruptive, it is impossible to just extrapolate current trends into the future. In these circumstances, we may rely on scenario-based studies to explore potential policy responses. Reasonable future scenarios can serve as thought-provoking tools that can help policy makers to think about potential responses to intelligent automation. To achieve this goal, we start by identifying the factors that are most likely to drive or hamper automation of work. At the core of development of intelligent automation lies the capacity of machines to perform and learn tasks with a limited need for human interference.

The first driver of change is the **speed of innovation**. This largely depends on the elimination of major engineering bottlenecks. In AI, limited availability of training data, limited computing power and limited data storage capabilities still form important engineering bottlenecks. In robotics, machines are still not able to perform tasks requiring fine motor skills and to function in unstructured environments at human level performance. While robots are increasingly capable of performing new tasks, many tasks that seem simple to humans are far beyond the reach of machines. This is Moravec's paradox: "it is comparatively easy to make computers exhibit adult level performance on intelligence tests or in playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility." However, as the development of AI progresses, a new generation of robots is emerging and partly even ready-to-use in industrial production.

The mere availability of technology does not automatically imply that innovations are actually adopted by industries and diffused across markets. Secondly, the impact of automation on work also crucially depends on market **adoption and diffusion rate** of crucial technologies. So, what factors underlie the speed with which new technologies are diffused and adopted? The extent to which companies adopt new technologies partly depends on characteristics of the technologies themselves. Innovations that offer a relative advantage in productivity or cost effectiveness are more likely to be adopted. Innovations that are less costly, more easily implemented (given current practices), can be pilot-tested, and that have easily observable results are more likely adopted. Furthermore, risk, relevance for task performance, and knowledge requirements are also important considerations. Some of the main bottlenecks for implementing new innovations are associated with characteristics of firms and organisations. The introduction of new technologies not only offers opportunities, but also brings along complex challenges for organisations. One key practical barrier to implementation of AI in firms involves cultural and organisational bottlenecks. These include problems of implementing AI in existing work-patterns, the potential to produce and analyse relevant data, organisational cultures, and the availability of human resources. Indeed, the problems to integrate AI into existing operating procedures prevents many early adopters from achieving results at scale. Such organisational bottlenecks are currently the most important hurdles to automation of work, and arguably more important than engineering bottlenecks. Studies indicate that the vast majority of EU businesses expect AI to significantly affect their value chain within the next three years and are currently labouring to adopt HR policies that will allow their companies to be ready for AI.

The third driver of change is the **automation risk**: the extent to which technological innovations affects actual work. New technologies are typically understood to be different from earlier technological developments, in that they are not just augmenting human labour to make workers more productive, but are actually able to substitute for human labour. A hammer that understands how to build a house no longer requires a carpenter. Economic forces (e.g. demand increase for goods and services that are cheaper because of automation) may compensate for the initial labour-saving effect of technological change.

Governments are not passive actors but can respond proactively to expected trends. Current related policy debates focus on reforming (a) labour markets, (b) social welfare programmes, and (c) education and training systems.

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[1] Based on: Levels, M., Somers, M., & Fregin, M-C. (2020). Scenarios for the impact of intelligent automation on work. Technequality White Paper (Deliverable D1.2: https://technequality-project.eu/files/d12fdscenariostudiesv20pdf).

Scenarios vary from gradual evolution to acute disruption on a massive scale[2]

Three variables are of key concern for shaping the impact of automation on work, i.e. 1) the speed of innovation, 2) the speed of adaptation, and 3) the impact on job tasks. By combining the potential outcomes of the three variables, we arrived at eight scenarios for the impact of innovations on future work. These scenarios serve to underline that the future is not fixed, but the way the future unfolds will (partly) depend on these important variables. The scenarios are neither mutually exclusive nor exhaustive and should not be mistaken for predictions. They describe how the world *could* be, given reasonable assumptions, and not how the world *will* be. It is not expected that the future will unfold precisely following either of these scenarios; rather, these scenarios will probably occur concomitantly, with some scenarios being more plausible in some economic sectors and countries than in others. The eight scenarios are:

1. Acute disruption

Innovation: boom

Adoption: fast

Automation risk : mostly substitution

2. Incremental automation

Innovation: boom

Adoption: slow

Automation risk: mostly substitution

3. Delayed disruption

Innovation: gradual

Adoption: fast

Automation risk: mostly substitution

4. Slow substitution

Innovation: gradual

Adoption: slow

Automation risk: mostly substitution

5. Abrupt volatility

Innovation: boom

Adoption: fast

Automation risk: mostly augmenting

6. Controlled adjustment

Innovation: boom

Adoption: slow

Automation risk: mostly augmenting

7. Delayed volatility

Innovation: gradual

Adoption: fast

Automation risk: mostly augmenting

8. Gradual evolution

Innovation: gradual

Adoption: slow

Automation risk: mostly augmenting

These scenarios plausibly follow from the logic that innovation, adoption, and impact on work are the main drivers of automation. They can form the basis for forecasting models that quantify the actual impact of automation on work. In the rest of this factsheet, we will present the results of such quantitative analyses. [3]

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2 Read more about the scenarios here:
Levels, M., Somers, M., & Fregin, M-C. (2020). Scenarios for the impact of intelligent automation on work. Technequality White Paper (Deliverable D1.2: https://technequality-project.eu/files/d12fdscenariostudiesv20pdf) & Technequality Policy Report (https://technequality-project.eu/files/d71fdpolicybrief1v11pdf-0).

