Technequality

Understanding the relation between technological innovations and social inequality

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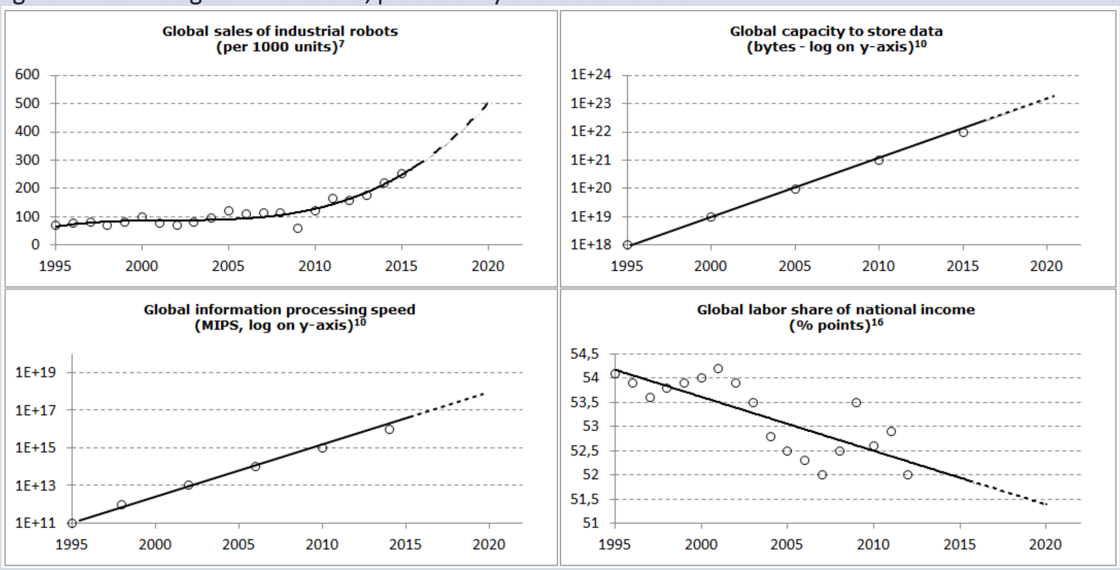
1. Objectives

Technological innovations like robotisation, big data, increased computing power, and machine learning promise great potential for growing productivity and boosting general welfare, and play a crucial role in securing competitiveness and growth of EU economies. However, these technological innovations will also fundamentally change social inequalities (income, skills, wellbeing and health). Relevant cognitive and non-cognitive skills and their continuous acquisition over the life course will probably become more important for labour market inclusion and success than (just) social class membership or educational credentials. However, the extent to which this is the case depends on a set of different institutional settings (like the educational system, the occupation-specificity of labour market allocation, or production regimes). This program studies how recent technological innovations impact the size and nature of social inequalities and labour market outcomes, and assesses which policies and institutional configurations will effectively reduce technology driven inequalities.

