DEMOGRAPHIC CHANGE: WHAT IMPLICATIONS AND OPPORTUNITIES FOR EUROPE’S R&I SYSTEM?

Final Report

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1 INTRODUCTION

This study report brings together an overview of the methodological framework, the steps undertaken and the insights collected within the Foresight on Demand (FOD) project on Demographic change - what implications and opportunities for Europe's R&I system?

Why demographic change?

From around 2030 onwards, Europe is expected to face a **growing population decline** and a **shrinking workforce**, which will significantly affect both the supply and demand for research and innovation (R&I)–skilled professionals, as well as overall economic growth.

Lower economic growth is likely to constrain personal incomes and reduce public budgets, with direct consequences for both public and private investment in R&I. At the same time, a **declining young population** will have substantial repercussions for the education system, including higher education.

These demographic shifts may lead to a reduced need for higher education institutions and academic teaching staff in quantitative terms, alongside a contraction in the range of research fields, reflecting both qualitative and quantitative decline. In parallel, **rapid technological developments** such as artificial intelligence, robotics, and digitalisation are expected to **transform the nature of research** itself. These advances will require significant adjustments within higher education systems to integrate new skill demands and to ensure that both public and private labour markets are supplied with researchers equipped with relevant and emerging competencies.

The study is guided by the overarching question of what the R&I fabric could look like by 2050, with a particular focus on researchers, both in quantitative and qualitative terms. Its primary objective was to **develop plausible scenarios** that capture the key drivers of demographic change and to assess their implications for the R&I system.

All this was embedded in a methodological approach as included in Figure 1. Details about the various steps are provided in the different sections of this report.

Infographic 1 Pressure areas

Source: Technopolis Group

Figure 1 Overview of the methodological steps

Source: Study team

Originally provided as individual reports, this version slightly regroups the findings in a logical process order – for example, by including the identified weak signals and trends as inputs to scenario building.

The remainder of this report provides some insights from the demographic data (section 2), followed by a section on the development of four scenarios (section 3) and the description of the scenarios (section 4). This is complemented by implications (section 5) as well as a section on challenges and opportunities (section 6). Details about the methodology as well as survey results are integrated in the annex.

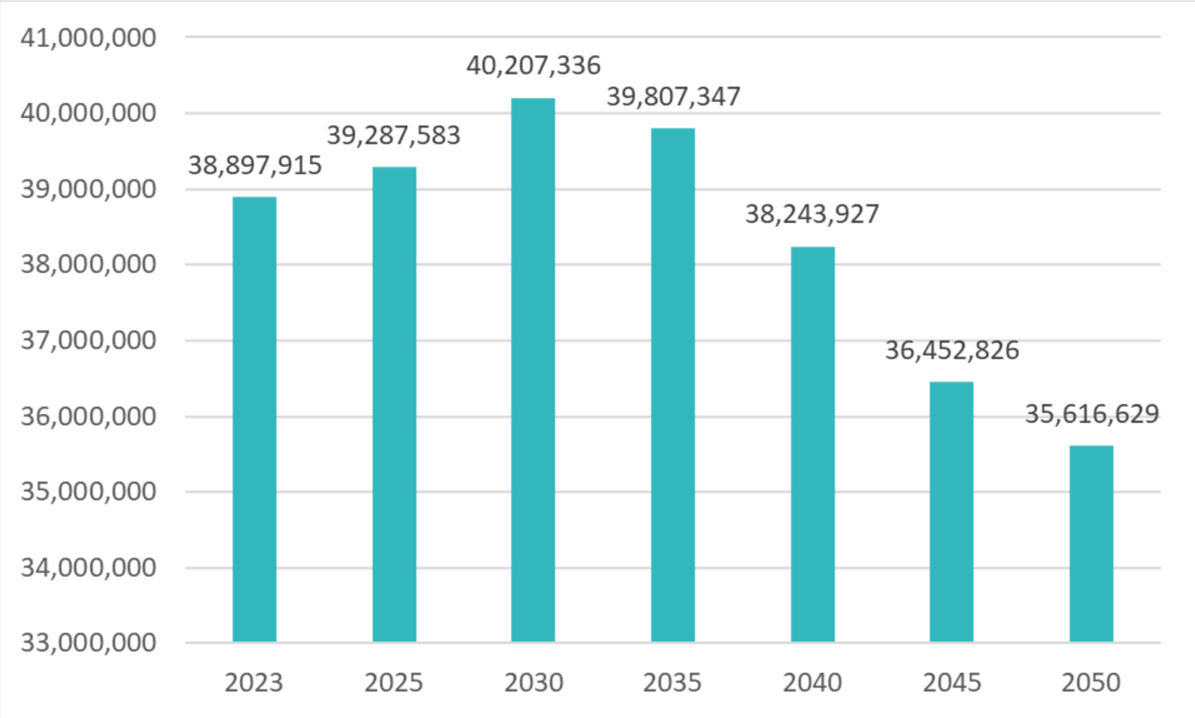
2 DEMOGRAPHIC CONTEXT

Europe is experiencing notable demographic changes, with the EU's total population projected to peak in 2026 at 453.3 million, before entering a period that is characterised by a gradual decline to 2050. In this period, the overall decline is about 3 people for every 10.000 residents each year (0.003%), on average. A key aspect of this demographic shift is the ageing of the population, with the proportion of individuals aged 85 and over is expected to more than double, reaching around 10% by mid-century. This will likely shift research priorities toward healthcare, gerontology, assistive technologies, and social care, with possible implications for the allocation of public R&I budgets.

At the same time, the working-age population (20 to 64 years) is projected to decrease in 22 out of 27 EU Member States. The population under-20 is set to decline across most of the EU between 2026 and 2050 except for Malta, Luxembourg and Sweden.[1] By 2050, there will be more than three million young persons less in the EU. This demographic trend may result in a smaller pool of students and early-career researchers available to both the public and private sectors, posing possible challenges to sustaining innovation capacity and skills supply in the longer term.

[1] European Commission (2024) 2024 Ageing Report

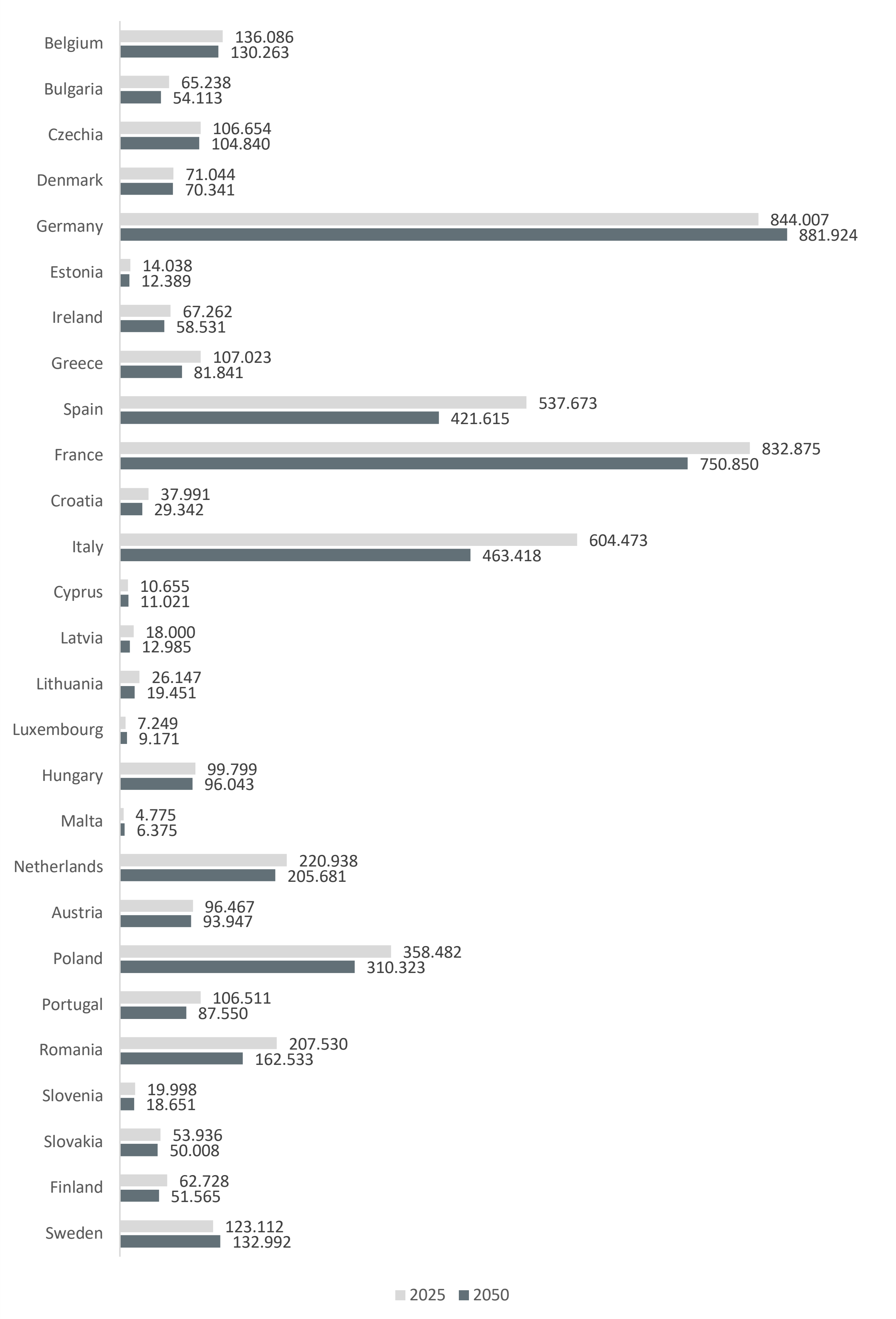
Figure 2 Projected numbers of 20- to 26-year-old persons in the EU-27



Data: Technopolis Group based on Eurostat projections

The overall decline is however not evenly distributed. Italy and Spain will be the countries losing more than 100.000 persons in the age group for 20-year-old persons (see Figure 2), but also in the years 21 and onwards, these countries lose large cohorts. Mos other Member States suffer losses, however to a smaller extent. France loses about 80.000, Poland and Romania about 40.000 of 20-year-old persons. Considering that this is often the starting year at university, one can also imagine that some universities will need to downsize due to lack of student supply - or develop alternative education offerings.

Figure 3 *Population aged 20 years in 2025 and 2050 by Member State (absolute numbers)*



Data: Technopolis Group based on Eurostat

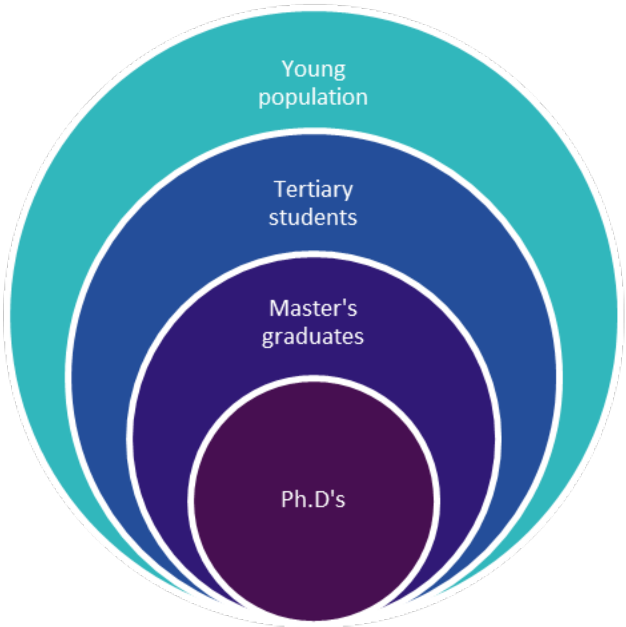
Tertiary student populations

So far, no projections of tertiary student populations have been attempted. In this study, we aimed to estimate the quantitative effects of population decline on the number of tertiary students, Master's graduates, and PhD students. The latter form a core group from which researchers and scientists emerge. They are the ones who choose an academic career and thus educate the next generations of students, or they decide to work in public research institutes or in the private sector and continue with R&I activities.

When considering the projected number of people aged 21 to 26—the average age group from which a proportion will be enrolled as tertiary students in the EU-27—one notes the expected peak in 2035. From then onwards, the number decreases significantly, by almost 2.5 million by 2050.