3 In the forecasting models, we use slightly more refined measures of the key variables, and a slightly different specification. This allows us to model also government interventions, and make more detailed predictions.

12.5 million to 106.6 million jobs lost by 2030[4]

Reducing uncertainty about EU employment

The impact of automation on jobs is uncertain. Our quantitative analysis[5] suggests that anywhere between 12.5 million to 106.6 million jobs could be lost to automation in the EU-28 by 2030 (equivalent to 5% and 44% of total baseline employment).[6] This wide range of potential outcomes reflects the range of scenarios that were modelled, to account for the uncertainty that surrounds the three factors we considered. **Error! Reference source not found.** presents results for 18 separate scenarios, one for each combination of the scenario assumptions presented in **Error! Reference source not found.**.

Table 1: Scenario assumptions

Factor	Scenario assumptions
Automation risk to occupations	1. High[7] 2. Medium 3. Low
Speed of adoption of automating technologies	Linear trajectory. Full adoption by: 1. 2035 2. 2055 3. 2075
Economic and socio-political barriers to their adoption	1. No employment protection. 2. Employment protection

Source: Heald, Smith and Fouarge (2019)

Table 2: Main scenario results (% difference from baseline by 2030 in EU-28 employment)

	No employment protection			Employment protection		
	2035	2055	2075	2035	2055	2075
High	-44%	-20%	-13%	-37%	-19%	-12%
Mid	-31%	-14%	-9%	-28%	-13%	-9%
Low	-18%	-8%	-5%	-17%	-8%	-5%

The greatest uncertainty lies in the ability of automation to create new jobs. Automation will create some new demand for jobs by increasing productivity and opening new markets. However, the dynamics of these effects are complex, and often involve structural shifts that make historical data less useful for modelling future trends. For this reason, our modelling did not include assumptions on job creation dynamics, and only considered the gross level of job destruction by 2030.

Significant uncertainty also exists in the automation potential of different occupations and the speed of adoption of automating technologies. Our results suggest that job destruction by 2030 will be twice as high under high automation risk assumptions than under low assumptions. Similarly, job losses by 2030 will be more than three times higher if full automation potential is realised by 2035 rather than 2075.

Socio-political barriers have a greater employment impact in more rapid transitions. A policy restrictor that prevents automation from causing redundancies[8] will create a bottleneck that slows the rate of automation in the short run. But in the long run, its impact will be less visible, as incumbents will eventually change occupation or leave the workforce. Consequently, we may expect that such a restrictor would have a stronger effect in more rapid transitions, a conclusion that is reflected in our results.

The pace of transition may be non-linear. Our modelling assumed a linear adoption of technology, whereas technological diffusion typically follows an 'S curve' (or 'tipping point') pattern, leading to more sudden rather than gradual transitions.[9] Such transitions may amplify the importance of socio-political barriers in easing the disruption caused by automation.

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[4] These computations are based on: Heald, S., Smith, A. & Fouarge, D. (2020). Labour market forecasting scenario's for automation risks: Approach and outcomes. Technequality Working Paper (Deliverable D1.4). https://technequality-project.eu/files/d14fdmethodologyscenariodesignv20pdf

[5] Our analysis made use of employment data from the Cedefop Skills Forecast 2018, and OECD data on automation risk by occupation.

[6] In the baseline, total EU-28 employment is forecast to be 243 million by 2030, an increase of 12 million jobs compared to 2018. In the scenario with 12.5 million jobs 'lost' to automation by 2030, total EU-28 employment is only 0.5 million lower than in 2018.

[7] The OECD automation risk data classifies occupations into three risk categories: low (0-50% of jobs automatable), medium (50-70%) and high (70-100%). Our 'high', 'medium' and 'low' scenario assumptions used the high ends, mid-points and low ends of these ranges, respectively.

[8] Modelled here as a restrictor to automation by filling vacancies only

[9] The linear adoption assumption was made due to the uncertainty in anticipating the precise timing of 'S curve' transitions. As a result, linear transitions produce more predictable and easily interpretable results.

Wages and skills in the age of automation

Different transitions will occur in different contexts. We ran three further scenarios which incorporated a more granular analysis of factors affecting the transition. Firstly, relative wages among occupations may affect the speed of adoption of automating technologies, as there is a stronger incentive to automate occupations with higher wages. Secondly, employment protection legislation varies across Member States, creating different barriers across regions. We accordingly designed three additional scenarios which incorporated these elements, using the three earlier assumptions regarding automation risk.