Figure 1: Technological innovations, productivity and labour share



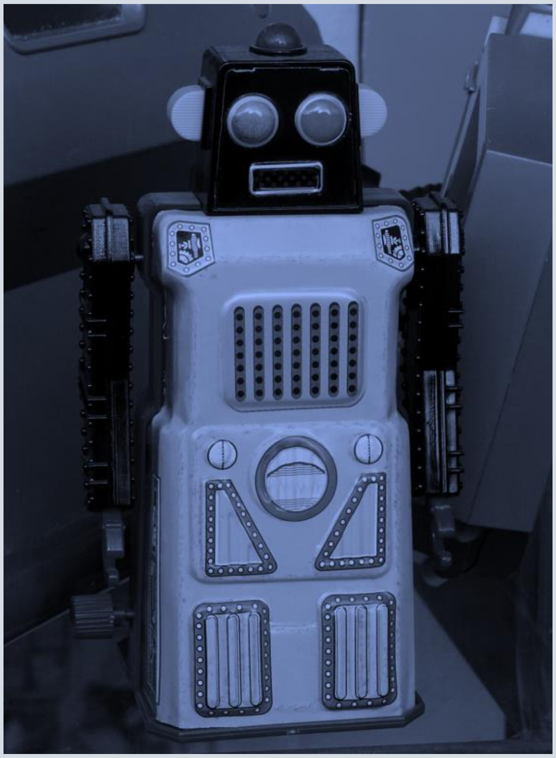
Sources: International Federation of Robotics. 2017. World Robotics 2017. Frankfurt am Main: IFR.; Walldrop, M.M. (2016). More than Moore. Nature 530, 144–147.; International Monetary Fund. (2017). World Economic Outlook. Washington DC: IMF; Hilbert, M., and López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. Science, 332(6025), 60 –65.; Karabarbounis, L. and Neiman, B., 2013. The global decline of the labour share. The Quarterly Journal of Economics, 129(1), pp.61-103.

Advanced economies are undergoing a technological transformation of unprecedented scale (Figure 1). Because of startling innovations in robotics, artificial intelligence (AI), computer capacity, and data storage, an increasing number of job tasks can be entrusted to machines. Machines have long been proficient in performing routine tasks (like assembling cars, or administrating data), but are now also increasingly proficient in complex non-routine tasks (like driving cars, diagnosing diseases, or support in elderly care). As a result, human labour contributes less and less to global productivity.

Technological innovations like AI, robotics, and big data are sometimes hyped, but many scholars assess that current technological developments have a historical parallel only in previous industrial revolutions. New technologies – particularly when combined – promise extraordinary economic growth, but will also have profound societal consequences. Occupations may disappear or change substantially, both in manufacturing and service sectors. Machines could replace many currently existing jobs or job tasks in the next two decades, and usher in a period of long-term technological unemployment. Machine replacement of entire jobs or certain job tasks may affect workers in routine jobs (e.g. coal miners or cashiers) but, and this is unprecedented, also non-routine jobs (e.g. truck drivers or secretaries) and complex high-skilled jobs in the service sector and the professions (e.g. doctors, accountants, lawyers, or data analysts). Current technological innovations are already increasing income inequality. Such technology driven inequalities will likely increase in the next two decades. Although technological developments have always played a crucial role in driving social inequalities, research still offers only limited insights into how recent technological innovations concerning cognitive tasks affect social inequalities. We do not know which social groups will be most affected, how the impacts will differ for different countries, and whether existing inequalities (e.g. between social classes, educational attainment groups, gender, or age) will be exacerbated or reduced.

TECHNEQUALITY aims to improve our understanding of the relation between current technological innovations (robotisation, automation, and digitisation) and social inequalities (income, skills, education, well-being and health) in European countries. The program will make six crucial contributions:

1. We **provide better predictions** of the consequences of technological innovations for European labour markets. We improve on previous studies by providing more realistic forecasting of how technological innovations will affect European labour markets, given plausible scenario's.
2. We **develop and test various theoretical explanations** of why technological innovations will affect income inequality and inequality in the labour market access, and test this model empirically. We assess which specific skills will play a crucial role in driving human productivity, and show how skill proficiency differences can result in technology driven inequalities (in income, education, skills, wellbeing and health). We show how technological advancements change the relation between skills and income and, skills and labour market inclusion, and show which social groups and European countries are likely to be most affected. We pay specific attention to gender differences and differences between social classes.
3. Whether technological innovations will be a blessing or a burden to European societies depends on governance. We **determine the role of education and educational policies** for preparing workers for tomorrow's labour market and exacerbating or reducing inequalities. One way in which the consequences of technological innovations can be governed is through education: education systems function to generate the skills demanded in the labour market and can increase or decrease social inequalities, depending on how they are designed. But the role of education will likely change. We demonstrate how formal, non-formal and informal education over the life course can prepare today's children and workers for tomorrow's labour market, and derive practical implications for their design.
4. Our fourth contribution is that we **assess how government can avert large-scale poverty** resulting from technological unemployment. We test various ways in which social policies can cushion effects of technological unemployment. Economists long maintained that innovation necessarily creates jobs in the long-run. However, this technological revolution may be a game changer. If workers' options to sell labour at ever-decreasing costs