This group is not only the primary target for universities and their education programmes, but also the segment of the population from which Master's graduates continue post-tertiary education careers by pursuing a PhD, and potentially entering either the academic or public-sector labour markets, or joining the private sector as research personnel.

Figure 4 Decreasing pipeline of future researchers



In 2023, there were 18.8 million students enrolled in tertiary education in the EU-27. Based on the population aged 21 to 26 in 2023, this represents a very high share of almost 64%. Since we know that about 43% of those aged 25 to 34 have a tertiary degree[2], one would need to extend the age bracket and include those aged 27 and 28. This leads to a lower rate of around 46%. We also know that there is a gap between enrolled students and graduates; the number of enrolled students is typically higher than the graduates because a share of students will not complete their studies.

To calculate future PhD numbers, one first needs to estimate the number of master's level graduates ,since a master's degree is typically required before a PhD can be pursued. The available Eurostat data offers at least two options: calculating ratios based on the number of graduates in a given year, or calculating rations based on the number of degree holders in a given age bracket of the population. These two entry points will generate two different figures.

[2] see EC: Education and training monitor 2025

In 2023, there were a total of 1.62 million master's level graduates and 102.730 PhD's – giving a ratio of 6.4% masters'' to PhDs.

- One may wish to limit the age bracket, since the majority of master's degrees are obtained when individuals are between 22 and 26 years old. In 2023, there were 935.200 Master 's graduates in the EU-27 within this age group.
- PhD's are predominantly obtained between the age of 25 and 34. In 2023, within the 25 to 29 and 30 to 34 age groups, almost 71.650 students obtained a PhD. Within these age groups, the ratio of PhDs to Master 's graduates is 7.6%.

Overall, the share may be slightly overestimated when the data of people with a given tertiary education background per age bracket is taken into account. According to Eurostat data, in 2023 and in the group of 30 to 34 years old (in total 28.3 million) persons, the share of persons with a PhD was 1.3%[3]. In absolute numbers: 36.852.

If for 2050 the same ratio of 1.3% is applied to the projected population aged 30-34 years old, there will be 33.170 persons with a PhD.

Employment rates and labour market trends

The employment rate for the EU's working-age population is expected to rise moderately, from approximately 75% in 2022 to around 79% by 2070. Participation among older workers, aged 55 to 64, is also projected to grow from 65.4% to 75.5%. However, despite these developments, the overall labour force is set to decline by 12%, or around 25 million people, as a result of demographic change.[4] This shrinking workforce implies fewer contributors to public finances through taxes and social contributions, placing additional pressure on pension and welfare systems. For research and innovation, this creates a potential risk: as fiscal pressures increase and spending on age-related services grows, governments may find it increasingly difficult to maintain or expand investment in R&I, despite its role in boosting productivity and long-term economic resilience.

Labour productivity

With the EU's working-age population in decline and total hours worked projected to fall, labour productivity is set to become the unique driver of economic growth over the coming decades. While real GDP in the EU is forecast to grow at an average annual rate of 1.3% between 2022 and 2070, the contribution of labour is expected to turn negative from the late 2020s onwards, detracting 0.2 percentage points per year on average. In contrast, labour productivity is projected to grow by 1.4% annually over the same period, reinforced by gains in total factor productivity (TFP) and capital deepening, contributing 0.9 and 0.5 percentage points respectively. TFP growth is assumed to converge to 0.8% across all Member States in the long term, a downward revision from the 1% assumed in the 2021 Ageing Report.[5]

As Europe's workforce shrinks, improving productivity will become increasingly important for maintaining growth. Yet, productivity alone is likely not to counterbalance the negative effects of the ageing and declining population. An increase in labour intensity with longer hours worked per employee and by bringing in groups of workers currently insufficiently utilised such as women and migrants, are deemed part of the mitigation measures.[6] Investment in research and innovation – capital investment such as new infrastructures, software, and other facilitating technologies is one of the most effective ways to support this, helping to offset the economic pressures of an ageing population.

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[3] the share of 1.3% is rather stable since 2015.

[4] EC (2024), p. 4

[5] ibid

[6] McKinsey Global Institute (2025), Dependency and depopulation? Confronting the consequences of a new demographic reality.

The projected rise in the old-age dependency ratio across the EU is set to increase pension spending over the coming decades. In 2022, there were 28 working-age individuals (in the age bracket of 20 – 64 years) for every 10 people aged over 65. This ratio is expected to fall to 19 by 2045 and further to 17 by 2070, reflecting the demographic shift towards an ageing population. As the number of contributors declines relative to retirees, pressure on pension systems will intensify. While the impact of population ageing will be particularly marked through to the 2050s, it is expected to stabilise somewhat in the second half of the projection period.[7]

Pension costs and fiscal pressure

Under the baseline scenario,[8] the total cost of ageing, including spending on pensions, healthcare, long-term care, and education, is expected to rise across the EU. In 2022, these costs made up 24.4% of GDP, with pensions alone accounting for 11.4%. By 2070, overall ageing-related spending is set to increase to 25.6% of GDP, with pension expenditure rising to 11.8%. Most of this increase is likely to happen by 2045, before levelling off or slightly decreasing in many countries. Because of its size and how much it varies between Member States, pension spending is expected to be the main factor driving the overall increase in ageing costs in the EU27.[9] Across the EU, the average benefit ratio is also expected to drop, from 43% in 2022 to 36% by 2070.

Pension spending is projected to go up in 16 Member States, while 11 are expected to see a small decline. For most countries, the majority of this increase will take place between now and 2045, as shown in Table 7 and Table 8 in Annex 2. After that, the trend flattens or even reverses. The rising costs of ageing will increase fiscal pressure, particularly in the short to medium term. This could redirect government spending away from forward-looking investments like research, innovation, and education.

Workforce education

Despite becoming smaller by the numbers, the labour force is expected to be more skilled than today, [10] affecting positively productivity and adaptation capabilities for changing job markets. The projected decrease of the labour force is expected to come mainly from low and middle levels of education. Overall, educational attainment is expected to increase – with more people obtaining either short post-secondary education (e.g., technical training) as well as tertiary degrees (bachelor, master's, or higher) (see Figure 5).

Yet, is a projection with constant levels of bachelor and master or higher degree students plausible? This may depend on a range of factors such as the cost of education and the expected income rent due to education investments. If the value of formal tertiary education decreases and the need for continuous training increases – a scenario which is plausible given the advances in technology as well as the pressures of labour markets to have younger people entering to fill in the gaps of retiring older workers or the gaps that come with new skills demand -, a rather short, basic education may be the norm for a large share of tertiary students. In such a scenario, lifelong learning and micro-credentials may become more important and common.

[7] EC (2024), p. 41

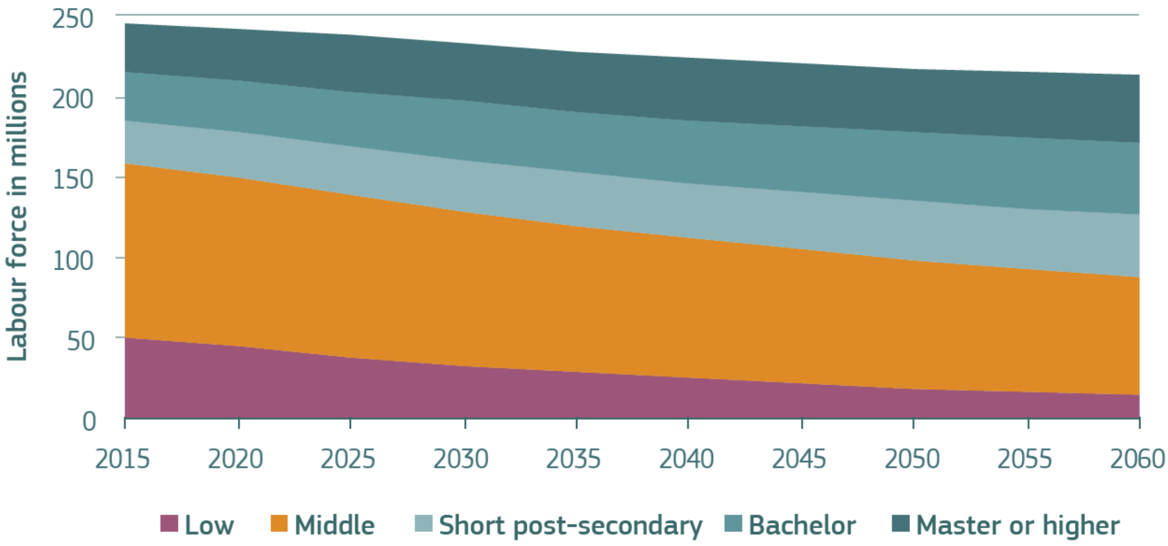
[8] The Ageing Report's baseline projections are based on a general 'no-policy-change' assumption, reflecting legislated measures, with a general cut-off date of 1 December 2023. (2024 Ageing Report, page 2)

[9] Ibid. page 12

[10] JRC (2019), Demographic scenarios for the EU. Migration, population and education

Micro-credentials certify the learning outcomes of short-term learning experiences, for example a short course or training. They offer a flexible, targeted way to help people develop the knowledge, skills and competences they need for their personal and professional development. [11] While already now a range of public and private providers offer short-term training, will this replace to a larger extent the offerings of universities in the longer run?

Figure 5 EU labour force by education level



Source: JRC (2019), Demographic scenarios for the EU. Migration, population and education

Technical progress

Since the rapid developments in artificial intelligence (AI) and its uptake in the workforce – including skilled labour and researchers in public and private sectors, expected technological effects range from being a means to counteract future workforce shortages (in production as well as services) to worries of a much more limited demand in knowledge workers and researchers. The transformation is in particular of concern with the developments of generative AI. Already today ChatGPT can replace researchers for a number of typical research functions such as data analysis, theoretic modelling, constructing (based on engineering principles), presenting results, or search of sources etc.[12] Generative AI can also free up time of researchers; for example, in replacing work related to administration and proposal writing.

There are range of factors that are likely to drive or hamper the uptake of AI[13] (e.g. regulatory frameworks, investments, energy availability and costs), This may affect the quantities – how many researchers may be needed in the public – higher education and public research system - and what will be their roles, functions, and qualities they will be needed (future skills).[14]

[11] https://education.ec.europa.eu/education-levels/higher-education/micro-credentials

[12] Ortelt, T. (2025) Digitale Labore – Stand der Dinge mit ChatGPT.

[13] See Futures Platform (2024) four scenarios on the future of AI in the workplace. https://www.futuresplatform.com/blog/future-of-work-ai-in-the-workplace-scenarios

[14] see Future skills im KI Zeitalter – Welche Kompetenzen brauchen wir. University Future festival 2025. Available at: https://www.youtube.com/watch?v=n69CtzFQ494&list=PLDE3NyZgHoK552yUzGRPNPb4f8AwRxv9&index=19

Human Resources in Science and Technology

The concept of *Human resources in Science & Technology* is based on the International Standard Classification of Occupations (ISCO), a tool for organising jobs into a clearly defined set of groups according to the tasks and duties undertaken in the job. ISCO does not include a class such as *researcher*.

HRST is defined by the OECD as persons:

- Having successfully completed education at the tertiary level in a science and technology field of study; or
- Not formally qualified as above but being employed in a science and technology occupation, where the above qualifications are normally required.

This broad category of so-called 'knowledge workers' contains also persons which have followed a doctoral education as well as persons which *perform* research and innovation related jobs.

Based on Eurostat data, between 2008 and 2024, the number of Human Resources in Science and Technology (HRST) in the EU[15] has shown a consistent upward trend across both the public and private sectors and is expected to continue. In 2008, the total HRST stood at approximately 46.8 million, with around 39.2 million employed in the private sector and 7.2 million in the public sector. By 2024, the total figure is sitting at 65.5 million, with 56.4 million in the private sector and 9 million in the public sector. Growth has been particularly strong in the private sector, which accounts for the majority of HRST employment throughout the period. While the public sector has also experienced gradual growth in HRST numbers, its scale remains significantly smaller in comparison.