Table 3: Assumptions for additional scenarios

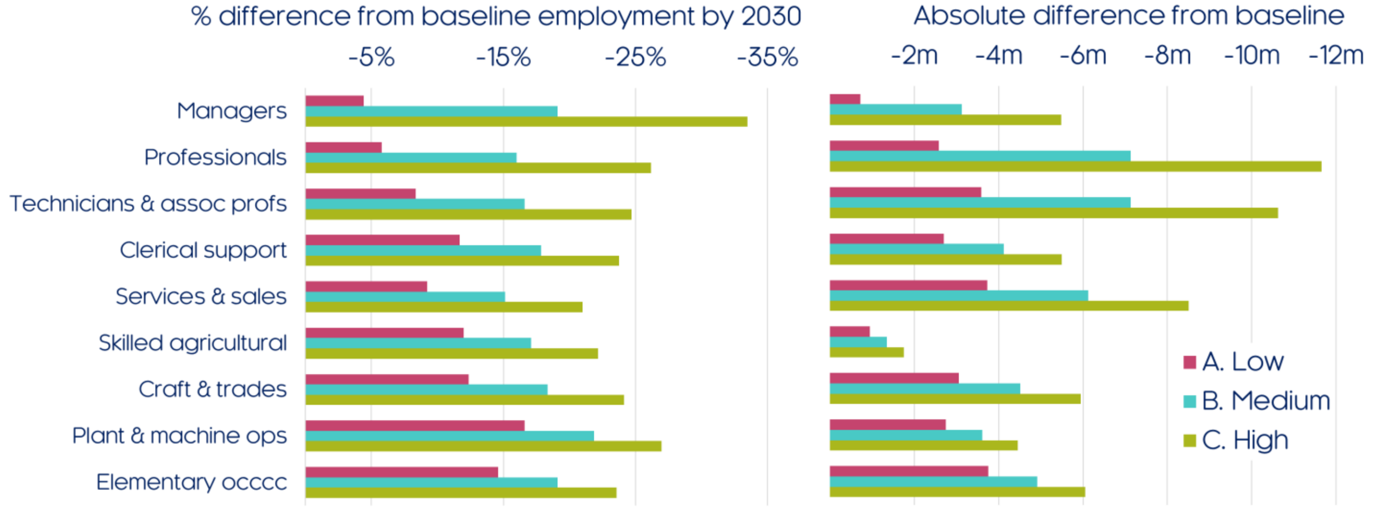
Factor	Scenario assumptions
Automation risk	A. Low B. Medium C. High
Speed of adoption	Linear trajectory. Sector/occupation-specific relative wage defines year of full adoption.
Economic and socio-political barriers	Restrictors placed in regions with stronger employment protection legislation*

* Using the OECD REG5 indicator for 'unfair dismissal' (one of its employment protection legislation indicators), we placed a restrictor on any Member State that scored a 4 or above.

Lower-skilled occupations are at risk in all scenarios, but outcomes for higher-skilled occupations are less predictable. Even under conservative assumptions, around 15% of jobs are forecast to be destroyed in occupations such as plant and machine operators and elementary occupations, equivalent to around 6.5 million jobs across the EU-28. The automating potential of more advanced technologies affecting higher-skilled occupations are less certain, and this is reflected in the wide range of outcomes for managers and professionals in percentage terms.

In absolute terms, the impacts of automation are broad-based. In our conservative scenario, around 2-4 million jobs are forecast be destroyed by 2030 in 7 out of 9 ISCO-08 occupational categories. The exceptions are managers and skilled agricultural workers, who form a relatively small part of the workforce to begin with.

Figure 1: Additional scenario results (% difference from baseline by 2030 in EU-28 employment by ISCO-08 occupation)



Recommendations for policy responses

- **Flexibility and adaptability.** A wide range of outcomes are possible, with unpredictable socio-political impacts. A broad set of policy options should be considered in response to these challenges.
- **Preparedness.** The impacts of 'S curve'-type transitions can be sudden and dramatic, limiting the effectiveness of ex-post policy responses, and underlining the need for policy measures to be prepared in advance.
- **Moderated transitions.** Any policies which can slow the pace of a rapid transition, such as the employment protection restrictors we considered, will reduce the likelihood of dramatic surges in unemployment, and give policymakers more time to react to unexpected developments.
- **Targeted solutions.** Automation is more likely to replace low-skilled jobs, and less likely to create new jobs at that skill level. Policies should especially target this segment of the workforce to prevent disruption and prepare them for the transition.
- **Alertness to unintended consequences.** Measures to protect workers may be counterproductive if they reduce the international competitiveness of EU firms, causing redundancies from failed businesses.