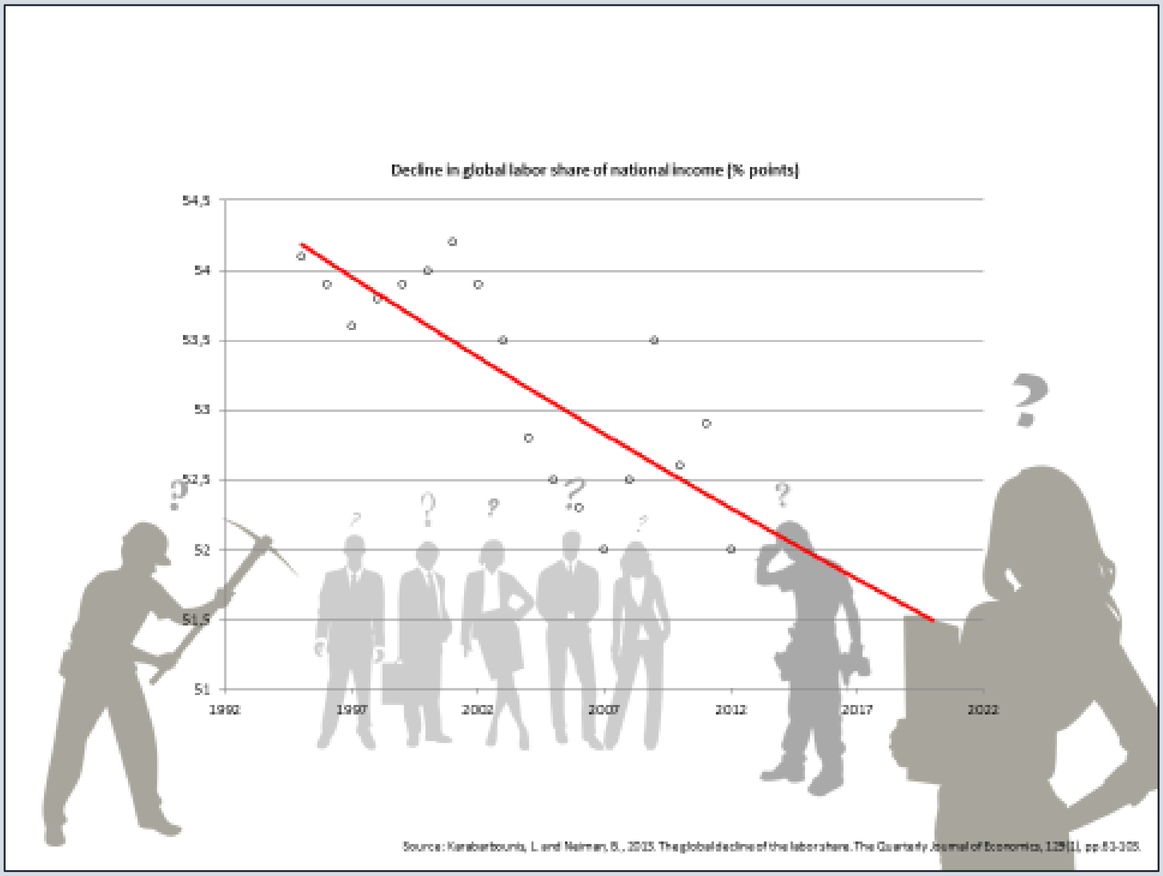
(picture: CC0 1.0 Public Domain)