In conjunction with the overall growth in HRST employment across the EU, there has also been a steady increase in the proportion of the young labour force (aged 25 to 34) in HRST. Between 2008 and 2024, this share rose from 42.8% to 57.2% of the population in the labour force within this age group. Notably, the data show a persistent and significant gender gap in favour of women throughout the period. In 2008, 50.2% of females in this age group were classified as HRST compared to 36.7% of males. By 2024, these shares have reached 65.2% for females and 50.3% for males. This suggests that the expansion of the HRST workforce has been strongly supported by increasing participation among younger cohorts, particularly women, reflecting broader trends in educational attainment and labour market engagement.[16]

Researchers

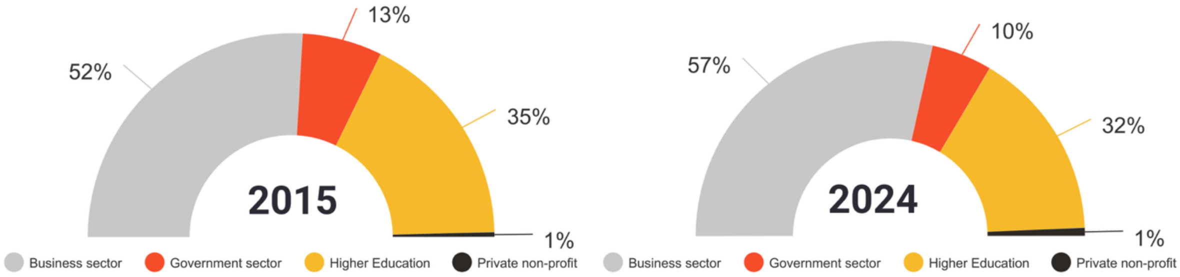
Defined within the Frascati Manual (OECD 2015), *researchers* are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned.

Eurostat data on researchers in Europe shows that between 2015 and 2024 (latest available data for the EU-27), the overall numbers of researchers in full-time equivalent rose from 1.6 million to 2.2 million in 2024; an average annual growth of 3.9%. In head count, the figure increased from 2.37 in 2015 to 3.18 in 2023 (an average annual increase of 3.7%). The overall growth affects positively mainly the business sector while the higher education and government sector decreased in terms of shares (Figure 6).

[15] https://ec.europa.eu/eurostat/databrowser/view/hrst_st_nsec2/default/table?lang=en

[16] Eurostat EUROPOP Projections (2023-2024)

Figure 6 Share of researchers by sector of employment, EU-27, 2015, 2024

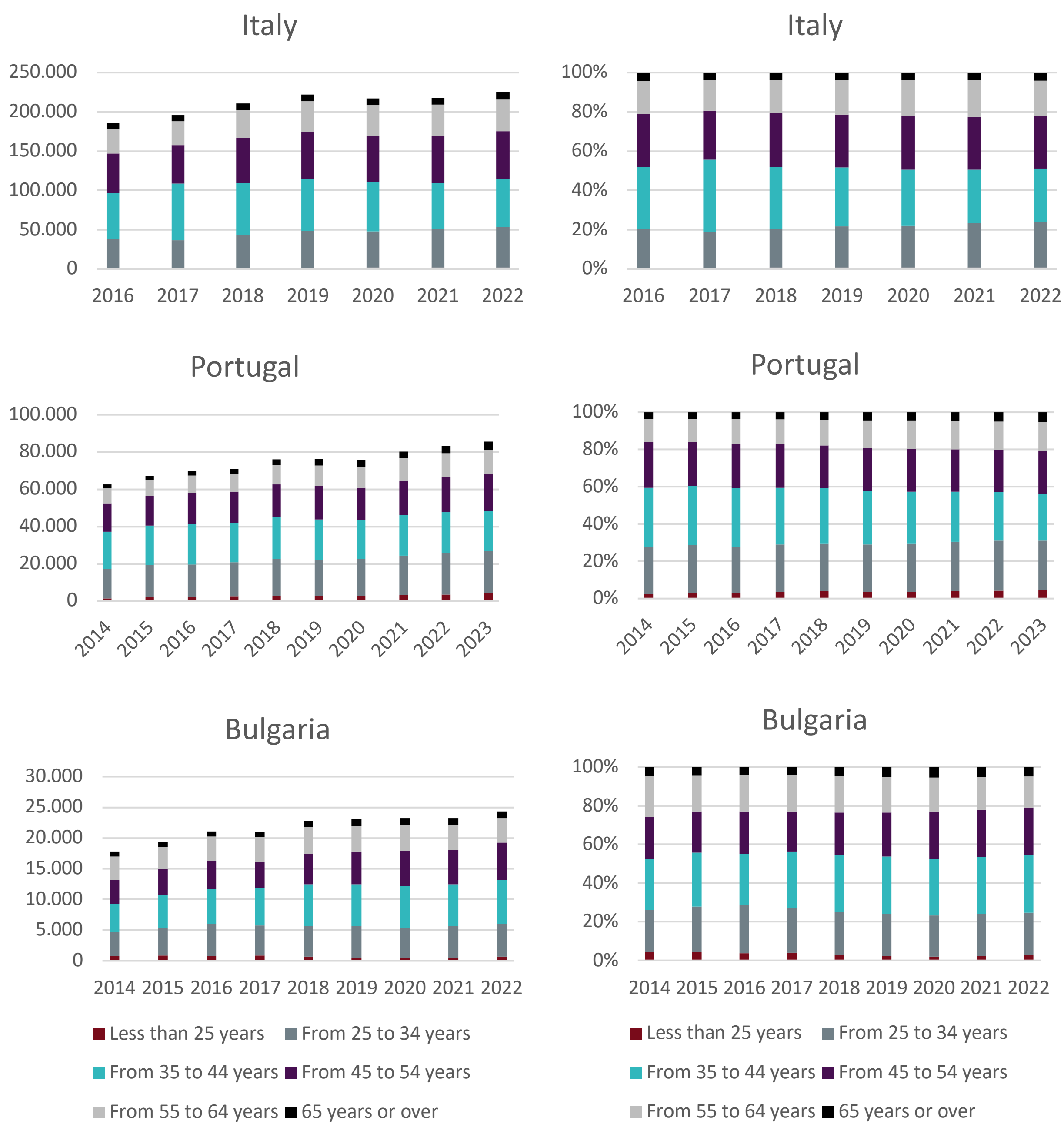


Data: Eurostat, Calculation: Technopolis Group

Breakdowns by age group are available only for selected countries. For demonstrating the variety among the EU-MS, Table 1 shows not only the large differences between three selected countries in terms of volume of the researchers over time (upper part) but also differences in shares of age groups.

In Italy for example, 50% of the researchers are up to 44 years while in Portugal, this share is almost constantly around 60%. For Bulgaria, this is somewhat more variable but equally above 50%. Italy also has a marginal number of researchers less than 25 years old (0.8%) – the two other countries have 2.7 (Bulgaria) and 3.3% (Portugal) respectively.

Table 1 Evolution of researchers by age group. Selected countries, 2014 to latest available year, in absolute and relative terms



Data: Eurostat, Calculation: Technopolis Group

For the selected countries, drilling down to the sectoral level shows similar patterns. For the researchers in the **higher education sector** in the selected countries, one can again observe differences in size: In 2022, Italy had the largest number of researchers with slightly more than 80.000, followed by Portugal (about 50.000) and Bulgaria (around 8.000).

Table 2 Evolution of researchers in the higher education sector. Selected countries, 2014 to latest available year, in absolute and relative terms

Data: Eurostat, Calculation: Technopolis Group

A similar absence of young researchers (under 25 years) can be observed in the Italian higher education sector, with only a small presence of this age group in Portugal and Bulgaria. In contrast, 30% of researchers in Italian higher education are aged over 55, compared to 23% in Portugal and 24% in Bulgaria.

When considering additional factors—such as country-specific fertility rates[17], female employment rates, and the absolute size, trends, and dynamics of the higher education system—a number of open questions and challenges emerge regarding the future size and sustainability of the sector.

Given that academic careers in the higher education system often span three to four decades, the number of researchers, natural turnover, and new hires can be estimated based on the average growth of different age groups. While it is possible for individuals to enter the profession before the age of 25—depending on the duration of tertiary and doctoral education—this is more likely the exception than the norm.

Similarly, at the end of an academic career, natural fluctuation typically occurs between the ages of 60 and 65, depending on general public sector employment rules and any specific retirement regulations in the higher education sector—though exceptions do exist. Changes in hiring patterns over time, along with the use of open-ended versus fixed-term contracts, also influence these trends.

For Italy, with the largest higher education system in terms of researchers among the selected countries showed since 2014 with almost 5% average annual growth in the age group of 25 to 34 years. In the next age group, one observes a negative growth, therefore one can note that some researchers leave the system. In absolute and relative terms, this age group provides the largest number/share of researchers. If this age group has been passed, the largest number of researchers stay on until the age of 64. While in 2014 still 47% continued with their careers in the higher education system, this share has dropped to 28% in 2022.

Portugal has a high growth in the age group of <25 years, yet, in absolute terms, this group is the smallest (2.680 in 2023). Similar to Italy, the largest volume is in the ager group of 35-44 years – at least between 2014 and 2021. Since 2022, the largest group is the group of 45-54 years old researchers. Other than that, the Portuguese system shows a large level of continuity. This can be seen through the growth in the last age groups. While in 2014 30% of the persons continued after the age of 65, this share increased to 38% in 2023.

Bulgaria, as the smallest higher education sector in terms of researchers shows a decrease in very young researchers (although its absolute number is small), but also in the age groups 25 to 34 and 35 to 44, the numbers remained rather stable, yet, similar to Portugal, since 2019, the age group of 45 to 54 years old researchers is the largest among the Bulgarian age groups. Similar to Italy, one can observe a phasing out of researchers aged 65 or above.

Table 3 Average annual growth rates (2014 to latest available year) within the higher education sector, by age group. Selected countries

Average annual growth rate 2014 to latest available year	Italy	Portugal	Bulgaria
Total	1,07	1,47	0,04
Less than 25 years	0,00	10,70	-6,07
From 25 to 34 years	4,97	2,44	0,26
From 35 to 44 years	-1,51	-1,09	0,27
From 45 to 54 years	0,80	1,11	1,94
From 55 to 64 years	2,59	5,11	-0,68
65 years or over	-3,82	8,20	-4,10

Data: Eurostat, Calculation: Technopolis Group

[17] see the EC's Communication: Demographic change in Europe: a toolbox for action (COM(2023) 577 final)

The previous figures and calculated averages suggest past and current challenges – an ageing pool of researchers within the higher education institutions, limited recruitment, and seemingly an exit after the initial years.

The impact of fertility

By 2070, the EU's total fertility rate is projected to rise slightly from 1.50 to 1.62 live births per woman, remaining below the replacement level of 2.10[18]. Life expectancy at birth is expected to increase from 78.4 to 86.1 years for men and from 84.0 to 90.4 years for women, with a gradual convergence between the sexes. Although birth rates saw a temporary dip during the COVID-19 pandemic, largely due to uncertainty around its economic and social impacts, they had largely rebounded by the second half of 2021. Nonetheless, fertility in Europe has been on a long-term downward trend since the 1960s, shaped by complex social, economic and gender-related changes. Despite some stabilisation in the 2000s, the average number of children per woman in 2020 stood at 1.5, well below the level needed to sustain population size without migration.

Looking ahead, natural population change[19] is projected to remain negative throughout the period from 2022 to 2100. Across the EU, deaths are expected to consistently outnumber births, with the largest gap occurring between 2055 and 2064, when annual natural decline is projected to exceed two million people. While a handful of countries (including Sweden, France, Ireland and the Netherlands) may experience intermittent positive natural change, most Member States are expected to record negative natural change every year.

The impact of migration

Net migration is anticipated to stay positive in nearly all Member States, averaging 0.3% of the EU population annually between 2022 and 2070. [20] Over the longer term, it is projected to remain the only driver of population growth in the EU, contributing an average of 1.2 million people per year from 2022 to 2100. While migratory patterns vary across countries, most are expected to experience continued inflows, which may help offset the effects of low fertility and population ageing, particularly in countries attracting a high share of working-age migrants. Conversely, in Member States experiencing negative net migration, the departure of younger cohorts may accelerate ageing and further depress fertility. Overall, net migration is expected to add 98.1 million people to the EU population by 2100, partially counterbalancing the natural decline of 125.3 million resulting from more deaths than births. [21] In the shorter term, 2023 data already highlights the significance of migration: among the 20 EU countries that experienced population growth that year, seven saw both positive natural change and net migration, while in the majority, growth was solely due to migration. In contrast, in several countries—including Bulgaria, Greece and Italy - net migration was not enough to offset a declining birth-death balance, resulting in overall population loss. [22]

3 SCENARIO BUILDING

This section details the methodological approach employed to develop the scenarios concerning the implications of demographic change on the European Research and Innovation (R&I) system. The core

[18] EC (2024), p. 3

[19] Defined as the difference between births and deaths.