"Robots and computers may soon take over certain job tasks or even entire jobs. TECHNEQUALITY studies the societal implications in Europe."

hit a natural floor of subsistence levels, technological innovations may lead to structural unemployment. Reskilling may not be an option for everyone, and technology may change too fast for jobless people to master the required new skills. To assure that technological innovation will not lead to high labour market inequality or mass poverty, scholars and policy-makers have argued for the introduction of some form of a Participation or Basic Income (PI/BI). However, the effectiveness and unintended consequences of the PI/BI schemes are not well-understood. A number of countries have been or are engaged in innovative social welfare approaches by way of setting up PI/BI experiments, such as Canada, US, Finland, the Netherlands and Scotland. We show how PI/BI affects individuals' economic decision-making (job search behaviour) and labour market outcomes (access to jobs, participation in society, wellbeing and health), and assess how the introduction of a PI/BI will affect labour market inequality, access to or inclusion on the labour market, and productivity in a number of European economies.

5. We **investigate the consequences of automation for public finances**. Policy interventions aimed at cushioning technological inequality (be it through education or welfare) will require substantial government funding. However, automation could affect governments' ability to implement such policies. On the one hand, changes in taxable income may reduce government revenues. On the other hand, given that the public sector relies on some routine jobs, an increase in productivity due to automation could offset lost revenue and result in lower per capita expenditures from public finances.

6. European economies have undergone transformative technological revolutions before. The computerization revolutions of the 1980s and 1990s and the internet revolution of the 1990s and early 2000s have transformed work and changed the occupational structure of European countries. They have also led to unprecedented economic growth and job creation. None of these innovations and revolutions have led to the net destruction of jobs or technological unemployment. We systematically compare the current technological boom with earlier technological innovations to **assess whether this time is different.**



The declining labour share of national income is seen by some as evidence that the fourth industrial revolution is fundamentally different from earlier tech revolutions. But is it? TECHNEQUALITY strives to find out.

2. Research questions

TECHNEQUALITY will meet these objectives by answering the following research questions and sub-questions:

1) To what extent will technological innovations affect **employment and employability of workers** in Europe?
    a. Which technological innovations have changed skill demands on labour markets in European countries in the past 20-30 years?
    b. To what extent will changing skill demands affect the occupational structure of European labour markets?

c. Which skills and tasks are most likely to be substituted away?
d. To what extent are occupations affected, and how does that differ between countries?
e. To what extent will technological innovations affect labour demand in European countries, using various plausible automation scenarios?
f. To what extent does robot adoption affect local labour markets?

2) To what extent and how will technological innovations affect **social inequalities** in European countries?
a. How do social mobility patterns of school-leavers with different educational attainment levels change because of technological innovations?
b. To what extent does precariousness of various insiders and outsiders on European labour markets change in the light of changing skill requirements?
c. What is the impact of technological innovations for workers of various social classes?

3) To what extent can formal, non-formal and informal **education** produce the skills that are required for the future labour market and society, and exacerbate or cushion technology-driven inequalities?
a. How can education systems remain relevant for preparing current and future workers for the labour market?
b. To what extent does foundational (primary, secondary, and tertiary/general and vocational) education teach skills required on tomorrow's labour market, and how does this vary across countries?
c. To what extent has the link between educational attainment and skills requirements (skill and qualification mismatches) changed over time?
d. How important are informal and non-formal adult education and training for the acquisition of relevant skills by adult workers?
e. What determines participation in adult education and learning?

4) What are intended and unintended consequences of the introduction of **social welfare** programs designed to cushion technological unemployment for people's economic decision-making (job search) and labour market outcomes (access to jobs, participation in society, wellbeing and health)?
a. What is the causal impact of various social welfare solutions (participation income, basic income) on participation and labour market reintegration, particularly of vulnerable groups?
b. What are unintended consequences of PI/BI social welfare programs?
c. How does the causal impact of basic income reforms differ between cities and countries?