[20] EC (2024) p. 3

[21] Ortelt, T. (2025)

[22] Eurostat. (2024). Population and population change statistics. Available at https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_and_population_change_statistics

of this methodology is a collaborative Scenario Building Workshop, designed to elicit diverse perspectives and generate rich, detailed narratives of potential futures. This approach aligns with established foresight methodologies, aiming to test the resilience of current understanding and identify potential future challenges and opportunities.

3.1 Theoretical Basis of the Scenario Method

The scenario method, as a key foresight technique, focuses on developing knowledge about how alternative future visions (scenarios) can influence the subject of analysis. It has three primary objectives:

Resilience testing

To evaluate the robustness of the analysed subject (e.g., strategies, visions, existing knowledge, or solutions) by examining whether it contains elements that could be negatively impacted by specific future events. This requires participants to thoroughly understand the scenarios and consider the direct impact of described events as well as the resulting phenomena and actions.

Assumption awareness

To sensitise participants to their internalised assumptions, thought patterns, and beliefs about the present and future, which can influence their thinking and actions. This process often leads to increased mindfulness in decision-making.

Strategic reframing

To trigger a re-evaluation of strategic goals, opportunities, and threats through a psychological process known as cognitive reframing. This involves identifying and then changing the way assumptions, experiential knowledge, concepts, and categories are perceived.

3.2 Application of the Scenario Method

Scenario analysis helps to reveal previously unnoticed or underestimated weaknesses and opportunities that can positively impact the analysed subject if addressed appropriately. The method generates insights about the studied solution, which can be further analysed for strategic purposes.

The application of the scenario method in this project centres around the development of plausible and challenging narratives depicting the future of the European R&I system under the influence of demographic change. This involves two key elements:

- **A set of scenarios.** These scenarios are being developed through a collaborative workshop process, leveraging the knowledge and insights of diverse stakeholders. The goal is to create scenarios that are plausible (imaginable and realistic), challenging (for participants and the subject of analysis), and useful for stakeholders and their objectives. To avoid bias and encourage comprehensive consideration, the scenarios will not be explicitly framed as purely optimistic, pessimistic, or average.
- **The subject of analysis.** In this project, the primary subject of analysis is the European R&I system and its capacity to adapt and thrive in the face of demographic change. The developed scenarios will serve as a backdrop against which the potential impacts and necessary adaptations of this system will be explored in subsequent workshop phases.

3.3 Background Research and Data Gathering

Prior to the scenario building workshop, an extensive research and data collection phase was conducted to establish a solid foundation for the scenario development. This phase included a comprehensive desk research effort, focused on demographic trends in Europe, labour market shifts, and projections for the R&I sector. Key findings from this research indicate a looming demographic challenge for Europe, with a projected population peak followed by decline, an ageing population, and a decreasing working-age population. The resultant pressures on public finances, particularly pension costs, were highlighted, alongside the increasing importance of labour productivity and investment in R&I as drivers of economic growth. This phase also involved an examination of Human Resources in Science and Technology (HRST) trends, revealing a steady increase in HRST numbers and a rising proportion of younger individuals in this workforce.

Supplementing the desk research, a survey was distributed to stakeholders to gather expert insights on emerging trends and potential disruptions affecting the European R&I system. The survey engaged a diverse group of participants including research scientists, policymakers, innovation actors, and other professionals from various geographical locations. Responses indicated a strong focus on the impact of Artificial Intelligence and technology-driven change on R&I, alongside concerns about open science, ethics, and trust. The survey also highlighted the strategic importance of public-private collaboration and the need for agile policy responses in a competitive global environment. Findings from both the desk research and survey were synthesised to identify key uncertainties, which then served as the basis for the 2x2 matrix used in the scenario-building workshop.

Table 4 presents the identified weak signals and trends, grouped into thematic clusters that emerged from the triangulated analysis of desk research, expert interviews, and survey responses.

Table 4 Identified weak signals and trends through desk research, survey and interviews

Artificial Intelligence and technology driven change
• **AI is becoming a key driver of productivity and economic growth.** Global investments in AI are projected to reach $ 3.636 billion by 2033, reflecting widespread uptake across sectors and its centrality to future economic competitiveness. • **Governments are institutionalising AI training in higher education**. Sweden's national strategy includes SEK 50 million in funding (2025 - 2027) to train academic staff and integrate AI into course content across disciplines. • **AI tools are reshaping academic workflows.** ChatGPT and similar tools are now commonly used in research writing, administration, and teaching. This shift introduces new challenges in assessing authorship, quality control, and critical engagement. • **Reflexive and ethical competences are gaining importance.** The use of text-generating AI in academic contexts signals the need for stronger ethical standards and reflexivity in how researchers use these technologies. • **AI is transforming scientific discovery through simulation.** AI-supported models enable researchers to run complex simulations and conduct experiments virtually - reducing cost, time, and environmental impact. • **Large language models (LLMs) are influencing research design.** AI tools are increasingly used to generate hypotheses, identify research gaps, and assist in designing interdisciplinary projects. • **Data-driven research analytics are becoming commercialised.** Companies are developing tools that analyse academic output and performance, opening new markets for AI-powered evaluation systems. • **AI is increasingly being applied in biological sciences** to model biomolecular interactions. • **The rise of the 'splinternet'** creates fragmented information ecosystems, undermining the universality of research outcomes. • Digital transformation is prompting some universities to integrate **AI literacy into curricula** and reconsider traditional academic roles.
Reform and evolution of Higher Education

- **Shift away from traditional academic disciplines**
New degree programmes are increasingly structured around interdisciplinary themes such as digitalisation, sustainability, and psychology, signalling a decline in the dominance of single-subject study fields.
- **Curricular integration of interdisciplinary perspectives**
Universities are introducing broader, cross-cutting degrees designed to provide graduates with flexible, hybrid skillsets aligned with real-world problem-solving.
- **Expansion of remote and hybrid education models**
The number of students in distance education programmes continues to rise, supporting access for non-traditional learners and those in rural or under-resourced areas.
- **Redesign of learning spaces for active education**
Universities are moving away from large lecture halls toward more agile and modular environments that support research-based, practical, and collaborative learning.
- **Integration of open, urban learning labs**
Some institutions are embedding "living labs" into urban settings, making learning and experimentation visible and participatory for local communities.
- **Rise of professional learning communities among educators**
Lecturers and teaching staff increasingly form collaborative networks focused on pedagogical innovation and shared reflection.
- **Shift in the role of professors from lecturers to mentors**
In some models, such as CODE University Berlin, professors act as mentors and facilitators of peer learning rather than content deliverers.
- **Team-based, interdisciplinary student collaboration**
Curricula are being designed to embed collaborative problem-solving in diverse student teams, aligning with innovation-driven workforce expectations.
- **Institutionalisation of lifelong learning**
Particularly in universities of applied sciences, lifelong learning is becoming a core part of the institutional mission, with co-developed programmes for adult learners and regional actors.
- **Renewed appreciation for face-to-face learning**
Following the COVID-19 pandemic, students increasingly value on-campus, dialogue-oriented education formats as a complement to online learning.
- **Growing focus on mental health** and the recognition of emotional intelligence in academic settings.
- Younger generations are influencing **institutional culture and research approaches.**
- **A prevailing risk-averse mindset** is seen to limit experimentation and innovation.

Research Careers and the Academic Workforce

- **Progress toward gender parity in doctoral education**
In Sweden, 52% of new PhD students in 2023 were women, a substantial increase from 23% in 1973. This trend reflects longstanding policy and institutional efforts to promote gender balance in research careers.
- **Expansion of academic research personnel**
Swedish higher education institutions have experienced significant growth in the number of associate professors and postdoctoral researchers, particularly in strategic fields.
- **Rising internationalisation of the research workforce**
The share of internationally recruited researchers at Swedish HEIs increased from 15% in 2012 to 23% in 2022, highlighting Sweden's growing reliance on global talent.
- **Emergence of hybrid academic–industry career paths**
Increasingly, researchers split their time between academia and industry, particularly in applied research areas. These hybrid models support knowledge transfer and career diversity.
- **Modularisation and flexibility in academic careers**
The academic profession is evolving toward more flexible, modular structures, allowing scholars to shift between roles such as researcher, coordinator, communicator, or mentor over time.
- **Need for professionalised leadership and management skills**
As academic institutions grow in complexity and pressure mounts for efficiency, researchers increasingly require skills in leadership, strategic planning, and institutional change management.
- **A rise in professional development training** for students and graduates.

Research Funding, Governance, and Autonomy

- **Expansion of national budgets for R&I**
The Swedish government plans to increase public funding for research and innovation from SEK 1.5 billion in 2025 to SEK 6.5 billion by 2028, signalling strong long-term investment in R&I infrastructure.

	• **Rise of university-led commercialisation strategies** Some universities are moving toward self-sustaining research models through venture studio partnerships, access to private equity, and participation in innovation ecosystems. • **Strategic earmarking of public research funding** Public investments are increasingly targeted at priority areas such as engineering, medicine, and teacher education, reflecting alignment with broader national policy goals. • **Increased reliance on external funding streams** External income—particularly in engineering and health sciences - now makes up over 50% of total research funding in many Swedish HEIs. This shift may challenge autonomy and sustainability. • **Diversification of university funding portfolios** Higher education institutions are increasingly dependent on third-party and competitive funding. While this diversifies revenue, it may also deprioritise curiosity-driven basic research. • A trend towards top-down priority setting is perceived to threaten **academic freedom.** • The growing role of tech industry funding creates ambiguity and potential conflicts of interest in the R&I ecosystem.
Public–Private Collaboration	
	• A move from institutionally anchored innovation to supra-institutional, multistakeholder networks is observed. • Stagnating public investment in research is prompting institutions to seek alternative funding via industry and philanthropic partnerships. • Strategic collaboration with large corporations is a double-edged sword, facilitating technology transfer but potentially increasing corporate influence in research.
International Collaboration	
	• A move from institutionally anchored innovation to supra-institutional, multistakeholder networks is observed. • Stagnating public investment in research is prompting institutions to seek alternative funding via industry and philanthropic partnerships. • Strategic collaboration with large corporations is a double-edged sword, facilitating technology transfer but potentially increasing corporate influence in research.
Open Science, Ethics, and Trust	
	• The emerging importance of trust in science as a new frontier, comparable to the rise of 'open science'. • Greater recognition of collaborative and societal contributions within research. • Concerns over epistemic relativism contributing to public distrust and conspiracy theories. • Enhanced patient involvement in shaping research agendas.
Political Uncertainty and Systemic Risk	
	• Declining voter engagement and growing political disenchantment are noted. • Perceptions of science are negatively affected by political instability, with concerns over a potential 'lost generation' of researchers. • Simultaneously, science is playing an increasingly influential role in policymaking, presenting both opportunities and challenges for its societal impact.

3.4 Identifying uncertainties – insights from the Rip Van Winkle exercise

Drawing upon established foresight methodology, the 'Rip Van Winkle' exercise was employed as a projective technique to elicit latent concerns, values, and emerging uncertainties pertinent to the future of European R&I. This involved prompting participants to formulate 'yes/no' questions directed towards a hypothetical 2050 inhabitant, a framing designed to facilitate abductive reasoning and challenge present-day cognitive biases regarding future possibilities.

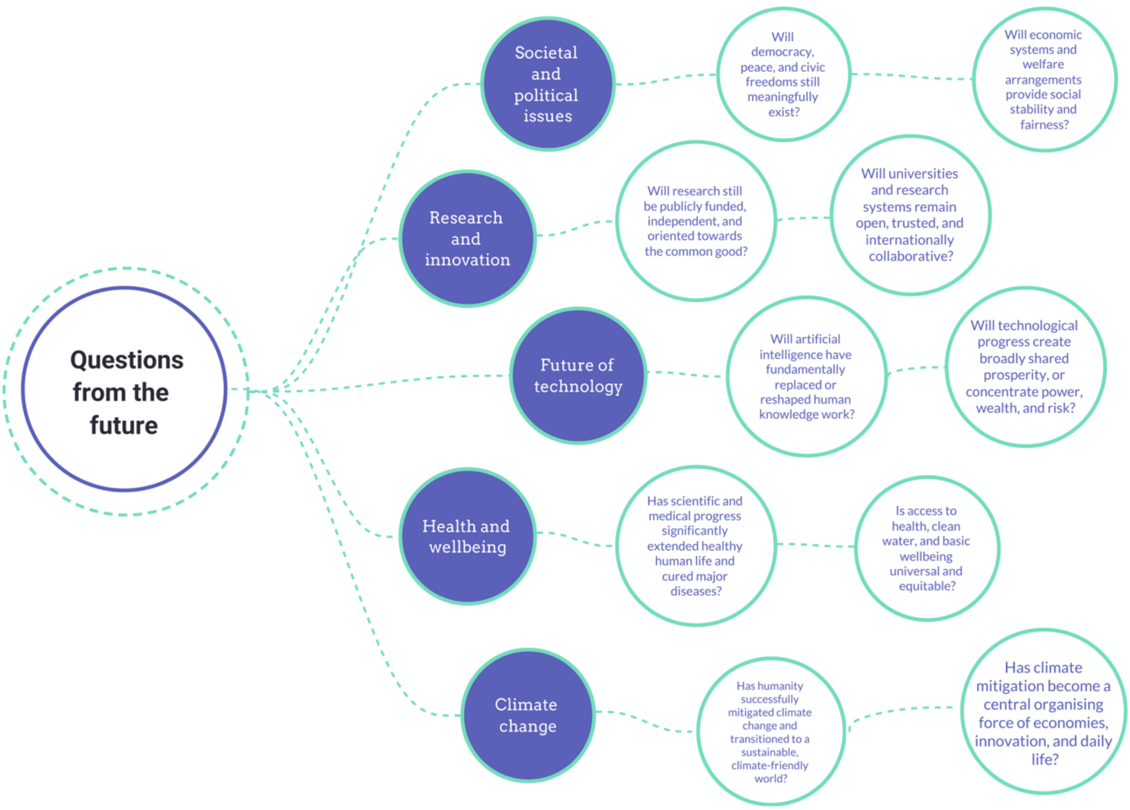
This narrative-based approach enabled the identification of underlying societal tensions, aspirational visions, and potential discontinuities that are often obscured by conventional trend extrapolation. Specifically, the method provided insights into complex systems dynamics and revealed tacit assumptions and worldviews. This exercise served to enrich the scenario development by collective anticipatory intelligence.

The questions submitted were clustered thematically into five dominant domains: societal and political futures, technological developments, the future of R&I systems, climate change, and health and medicine. These clusters informed both the scenario matrix and the qualitative context developed during the scenario workshop.

Across responses, several patterns emerged:

- **A mix of concern and cautious optimism**: Questions frequently expressed critical reflection on societal resilience, equity, and continuity.
- **AI and ethics featured prominently**, signalling widespread anticipation of both technological disruption and normative dilemmas.
- **Systemic thinking**: Many questions reflected an integrated view of governance, societal values, and innovation—rather than isolated developments.

Figure 7 Selected questions occurring in the Rip Van Winkle survey



Source: Study survey. Note: Summarised using AI. Original responses see Annex

Examples of repeated questions illustrate shared foresight imaginaries across diverse respondents:

- *Governance and the EU*: "Does the European Union still exist?" / "Has Europe remained peaceful and democratic?"
- *AI and research ethics*: "Has Artificial General Intelligence been developed?" / "Is generative AI capable of credible scientific output?"
- *Funding and innovation models*: "Is research still publicly funded in 2050?" / "Who drives innovation, public procurement or private enterprise?"
- *Sustainability*: "Is climate change still a major issue?" / "Do people fight over water and food?"
- *Health and longevity*: "Has cancer been cured?" / "Do people live significantly longer in 2050?"

These reflections, while diverse in content, collectively contributed to shaping plausible and provocative futures in the scenario development process.

3.5 Scenario Building Workshop Design

The Scenario Building Workshop methodology was designed to collaboratively generate distinct narratives of the future impact of demographic change on the European R&I system. During the workshop held on April 11th, 2025, participants were divided into working groups based on a 2x2 matrix of key uncertainties and systematically enriched initial scenario outlines. This process involved integrating selected future disruptions, elaborating the broader PESTLE (Political, Economic, Societal, Technological, Legal, Environmental) context through guided questions, and specifically exploring the implications for the R&I sector, including evolving priorities, funding mechanisms, and collaborations.

Each group developed a comprehensive scenario narrative, which was then presented in a plenary session for shared understanding and discussion. This methodology, ensured a multi-dimensional exploration of potential futures, leveraging the diverse expertise of stakeholders to create rich and plausible scenarios.

The resulting set of distinct scenarios will serve as a crucial foundation for subsequent project phases, enabling a robust analysis of potential challenges and opportunities for the European R&I system and informing the development of future-oriented strategies and recommendations.

3.6 Development of the 2x2 Matrix and Scenario Quadrants

The foundation for the Scenario Building Workshop involved the creation of a 2x2 matrix, designed to frame the key uncertainties influencing the future of the European R&I system in the context of demographic change. The axes of this matrix were derived from a comprehensive analysis of desk research findings and the insights gathered through a pre-workshop survey.

The desk research phase involved a systematic review of existing literature, statistical data, and reports pertaining to demographic trends in Europe and their potential impact on the R&I landscape. This analysis identified a wide range of potential drivers of change and emerging signals. Simultaneously, a pre-workshop survey was distributed to potential workshop participants. This survey incorporated elements of the "Rip van Winkle" technique,[23] asking participants to envision the long-term future and identify potential significant shifts. The survey also collected information on perceived emerging signals of change and potential disruptions relevant to the R&I system and demographic shifts.

The responses from the "Rip van Winkle" survey and the identified signals from both the survey and desk research were categorised and analysed. This analysis aimed to identify the most critical and independent uncertainties – those with high potential impact and a significant degree of unpredictability. Through this process two dominant axes of uncertainty emerged. These axes represented contrasting trends related to:

1. **The Degree of Automation in Research:** This axis ranged from a future where research is predominantly conducted by human researchers, emphasising traditional scientific methods and potentially less reliance on advanced, automated technologies (Human-Driven Research) to a future where research increasingly involves non-human actors (e.g., advanced AI, autonomous systems) playing a significant role in the research process and potentially employing methodologies heavily reliant on sophisticated technologies (Technology-Augmented Research). Given the background research findings detailed in the report, which note a looming demographic challenge with an ageing population and a decreasing working-age population in

23 Participants imagine conversing with someone from the future who has complete knowledge of that future world. The close-ended questions formulated by the experts in the survey reveal certain aspects of the future that they are unsure about. The number of questions that can be asked is limited to encourage a focus only on those uncertainties that may have an impact on the topic under discussion.

Europe, it is crucial to consider the extent to which technology, specifically automation and AI, could supplement or even substitute for human researchers. As the labour force shrinks, the potential for technology to enhance research productivity and address skills gaps becomes a vital uncertainty to explore.

2. **The Primary Research Providers:** This axis spanned from a future where the main emphasis and activity of research are concentrated within business and industry settings (Business-focused) to a future where universities, research institutions, and public sector organisations maintain the primary role and focus in conducting research (Public research -focused). The desk research results highlight pressures on public finances due to increased pension costs and healthcare expenditures associated with an ageing population. These financial constraints could potentially limit the ability of public institutions to fund and conduct research. Simultaneously, the data shows a steady increase in Human Resources in Science and Technology (HRST) in both the public and private sectors, indicating the potential for business to take on a larger role in R&I.

The intersection of these two axes resulted in the four quadrants that formed the basis for the initial scenario outlines assigned to the workshop groups:

Quadrant 1: Human-Driven Research + Business

This scenario explored a future where European science is almost entirely the domain of the private sector. Talented scientists migrate in large numbers to business, attracted by better conditions, while weak states and a marginalised EU do not compete in research funding. Universities become mainly educational centres, and research strongly focuses on commercial applications and short-term profits, leading to widespread ethical dilemmas. Europe faces accelerated ageing and declining birth rates, leading to a shrinking workforce that tech giants fill by attracting global talent, while also investing in age-related solutions and navigating geopolitical competition for research talent.

Quadrant 2: Human-Driven Research + Public research

This scenario envisioned a future where technological development is significantly slowed down and lies in the domain of big tech. Science struggles to break through disinformation, and public research institutions, trying to save the situation but trapped in outdated structures, face reluctance from young people to pursue academic careers, an ageing staff conducting niche research, and efforts to build societal bridges through transparency. This scenario sees a significant ageing population and declining birth rates resulting in a smaller workforce, prompting the EU to manage immigration for labour shortages and prioritise social integration, all while navigating global demographic trends and grappling with climate change.

Quadrant 3: Technology-Augmented Research + Business

This scenario depicted a future characterised by escalating global crises and closed borders. Despite this, there is immense faith in the effectiveness of artificial intelligence and new technologies, with business dominating the sphere of research, displacing public research institutions and marginalising long-term research and social sciences in favour of rapid technological solutions to immediate problems. Europe confronts a rapidly ageing demographic, severely limited immigration due to closed borders, and a growing youth population only due to government support amidst automation, all within a fragmented global context of geopolitical tensions and climate change.

Quadrant 4: Technology-Augmented Research + Public research

This scenario explored a future where a strong and united EU strategically invests in public research, focusing the EU's R&I system on solving local challenges while attracting highly qualified migrants.

Questions arise about the ethical implications of algorithms and the future of scientists' work, alongside rapid technological progress achieved through strong human-AI cooperation, although inequalities in access to digital resources cause tensions among scientists. This scenario addresses ageing populations through consolidating higher education and strategically attracting talent from within the EU, balancing this with questions of ethical AI use and navigating geopolitical trade tensions in pursuit of strategic autonomy.

These quadrants provided distinct starting points for the workshop participants to develop detailed and contrasting narratives of the future of the European R&I system under the influence of demographic change. The underlying uncertainties captured by the matrix ensured that the developed scenarios explored a range of plausible and challenging future landscapes regarding the actors and methodologies dominating research and its primary location.

4 SCENARIOS

4.1 Scenario 1 - Corporate Ascendancy

4.1.1 Narrative through PESTLE categories

In the 2030s and early 2040s, Europe grappling with an ageing workforce and declining birth rates heavily invested in "Smart Infrastructure" driven by efficiency targets and AI-managed systems. This was partly an attempt to compensate for a shrinking labour pool in essential services, a trend exacerbated by the EU's significant acceleration of population ageing, where extended lifespans and a rising old-age dependency ratio strained public finances. The integration of all aspects of life into unified digital platforms controlled by a few tech conglomerates inadvertently created systemic vulnerabilities. This led to a crisis when a sophisticated cyberattack targeted the core operating system of European cities, causing cascading failures in energy, transportation, water, and public safety systems. Governments, having outsourced infrastructure management to private companies, were unprepared and public trust plummeted. In response, further privatisation was proposed as a "faster" solution, but it came with loosened regulations and a focus on profit, ultimately paving the way for a future where private companies dominate research and innovation, driven by commercial interests.

Subsequently, cyberattacks were carried out on large corporations. Despite rapid and effective response, their scale caused billions of dollars in losses and exposed critical security vulnerabilities, which became a harsh lesson for the corporations that now stand at the forefront of Europe's technological future. Having weathered this storm, these tech giants adopted an extremely cautious stance towards the rapid and unverified implementation of new technologies, prioritising robust security measures and meticulously risk-assessed deployments. They employ a strong human-led approach at all stages of research and implementation.

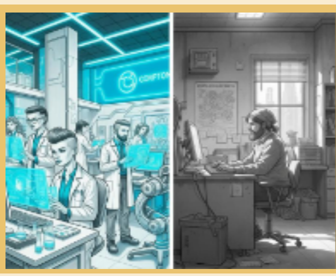
In 2050 Europe is a continent sculpted by the pervasive influence of these powerful corporations. National borders still exist on maps, but their significance has waned in the face of multinational giants whose reach extends across the globe, offering specialised services through a vast network of smaller, agile start-ups. This corporate dominance is partly fuelled by their ability to attract and retain talent in a demographically challenged Europe, offering competitive salaries and opportunities that national governments, facing pressures from ageing populations and increased social welfare demands, struggle to match. Political landscapes are subtly yet decisively shaped by corporate profit motives. The intense competition among these corporate behemoths, while driving innovation in certain sectors, also casts a long shadow of potential instability and ethical compromise. In parallel, these powerful corporations established their own comprehensive private Higher Education Institutions (HEIs).