5) What are consequences of automation for **public finances** at a local and regional level?
a. How susceptible are different countries' public finances to the increasing levels of automation?
b. How will fiscal revenue streams change?
c. Which regional governments would be most affected?
d. To what extent can a "robot-tax" help to shift resources to regions that are most affected?

6) How does the impact of current technological innovations differ from that of **previous technological revolutions** within Europe?

a. What are the main characteristics of the earlier waves of technological change and automation?
b. How did these earlier waves of technological change and automation correlate with major trends on the labour markets in Europe?
c. To what extent did past waves of technological change and automation affect labour market outcomes?
d. To what extent and why did the impact of technological change and automation on labour market outcomes differ between European countries?

3. Theories on social inequality

To answer these questions, we may want to turn to trusted social-scientific theoretical explanations for social inequality, However, current technological developments may change the very nature of inequality in European countries, and human capital theory, positional good theories, social closure theory, cultural capital theory may become less capable of explaining which people are more likely to experience upward or downward social mobility, both within and between generations. To gain better insights, we will enrich theories and – if need be - introduce new assumptions on required and acquired skills to explain the relationship between technological innovations and social inequalities in European countries. We will provide theoretical advancements in three domains: skills, education, and social welfare.

Table 1: Automatable tasks (2018)

Innovated	Innovation	Skill	Tasks	human expert	Jobs affected	Sources
1988	DeepBlue	Brute force computing, pattern recognition, planning, problem-solving	Optimize strategies	1997	Stock brokers,accountants	69
2006	Lex Machina MLA	Data mining, pattern recognition	Analysing litigation data and advising legal strategies	2006	Lawyers,judges	70
2008	IBM Watson	Natural language question answering	Understanding questions, finding and communicating answers	2011	Medical doctors,teachers	71
2011	DeepMind AI	Complex pattern recognition	Recognizing faces, voices, emotions	-	Intelligence officers	72
2015	CFR+, DeepStack	Intuitive decision-making with imperfect information	Strategic decision-making	2017	Managers,business analysts	73,74
2015	DeepMind MLA	Learning rules without prior information	All tasks requiring general intelligence	2015	All	75,76
2015	AlphaGo	Complex reasoning, intuitive decision-making	Policing, advertising, flying,	2016	Pilots, scientists	77
2016	Quantum Computing	Extremely fast computing	All computational tasks	2016	Data analysts	78
2017	PathNet	Transfer learning	All tasks requiring general intelligence	-	All	80

Sources:[69-80]

Rethinking the role of skills

In a classic human capital framework, being highly skilled increases labour market value. This verity may need to be revisited. Due to technological innovations, social inequalities will be more strongly driven by a specific type of skills. Machines are increasingly able to autonomously perform tasks that were long thought to be exclusively reserved for humans, including reading, writing, recognizing patterns, strategizing, and complex decision-making (Table 1). As a consequence, the content of many jobs will change. To be employable, humans need to be able to compete with machines, to work with machines, to build machines, or to complement machines. The skills that are required in many jobs may differ fundamentally than the skills required right now. There is ample literature that suggests the following skills will become essential for employability in the near future:

- problem solving skills
- interpersonal skills
- ideation
- math
- information processing
- ICT skills
- complex communication
- fluency of ideas
- active learning

These higher order skills are usually thought of as **general skills**, and juxtaposed with **occupationally specific skills**. To fully capture the way in which these skills play a role in explaining technological inequalities, we need to reconceptualise this dichotomy. Indeed, mounting evidence suggests that teaching general and occupationally specific skills are not separate activities. First, to effectively learn occupationally specific skills, some higher-order general skills (like learning ability) are required. Second, we know that learning general skills is most effectively done in domain specific settings. For example, students learn best to be creative by applying problem solving skills to domain-specific cases. Similarly, few universities offer abstract skill courses in analytic thinking, but teach students these skills by teaching them to do scientific research. Third, and related, many skills that are commonly defined as general have a strong occupationally specific component. For example, while both psychiatrists and sales managers rely heavily on their ability to effectively communicate, both use fundamentally different communication skills. To gain better understanding of how education changes in light of technological changes, TECHNEQUALITY conceptually moves passed the dichotomy and aims to understand skills in their collective interplay.