These internal academies became the primary channels for acquiring new talent and conducting their own research and innovation, entirely funded by the corporations' vast financial resources, making them largely independent of public funding which is increasingly strained by the needs of an ageing population. Entry into these corporate HEIs constitutes the initial level of employment, characterised by an immersive learning-by-doing approach. Employee performance is crucial in this system; failure to meet constantly rising expectations leads to a demotion and ultimately ends in the necessity of leaving the corporation's ranks. Subsequent levels of employment and advancement within these organisations are strictly dependent on successfully passing rigorous and continuous employee evaluation systems, designed to identify and reward the best employees who identify with the corporate ethos and strategic goals.

1

Corporate Ascendancy in Research

Market-led research thrives on private investment, prioritizing commercial ventures.
Private higher education institutions become key talent and innovation hubs, driving growth.



Employment in these dominant multinational corporations has begun to confer significant social prestige and offers real paths for social advancement, often seen as a sign of success in this corporation-oriented era. This is particularly attractive to younger generations in regions with fewer traditional employment opportunities or those facing limited prospects due to underfunded public education systems. However, this coveted status requires unwavering adaptation to the corporation's internal culture, strict adherence to their operational frameworks, and a constant striving for excellence in their results-driven environments. Individuals who are unable to thrive in this intensely competitive and often stressful system face a clearly different path. Their options often include undertaking studies in potentially less directly work-related fields at underfunded public universities, institutions increasingly marginalised in their ability to provide industry-relevant skills, or taking up work in a lower-skilled and less prestigious sector, which further emphasises the socio-economic stratification that has begun to define the European landscape in 2050 creating intergenerational tensions and disparities. This stratification can be further exacerbated by differing demographic trends across Europe, with regions experiencing higher youth unemployment and lower investment in public education being more susceptible to this corporate dominance. The global demographic context sees the US as a key competitor in R&I due to its relatively stable demographic profile, while the EU grapples with attracting and retaining talent in an ageing society.

2050 is an era of resurgent technological advancements, particularly in areas deemed commercially viable. The absence of stringent public regulations on research, partly due to the weakening of national governments facing demographic pressures and lobbying from powerful corporations, has unleashed a torrent of innovation, though often with limited consideration for broader societal or environmental consequences. Legally, the framework remains largely permissive, reflecting the diminished regulatory power of national governments in the face of powerful corporate interests. While some progress has been made in profit-driven green technologies, particularly in the energy transition sector, critical areas like biodiversity protection have received far less attention. The prevailing profit-oriented development paradigm has, in many instances, exacerbated environmental degradation, leading to more frequent and severe climate-related events. The hope that technological fixes alone can address the multifaceted environmental crisis remains a point of contention, with many fearing that these solutions are often piecemeal and fail to address the root causes.

Table 5 Scenario 1 - Corporate Ascendancy by PESTLE categories

Political • Weakened regulatory power of national governments due to privatisation. • Political landscapes subtly shaped by corporate profit motives.	**Economic** • Dominance of multinational corporations and a network of smaller start-ups. • Prosperity driven by corporate dynamism but unevenly distributed.
Societal • Diminishing trust in science perceived as solely profit-driven. • Two-tiered education system impacting public universities	**Technological** • Cautious approach to new technology adoption by corporations post-cyberattacks. • Major technological advancements in commercially viable areas.
Legal • Permissive legal framework reflecting diminished government power.	**Environmental** • Environmental degradation exacerbated by profit-oriented development. • Limited attention to critical areas like biodiversity protection.

4.1.2 R&I focus

In 2050, the European research and innovation landscape has been fundamentally reshaped by the overwhelming dominance of the private sector. Weakened nation states and a marginalised EU, facing the fiscal pressures of ageing populations and increased healthcare costs, have ceded their influence in research funding, leaving corporations as the primary drivers of scientific advancement, often focusing on areas with the most immediate commercial potential for their target demographic, including a significant market for age-related solutions. The rise of private Higher Education Institutions, governed by big industries, has inadvertently created a two-tiered system, impacting the quality and accessibility of public universities (which struggle with declining enrolment in some regions due to a shrinking youth population and the allure of corporate HEIs) and leading to a distortion of education that prioritises specialised skills over broad general knowledge. Vulnerable groups find themselves further marginalised in this intensely competitive environment, and those who stayed within the traditional education system are increasingly left behind, their long-term opportunities significantly curtailed. The EU's ageing demographic necessitates a radical overhaul of research methodologies, with increased reliance on AI and automation in the R&I sector to compensate for a shrinking workforce.

Talented scientists, drawn by superior working conditions and lucrative opportunities, have largely abandoned public institutions for the dynamic environments of private enterprises and HEIs. Universities, once centres of groundbreaking discovery, have primarily evolved into educational hubs, focused on delivering standardised curricula rather than fostering cutting-edge research. Consequently, the pursuit of knowledge is heavily skewed towards immediate commercial applications and the generation of short-term profits. This intense focus on market viability has triggered widespread ethical concerns surrounding the commercialisation of knowledge, as the lines between proprietary interests and the broader societal good become increasingly blurred, impacting equitable access to crucial innovations across different demographic groups. Globally, the competition for research talent intensifies as developed economies with ageing populations like the EU, Japan, and South Korea vie for skilled workers. International collaboration becomes crucial for the EU to access global talent and tap into new markets, particularly in age-tech.

The demographic shifts of 2050 have profoundly impacted tertiary education. Highly prestigious, internationally renowned HEIs with significant student mobility exist alongside a growing number of public universities that have disappeared due to declining student populations. The research landscape is heavily skewed towards STEM fields and profit-driven inquiries, with a noticeable decline in the prominence and funding of humanities and social sciences. Consequently, there are fewer centres of excellence in niche academic areas capable of attracting specialised talent. The interactions between the R&I ecosystem and related markets are characterised by a strong internalisation of R&I activities within companies and their HEIs, leading to a marginalisation of publicly funded universities and a decline in collaborative projects between academia and industry, limiting the diversity of perspectives and research directions in a demographically diverse Europe. The retreat of the state from universal public services, particularly healthcare, means that R&I in this sector is increasingly focused on solutions accessible only to those with financial means, exacerbating health inequalities across different socioeconomic and age groups. For the EU R&I system, funding priorities shift towards age-related research and technologies that can boost productivity to offset the shrinking workforce. Ethical considerations surrounding AI and automation in research become paramount.

The Effects of Demographic Change on Tertiary Education Systems

- Coexistence of prestigious private HEIs with high mobility and disappearing public universities due to declining student numbers.
- Increased focus on STEM and profit-oriented research, less on humanities and social sciences.

Interactions Between the R&I Ecosystem and Related Markets

- Strong internalisation of R&I activities within companies and their private HEIs.
- Decline in collaborative projects between traditional academia and industry.

The Impact on R&I Funding

- Overwhelming dominance of private sector funding for research and innovation.
- Industrial PhD programmes prevailing over traditional public education pathways.

Socio-Spatial Implications

- Private companies directly recruit international researchers through private channels and scholarships.
- Career paths increasingly tied to the success and global expansion of multinational corporations.

The funding landscape for R&I has undergone a significant transformation. Private education initiatives for employees have led to the development of highly specialised and qualified workforces within selected companies, creating distinct career advantages for those individuals. Industrial PhD programmes have become the dominant model, eclipsing traditional public education pathways. Public funding for public research institutions has dwindled, primarily because of the fiscal demands of an ageing population, particularly increased pension and healthcare expenditures, contributing to the closure of many institutions already struggling with decreasing young populations. The socio-spatial implications of this shift are considerable. Private companies are likely to directly recruit international researchers through their own private channels and scholarships, potentially impacting talent pools in sending countries.

Regional specialisation becomes more pronounced as specific geographic areas become hubs for particular industries and their associated research activities. Career paths are increasingly tied to the success and global expansion of multinational corporations, while smaller, specialised start-ups also emerge, offering niche services.

4.2 Scenario 2 - Inclusion and purpose?

4.2.1 Narrative through PESTLE categories

The year is 2050. The European Union is characterised by a significant ageing population and declining birth rates, leading to a shrinking workforce, while globally, demographic trends are diverse, with some regions experiencing rapid growth and others facing similar ageing challenges. The digital revolution, once a surging tide full of promise, has, over the years, been marked by a flood of contradictory information and disillusionment with unfulfilled technological utopias, transformed into a more controlled flow. This experience of constant overstimulation and exposure to disinformation has triggered a growing "digital fatigue and scepticism" within older generations, weakening the ability and willingness to engage with complex information, including scientific findings. In this atmosphere of distrust, scientific breakthroughs, although still occurring, struggle to gain widespread recognition and acceptance. In response to this crisis of confidence and in the face of the power of a few global technology giants dictating the flow of information, governments in Europe have decided to strengthen control over the digital space. Regulations for platforms, educational initiatives, and measures aimed at limiting online anonymity have been introduced, with the aim of restoring informational order. However, these actions, although driven by good intentions, carry the risk of limiting freedom of expression, creating state-controlled "information bubbles," and consequently – weakening innovativeness and further eroding trust, this time towards governmental institutions, creating a complex and tension-filled informational and social reality.

Universities, the traditional bastions of research and learning, find themselves in a precarious position, their rigid structures ill-suited to navigate this shifting landscape. A significant portion of their faculty, now advanced in years, pursues specialised research that often fails to resonate with the immediate needs of society. Simultaneously, the allure of academia has diminished for younger generations, who are drawn to more dynamic and immediately impactful careers, often within the very tech giants that now dominate the innovation sphere. In a bid to regain relevance, universities are making earnest efforts towards transparency, hoping to rebuild bridges with a sceptical public.

The world in 2050 is characterised by a persistent rise in populist sentiments and a general erosion of trust in institutions. The intricate dance between China and a still-powerful United States continues to define the global order, leaving the EU to carve out its own distinct role in this evolving power dynamic. The United States, while experiencing its own ageing trends, has historically maintained a relatively stable demographic profile compared to some other developed nations due to higher birth rates and consistent immigration, allowing for a larger and younger workforce contributing to its economic and military strength. China, despite its massive population, faces significant demographic headwinds with a rapidly ageing population and declining birth rates due to past policies, which could eventually impact its long-term economic growth and global influence, even as its sheer population size and economic development maintain its current powerful position. Within the EU, there's a push towards greater democratisation of both its political and scientific systems, yet undercurrents of chauvinism among the younger generation, who are increasingly stepping into leadership roles, present a challenge to this collaborative spirit.

② Inclusion and Purpose?

Research aligns with societal needs, focusing on ageing and digital health.

Public funds support inclusive, participatory projects to address social challenges.

The EU has forged a unique path, increasingly concerned with post-growth economic models that prioritise sustainability and societal well-being over relentless expansion. The EU's increasingly diverse population presents both a challenge and an opportunity in terms of access to a wide range of talents. However, a noticeable generational shift in values is underway, contributing to a talent drain from academia to the more agile private sector. The labour market faces the dual burden of an ageing population entering retirement and a younger workforce grappling with evolving skill demands. Consequently, lifelong learning models are becoming increasingly vital to ensure the continued productivity of an ageing workforce and to equip younger generations with the necessary skills in a changing economic landscape. The EU's carefully managed immigration policies aim to address labour shortages resulting from its ageing population while prioritising social integration.

Technological advancements in 2050 are viewed through a lens of responsibility, with growing emphasis on the ethical implications of artificial intelligence. AI plays an increasingly significant role in enhancing the efficiency of healthcare systems and in disease prevention, crucial for managing the healthcare needs of an ageing population. Robust frameworks governing the ethics and responsibility of emerging technologies are in place. The EU is actively experimenting with novel funding schemes to support research and innovation. Legal protections for researchers against undue political pressures are becoming more harmonised across member states. Universities are also experiencing increased flexibility in their educational and certification models to adapt to the changing needs of learners across different age groups and the evolving demands of a labour market shaped by demographic shifts in a world of slower technological change. The EU actively invests in education and infrastructure in less prosperous regions to ensure they benefit from the knowledge society, mitigating regional disparities exacerbated by demographic shifts.

The pressing reality of climate change acts as a significant driver of innovation, rather than solely being perceived as a constraint. Climate-induced migration has a notable impact on political landscapes. The elephant in the room remains the environmental consequences of increased global rearmament. Despite some progress, overall global efforts to address environmental challenges are deemed limited and insufficient. While the environmental crisis has the potential to catalyse a significant resurgence in research focused on sustainable solutions, in many areas of the world this may be hampered by slow implementation and a lack of decisive political leadership. However, the post-growth paradigm in the EU and a more reasonable use of new technologies are beacons of hope in the fight against climate change in Europe.

Table 6 Scenario 2 – Inclusion and purpose? by PESTLE categories

Political • Stricter government control over digital space due to disinformation. • Rising populist sentiments and distrust in institutions. • Potential hindrance from younger leaders' chauvinism within EU.	**Economic** • EU prioritising post-growth, sustainability over pure expansion. • Talent moving from academia to more agile private sector. • Labor market strain from ageing workforce and new skill needs.
Societal • Older generations' "digital fatigue" and scepticism towards information. • General erosion of public trust in various institutions. • Climate change drives social displacement through migration.	**Technological** • The digital revolution is becoming more regulated and less free-flowing. • Growing focus on the ethical implications of AI development. • Universities showing more flexibility in education and certifications.
Legal • Efforts to standardise legal protection for researchers in the EU. • Development of legal frameworks for ethical technology use.	**Environmental** • Climate change acts as a key driver for innovation. • Climate-induced migration impacting political landscapes.

4.2.2 R&I focus

The European research and innovation system in 2050 is grappling with a complex interplay of demographic shifts, evolving market demands, constrained funding landscapes, and shifting socio-spatial dynamics. The ageing population across the EU is leading to a smaller pool of younger researchers and a greater need for research focused on the needs and challenges of older adults, such as healthcare, assistive technologies, and maintaining quality of life in retirement. Simultaneously, declining fertility rates in many European countries contribute to a shrinking domestic talent pool, making the attraction and retention of international researchers even more critical. This demographic reality necessitates a significant increase in lifelong learning opportunities to upskill and reskill the existing workforce, including older individuals, to adapt to the evolving, albeit slower, technological landscape and to compensate for labour shortages. The differing demographic trends in other parts of the world, with some regions experiencing youth bulges and others facing rapid ageing, influence global talent flows and research priorities. The distinction between attracting international students from within Europe and from outside the continent becomes increasingly important in a context of shrinking youth populations in traditional source countries. This necessitates a diversification of recruitment strategies for universities.

The interaction between the R&I ecosystem and related markets is increasingly defined by the imperative to address the needs of an ageing society, particularly in healthcare innovation. Research priorities are more frequently aligned with social demands, leading to a greater emphasis on joint initiatives between academia and industry. The demographic changes are also fundamentally altering the logic of R&I funding. Public funding priorities have demonstrably shifted towards areas such as ageing and digital health, the psychosocial impacts of advanced technology, disruptive technologies and their economic implications, biomedical technology, the future of work, inequalities, technological and economic history, and the impacts of AI on climate. While novel funding mechanisms like public, peer, or crowdfunding emerges, their inherent instability poses a challenge. The EU R&I system emphasises participatory research and citizen engagement to ensure that advancements benefit all age groups and segments of society, particularly in light of demographic shifts.

Socio-spatial implications of these trends are significant. Migration patterns, influenced by global demographic imbalances and the EU's need for labour to compensate for a shrinking workforce, are reshaping research agendas, with a growing focus on issues related to urban concentration and health equity. The ageing of the population in certain regions lead to a concentration of research activities focused on elderly care and related services in those areas, while regions attracting younger migrants see more research on integration and workforce development. There is a discernible push towards decentralisation of research activities and a greater emphasis on addressing regional disparities with investments in infrastructure and education in less prosperous areas to foster local innovation and address the needs of the local demographic.

The Effects of Demographic Change on Tertiary Education Systems

- Increased demand for lifelong learning opportunities across all disciplines.
- Notable surge in interest in "futures," "innovation," and "disruptive technologies" among younger generations.
- Growing divergence in dynamics between intra-European and extra-European international student mobility.

Interactions Between the R&I Ecosystem and Related Markets

- Healthcare innovation becoming a central focus of R&I due to the ageing population.
- Research topics increasingly driven by alignment with social and market needs.

The Impact on R&I Funding

- Public funding priorities demonstrably shifting towards areas like ageing and digital health.
- Emergence of novel funding mechanisms (public, peer, crowdfunding) with inherent instability.

Socio-Spatial Implications

- Migration patterns significantly influencing research agendas, with a focus on urban concentration and health equity.
- Discernible push towards decentralisation of research activities across Europe.
- Greater emphasis on addressing regional disparities through innovation and research.

This creates opportunities in areas with ageing populations or those experiencing outmigration of younger individuals in a less technologically driven economy. The mobility of students and researchers remains a crucial element of the European R&I landscape, and the ageing of the population is a key driver for the expansion of lifelong learning models, making access to education and training across different regions and age groups a priority in a world where continuous adaptation to even gradual change is essential. The EU R&I workforce is diverse and inclusive, promoting gender equality, intergenerational collaboration (recognising the value of experience in an ageing workforce), and the integration of researchers from diverse cultural backgrounds to enrich problem-solving in a less technologically homogenous world.

4.3 Scenario 3 - Splinters & Stratification

4.3.1 Narrative through PESTLE categories

The year 2050 dawns on a world irrevocably reshaped by a seismic technological event: China's unprecedented breakthrough in quantum computing a decade prior. This sudden leapfrogging of technological capabilities sent shockwaves across the globe. It was significantly fuelled by China's demographic dividend in the early 21st century: a large, relatively young, and increasingly educated population providing a vast talent pool for advanced technology sectors. While China was also beginning to face its own ageing challenges, the sheer scale of its young and middle-aged workforce at that critical juncture provided the human capital necessary for such a rapid advancement. This demographic advantage contrasted sharply with the European Union, which, by the 2040s, was already characterised by a significantly ageing population, declining birth rates leading to a shrinking pool of young researchers, and increasing pressure on social welfare systems. To avoid technological and geopolitical dominance, the EU, followed by other ageing major players with limited domestic talent in cutting-edge fields, reacted decisively, erecting digital and physical barriers that fractured the world, particularly through the establishment of power blocs like the European Federation and broke internet into a "Splinternet" – a collection of tightly controlled national and bloc networks, hindering seamless global information flow.

Faced with the urgent need to catch up and respond to escalating global crises – from climate change and resource scarcity to demographic shifts and political instability – governments increasingly ceded the reins of technological research and development to the private sector. Universities, once centres of groundbreaking inquiry, largely transformed into educational institutions, struggling to retain talent and funding as corporations, driven by the promise of rapid solutions and lucrative returns, aggressively poached researchers and directed investment towards immediate, application-oriented projects. Long-term fundamental research and the social sciences were relegated to the back burner.

Within the isolated territories of the Splinternet, a vibrant but fragmented ecosystem of AI research agents emerged, their capabilities and biases deeply imprinted by the distinct data landscapes and regulatory frameworks of their respective blocs. The initial Chinese quantum supremacy inadvertently empowered a new class of global quantum computing providers, whose control over this foundational technology became a critical chokepoint influencing the very trajectory of innovation within each walled-off digital realm. The global economy, now operating within these isolated spheres, experienced more pronounced and volatile boom-and-bust cycles, largely contained within bloc boundaries.

Governments, while relinquishing significant control over technological advancement, focused their energies on other pressing matters. They grappled with evolving social norms and values, navigating complex ethical debates arising from the rapid technological changes. They also shouldered the primary responsibility for responding to escalating crises: managing the socio-economic fallout of the European Federation's severe demographic imbalance, particularly the overwhelming burden of healthcare, pensions, and social security for a large elderly population supported by a relatively smaller working-age cohort, particularly the increasing burden of healthcare and social security for ageing populations, and coordinating responses to increasingly frequent and severe environmental catastrophes.

Large corporations, now at the forefront of technological innovation, operated in close, mutually beneficial partnerships with their respective governments. This symbiotic relationship allowed nations to accelerate their technological catch-up, leveraging corporate agility and resources, while providing corporations with the capital, regulatory frameworks, and societal stability necessary for continued growth and profit generation. The Splinternet structure conveniently simplified the taxation of businesses within each bloc, further solidifying this cooperation.

The relentless drive for technological solutions, however, continued to blur ethical lines. Concerns mounted regarding the potential instrumentalisation of human data and even human populations in the pursuit of AI breakthroughs, though overt exploitation remained largely within the realm of dystopian speculation. The pervasive threat of climate change amplified the urgency for immediate technological interventions, even as the resource intensity of AI, particularly its voracious appetite for water and energy, necessitated its careful and prioritised application to only the most critical tasks.

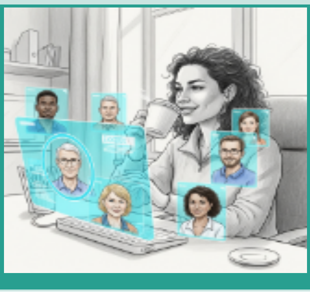
Politically, governments within their bloc boundaries issued specific technological challenges, and private companies engaged in fierce competition to provide AI-driven solutions. The ability to craft precise and effective AI prompts became a crucial strategic asset, both for corporations seeking to innovate and for governments aiming to address societal challenges. Governments maintained tight control over their splinternet domains, directly influencing the information accessible to their citizens and, consequently, the inherent biases within their domestically developed AI agents. Closed borders necessitated stringent migration controls, often favouring younger, able-bodied individuals deemed essential for the workforce. The economic isolation of the major power blocs led to minimal cross-border trade, necessitating substantial national investments in military capabilities to ensure security within their respective spheres of influence, along with significant focus on achieving food and energy independence, securing critical resources, and fostering technological sovereignty across key sectors to secure self-reliance.

3

Splinters and Stratified R&I

Corporate-led research favors short-term commercial goals.

Governments influence direction through AI-driven tenders, while security concerns affect collaboration and mobility.



Societally, the fundamental human need for basic services persisted. However, the power to define the initial research questions for AI systems became the ultimate lever of influence, residing primarily with those who controlled the funding and strategic direction – largely the corporations. The implementation of research outcomes also remained firmly within the corporate domain. An ageing European population presented a complex duality: a shrinking traditional workforce juxtaposed with a significant consumer base, particularly as automation freed up more leisure time. Within the European Federation, the widespread automation leading to reduced labour demands and increased leisure time, coupled with significant technological advancements and robust state support for the elderly, resulted in a notable demographic shift. Younger generations, freed from the intense caregiving responsibilities for seniors prevalent in the past, and further incentivised by strong government support within the closed political ecosystems (where migration was severely limited), increasingly chose to have children.

Technologically, relentless advancements in automation and AI significantly reduced the demand for human labour in many sectors, leading to increased leisure time for a substantial portion of the population. To capitalise on this surplus time and maintain economic activity, corporations aggressively developed immersive virtual entertainment and leisure platforms within their respective splinternet territories. This provided both a lucrative market for corporations and subtly diverting public attention from the concentration of power in corporate hands. Furthermore, education underwent a transformation, potentially evolving into a leisure pursuit for many, a means to cultivate a more informed populace within each bloc, perhaps with selective criteria for engaging with AI research tools.

The immense costs associated with developing and maintaining advanced technological infrastructure necessitated shared funding models between governments and corporations. Technological innovation increasingly focused on addressing the needs of the substantial elderly populations within each bloc, creating a significant "silver economy." Legally, international trade remained heavily restricted by strong protectionist measures, and intellectual property rights were fiercely guarded within bloc boundaries. Data and AI ownership became a complex issue, often subject to shared regulatory frameworks between the private and public sectors within each bloc. Environmentally, the resource demands of AI mandated its highly focused application, while the isolationist policies encouraged greater circularity and resource independence within each bloc's economy.