Rethinking education

Technological innovations may also require that we reconceptualise traditional views of education. The traditional view of education strongly emphasizes conceptual distinctions. First, 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. The lines between the realm of initial schooling and all other education will blur, and to be successful in answering questions posed by innovations, education systems may have to emphasize continuous learning of key skills more strongly. We therefore employ a holistic view of education that considers education over the life course and includes all forms of education (formal, non-formal and informal as well as workplaces as learning environments). Second, 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 soon be 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 dexterity/specificity may disappear.

Rethinking social welfare

The technological revolution may require that we reconceptualise traditional views on social welfare. Many European social welfare programs are built on the assumption that for many, 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. The social model assumes fundamental employability, and as a consequence, reintegration on the labour market is usually heavily incentivized. Theory and simulation studies predict that current technological innovations (automation, robotisation, digitization, AI, big data) may require us to rethink these assumptions, and that higher levels of structural unemployment may be possible. This has three reasons. First, some simulations predict destruction of jobs and a reduction in labour demand. Technological innovations may thus lead to structural unemployment. Second, the equilibrium on the labour market may change: even if jobs remain, labour costs may be dramatically 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 technological unemployment calls for a reconceptualization of the social contract that underpins social welfare programs. If potential workers cannot be reskilled, or there are no jobs, they will not be able to abide by the social contract. For this reason, an increasing number of intellectuals, politicians, scholars and policy-makers are arguing for a reconceptualization of the contract and the provision of a participant (PI) or basic income (BI). However, as empirical evidence is still rather scarce (limited to experiments in Finland), these debates remain rather theoretical and often normative. By experimentally assessing intended and unintended consequences of various basic income schemes, this project informs the debate about renewing the social contract that underlies social welfare with facts.

4. Methodology

We have built TECHNEQUALITY on three pillars:

PILLAR 1: Theory, concepts, measurement: This pillar has three goals: (a) to further develop and test the conceptual and theoretical basis to understand the relation between technological developments, skills, and inequalities, (b) to provide measurements of key concepts, and (c) to evaluate the extent to which current technological innovations and their labour market impact are different from earlier developments by placing them into larger trends.

PILLAR 2: Research on key consequences: WPs 2 to 6 in this pillar will create new evidence for the way technological innovations impact social inequalities, and show how education, social welfare, and taxation can be used to reduce these inequalities. The three policy areas were selected because of the pivotal role they play in theoretical frames on reducing inequalities, and because they provide the basis for a range of concrete policy interventions. We focus on their intended and unintended consequences, and use a combination of qualitative and quantitative methods, (quasi-)experiments, and innovative forecasting techniques to answer our various research questions.

PILLAR 3: Policy advice: The theoretical and empirical working packages will systematically provide the policy implications of their findings. By triangulating these findings with the policy debates, TECHNEQUALITY will develop policy briefs with bold and actionable concrete policy recommendations. But perhaps the distinguishing factor of TECHNEQUALITY is that we focus on ensuring our recommendations are followed. By co-creating the recommendations with policy makers and stakeholders we will ensure that our policy recommendations represent the state-of-the-art, are linked to the current realities of policy makers and stakeholders, and are actionable and astute.

TECHNEQUALITY projects:

1. The future of work in Europe
2. Technology, skills, and inequality
3. Educating today for tomorrows labour market
4. Reinventing social welfare
5. Automation, taxation, and public finances
6. Is this time really different?
7. Inclusive policies for reducing technological inequalities
8. Project management, dissemination and communication

Consortium

The TECHNEQUALITY consortium is formed by internationally acclaimed academics, researchers, and managers from renowned research institutes, including:

- Maastricht University: Research Centre of Education and the Labor Market (lead)
- The University of Oxford: Oxford Martin School
- The European University Institute: Department of Social and Political Science
- The Berlin Social Science Centre: Research Unit on Skill Formation and the Labor Market

- Stockholm University: The Swedish Institute for Social Research)
- The University of Tallinn: School of Governance, Law and Society
- The University of Tilburg: Tilburg School of Social and Behavioral Sciences
- Cambridge Econometrics: E3ME

The consortium has been designed to realize appropriate complementarities on several key variables, including expertise, skills, research experience, management, and multidisciplinarity, as well as geographic and social diversity. Through specific connections established by the project, the joint work of consortium partners will optimize knowledge creation and policy implications. TECHNEQUALITY consortium partners have been selected based on six criteria:

- Proven high performance and excellence in research,
- Relevant experience and expertise complementarities
- Successful experience in leading and developing cross-national projects.
- Geographical complementarities
- Disciplinary complementarities
- Fair gender balance

Statue of steel driver and hammer swinger John Henry, in Talcott, West Virginia. The legend of John Henry symbolises the struggle of workers to compete with machines during the previous Industrial Revolutions.

Excellence in research and policy: The consortium combines unique, world class competences in:

- Research: combining expertise in key scientific areas for the topic such as social inequality, skill acquisition, skill requirements, automation impacts, and social welfare.
- Policy: delivering high-level strategic advice on potential impacts and intervention policies to governments at international national and subnational levels

Relevant expertise and expertise complementarities: The consortium gathers the specialised knowledge and skills of reputed researchers required to ensure TECHNEQUALITY's success. Partners include and are coordinated by leading international scholars on automation impacts, social inequalities, skills acquisition, and formal, informal and non-formal education. The team responsible for the field experiments on social welfare and universal basic income has gained extensive experience leading one of the few field experiments on UBI in the world. The team responsible for the forecasting of European labour markets is a renowned research organisation in the field forecasting, and the econometric models it owns are the basis for the European labour market forecasting models used by CEDEFOP and the European Commission. The respective team leaders have played an important role leading national and international research projects on skill acquisition, adult learning, forecasting, and automation.

Joint work in previous EU projects: All European partners know what it is to collaborate at the European level, and some have repeatedly been European project coordinators. The project coordinator has an established record of leading and coordinating relevant international projects for the EU and the OECD.

Geographical complementarities: Since the project objectives are of European interest and the empirical and field work aim to draw a European picture of the sectors and themes treated, great attention has been paid in creating a geographically balanced consortium. Nordic (Sweden), Anglo-Saxon (United Kingdom), Central (Germany, the Netherlands), Mediterranean (Italy) and Eastern (Estonia) European countries are represented. This means much more than the mere geographical coverage of the EU. TECHNEQUALITY covers international (political social, cultural and economic) diversities and exploits them to produce outcomes of European relevance.

Multi- and interdisciplinary background complementarities: Technological inequality plays on the intersections of sociology, economics, and technology. To understand it, insights and methods of various scientific disciplines must be combined and integrated. Methods required to produce knowledge of high quality include forecasting, simulation studies, automation risk assessment, field experiments, quasi-experiments, and predictive analyses, all of whom are strongly grounded in the various disciplines represented in the consortium. TEHCNEQUALITY combines different approaches for more comprehensive understanding of the research topics, for a rich quality exchange and debate on issues that are at the frontiers of the cited disciplines, and, lastly, for complementarity in the views expressed in debates about the future of social inequalities, work, education, and social welfare.

Fair gender balance: the consortium strives for a good gender balance. We will pay particular attention to hire female and non-binary researchers in order to provide them with this excellent research environment, supporting their careers, and include diverse perspectives.