Political: ● Governmental bodies operate through a tendering system for problem-solving, with private companies responding to specific prompts for AI-driven solutions. ● Governments exert significant control over their respective segments of the "Splinternet," thereby influencing the information access and inherent biases of AI agents operating within their digital borders.	**Economic:** ● Large global power blocs maintain a high degree of economic isolation, characterised by minimal cross-border trade and limited collaborative economic initiatives. ● The "Splinternet" structure facilitates the taxation of businesses within each bloc, offering governments greater control over digital economic activity within their borders.
Societal: ● Despite technological advancements, the fundamental human need for basic services (e.g., healthcare, essential goods) persists as a stable societal demand. ● An ageing demographic presents a dual economic consideration: a potentially smaller workforce but also a significant consumer base, particularly if automation trends lead to increased leisure time and subsequent demand for goods and services.	**Technological:** ● Technological inventions, particularly in automation and AI, lead to a reduction in the necessity for traditional paid employment, potentially increasing leisure time and driving consumer spending. ● The substantial costs associated with developing and maintaining advanced technological infrastructure necessitate potential collaborative funding models involving both private companies and government entities.
Legal: ● International trade relations are dominated by strong protectionist policies within each of the major power blocs. ● The ownership and rights to data and AI algorithms may be subject to shared agreements or regulations between the private and public sectors within each bloc.	**Environmental:** ● The significant water and energy consumption of advanced AI systems necessitates a pragmatic approach, limiting their application to the most critical and impactful tasks. ● The prevailing isolationist tendencies among the power blocs foster higher levels of circularity within their economies, encouraging localised resource management and waste reduction.

4.3.2 R&I focus

Within the fragmented world of 2050, the European R&I system is deeply influenced by the dominance of business and the technological imperative for immediate solutions. The tertiary education sector's transformation into a more flexible, ad-hoc, and leisure-oriented space has resulted in a diminished emphasis on formal academic credentials within the R&I landscape. This shift can be particularly challenging for older workers seeking to retrain or acquire new skills relevant to the evolving technological landscape, as traditional academic pathways become less central. The limited student mobility across the closed global systems further constrains the traditional flow of knowledge and talent within the European Federation, hindering the introduction of fresh perspectives and skills from regions with different demographic profiles or technological specialisations. Universities, while no longer the primary engines of groundbreaking research, persist as crucial institutions for education and the cultivation of a technologically literate populace. They offer modular learning programmes, often tailored towards specific industry needs or individual interests, catering to both younger generations and an ageing population with increased leisure time. However, ensuring equitable access to these programmes across different age groups and socio-economic strata within the European Federation remains a key demographic challenge. This is because older individuals may lack the digital literacy or prior technological familiarity to easily engage with online platforms. Furthermore, socio-economic disparities can limit access to the necessary technology and internet connectivity. Even with increased leisure time for some, financial constraints or lack of awareness about available programmes can prevent participation. While their research funding has significantly decreased, some specialised university departments, often in collaboration with corporations, focus on foundational knowledge and the development of critical thinking skills, essential for effective AI prompting and navigating the complexities of the Splinternet. They also serve as centres for ethical debates surrounding AI and technology, albeit with less direct influence on corporate-driven innovation. The ageing academic workforce within universities also presents a demographic challenge, potentially limiting the capacity for innovation and adaptation to new research paradigms.

The primary driver of R&I within the European Federation is the private sector, with funding heavily skewed towards short-term, commercially viable projects. The European government's role in steering research is largely confined to the procurement of specific, longer-term research directions through AI prompt tenders, highlighting the critical need to identify individuals capable of formulating effective queries for these advanced systems. However, corporations also recognise the strategic advantage of a well-informed populace. Intelligent prompting and the continuous evolution of the European Federation's Splinternet require a regular influx of novel data and perspectives to avoid stagnation within existing datasets, upon which AI systems are built. While AI generates new content, the value of human insight in shaping this feed remains significant, making a reasonably educated populace a crucial resource for maintaining the dynamism of the European Federation's digital ecosystem. The substantial costs of maintaining R&I infrastructure necessitate collaborative funding models, often involving partnerships between companies or between the private and public sectors.

The closed borders of the European Federation have significant repercussions for its R&I activities. The restricted migration, potentially favouring younger individuals deemed adaptable to the European Federation's technological ecosystem, can lead to a degree of redundancy in research efforts and limit the diversity of thought and expertise. The European Federation is constantly struggling to counteract the potential slowdown in the pace of innovation caused by this limited inflow of new talent, particularly in emerging fields where younger generations often bring novel perspectives and skills. This isolation also creates a heightened risk of industrial and R&I espionage from other dominant power blocs, forcing the European Federation to invest heavily in security measures rather than collaborative research.

The Effects of Demographic Change on Tertiary Education Systems:	Interactions Between the R&I Ecosystem and Related Markets:
• Tertiary education increasingly becomes a choice for personal growth and societal contribution, less tied to direct job requirements. • Learning formats become more adaptable and individualised. • Formal academic qualifications decrease in importance compared to practical skills.	• Technological advancements in R&I are primarily geared towards the needs of the elderly. • Companies fund immediate research; the government procures longer-term projects.
The Impact on R&I Funding:	**Socio-Spatial Implications:**
• Funding for R&I infrastructure is shared between companies or with the government. • Systems are developed to identify individuals capable of creating effective AI research prompts.	• Closed borders lead to potential duplication of research efforts. • Limited immigration, potentially favouring younger, able-bodied individuals.

4.4 Scenario 4 - Hybrid hubs

4.4.1 Narrative through PESTLE categories

The year 2050 paints a picture of a world marked by profound transformations, catalysed by turbulent events from two decades prior. The trade wars between Europe and the United States, extending to the services sector, triggered global economic shocks. The culmination was a widespread technological disaster in Europe, which exposed the fragility of digital infrastructure and accelerated the Old Continent's pursuit of strategic autonomy.

In response to these threats, the EU strengthened cooperation, leveraging a fresh talent pool from younger, ambitious societies in Central-Eastern Europe, regions that generally experienced a demographic transition later than Western Europe and often possessed a younger, more mobile, and highly educated workforce. The attraction of talent from these areas represented a form of internal EU migration, counteracting some of the ageing trends in the West. The EU invested vast resources in building its own independent digital infrastructures – from cloud computing to advanced artificial intelligence systems. This move aimed to safeguard against future crises as well as to position Europe as a key player in the global technological landscape.

Simultaneously, the world experienced a significant slowdown in globalisation. Supply chains were shortened and regionalised, and the emphasis on local production and self-sufficiency increased. Europe, while striving for autonomy, remained strategically open to cooperation with selected partners, especially in areas crucial for ecological and digital transformation. Other parts of the world presented a diverse demographic landscape. The US, while possessing a relatively more stable demographic profile than Western Europe due to higher birth rates and consistent immigration, still faced its own ageing challenges and potential labour shortages in specific sectors. These domestic pressures might have contributed to a more protectionist stance in trade, seeking to safeguard American jobs and industries. Some developed nations mirrored Europe's ageing trends, while many developing economies, particularly in Africa and parts of Asia, continued to experience significant population growth, potentially becoming future sources of labour and new markets, although geopolitical and economic factors influenced the extent of interaction.

4

Hybrid Hubs & Collaborative Nets

Specialized centers form regional networks with shared funds.
EU priorities guide virtual, dynamic innovation ecosystems.

Technological progress did not cease; on the contrary, it gained momentum thanks to the synergy between creativity of young researchers and the capabilities of artificial intelligence. Algorithms permeated almost all aspects of life, from work organisation to social interactions. This, in turn, sparked serious ethical debates regarding the impact of AI on the labour market, privacy, and individual autonomy.

In this new order, demographically stable China solidified its position as a global scientific and technological leader, and its dynamically developing higher education system attracted talent from around the world. China's relative demographic stability in this period, stemming from a large population base even as its birth rates eventually declined, coupled with massive investment in higher education, allowed it to cultivate a substantial domestic talent pool and attract international students and researchers, further cementing its global S&T leadership. This prompted Europe to consider deeper integration with selected non-EU universities within the framework of the European University Alliances, while remaining aware of the potential risks associated with research security.

The information space became a field of constant struggle. Technological progress created new, sophisticated tools for disseminating disinformation, and universities played a crucial role in shaping critical thinking and countering manipulation, both from domestic nationalist circles and foreign actors.

Demographic changes left their mark on society. Ageing populations in many EU western European countries led to the consolidation of higher education institutions and a greater emphasis on remote forms of education. At the same time, the demand for workers in the care sector surged, leading some countries to consider legal obligations to work in this sector.

The economy is characterised by intense competition within the demographically shattered EU and the growing importance of the circular economy, although its full implementation still faces challenges, especially in regions heavily dependent on fossil fuels. Energy costs remain high, partly due to the energy intensity of the developing digital infrastructure, including AI data centres. The EU's demographic landscape, with regional variations in the pace and intensity of ageing and population change, contributed to diverse economic challenges and opportunities across the continent.

The social landscape shows an emphasis on the development of soft and interdisciplinary skills, essential in a rapidly changing world of work. Debates on the use of personal data have taken on new forms, in the face of the ubiquity of algorithms and advanced AI systems.

Political:	Economic:
● A strong and united EU strategically invests in its technological independence. ● Despite the slowdown in globalisation, Europe maintains a strategic openness for cooperation with selected partners.	● The economy has regionalised, characterised by shorter global supply chains. ● Competition within the EU is increasingly intense.
Social:	**Technological:**
● Remote forms of education are becoming more prevalent, offering flexible access to learning. ● The demand for workers in the care services sector is increasing.	● Europe is developing its own sovereign digital infrastructure, reducing dependence on external providers. ● Cooperation between human intelligence and AI capabilities drives technological progress.
Legal:	**Environmental:**
● Legal systems are adapting to the development of artificial intelligence and regulating the use of personal data. ● Due to the increasing demand for care services, some countries are piloting legal requirements for citizens to work in care jobs for a limited period.	● Ambitious climate policies and widespread adoption of clean technologies have substantially lowered greenhouse gas emissions in the EU. ● Significant investments in adaptation measures and infrastructure have made Europe much more resilient to the impacts of climate change.

4.4.2 R&I focus

The R&I landscape in 2050 was shaped by strategic decisions made after the technological crisis and in the context of global competition. A key feature is a dispersed but strongly interconnected network of research centres, with less emphasis on traditional metropolises. Strategic investments in modern infrastructure in smaller cities and regions with unique competencies enabled the emergence of strong, specialised centres. To optimise resources and foster collaboration across the EU's diverse demographic landscape, interregional partnerships between research institutions and universities became crucial. This facilitated the exchange of expertise between established centres in the West and emerging talent in the East, recognising that both regions faced demographic transitions. Investments in modern R&I infrastructure, including local data centres and specialised AI laboratories, were a priority, facilitating the development of robust innovation ecosystems across various regions of Europe. These collaborations aimed to create a resilient R&I system that could draw upon the strengths of different regions facing shared demographic challenges.

Specialisation became a dominant trend among research institutions and universities. The decreasing number of students and the need to optimise resources forced the profiling of research offerings in areas of strategic importance for the EU and corresponding to local economic needs. Universities often joined forces through local and interregional mergers, creating stronger and more specialised units.
Cooperation between academia and industry intensified. Industry, relying on advanced technologies, seeks highly qualified graduates with interdisciplinary skills capable of implementing innovative solutions. The transfer of knowledge and technology from universities to businesses became a key element of regional development strategies across the EU, aiming to boost economic activity in areas affected

by demographic shifts. This collaboration often involved connecting industries in regions with ageing workforces with the talent emerging from universities across the continent.

The European University Alliances evolved into complex cooperation networks, encompassing both European and carefully selected non-EU universities, especially from countries with complementary research strengths. This cooperation, while beneficial in terms of knowledge exchange and access to unique competencies, involves continuous monitoring and management of risks related to research security.

R&I funding is strongly focused on EU political priorities, such as digital and ecological transformation, public health, and security. Competition for resources is high, stimulating interdisciplinary collaboration and the search for innovative approaches to solving complex problems. Funding mechanisms often prioritised projects that addressed the challenges of an ageing society and leveraged the diverse talent pool within the EU.

In the context of demographic changes, research is increasingly focusing on health, prevention, and social care. ageing societies generate new challenges and needs, that require interdisciplinary research approaches, combining medical, social, and technological sciences. This focus on the "silver economy" and related social sciences reflects the demographic realities of much of the EU.

Virtual mobility became a common form of research collaboration and knowledge exchange, compensating for limitations in physical mobility. Advanced digital platforms enable researchers from different countries to jointly conduct projects, exchange data, and participate in virtual conferences and seminars.

Despite technological progress, the role of scientists as critical thinkers and experts remains irreplaceable. In the face of information overload and disinformation, their ability to analyse, verify, and interpret data is crucial for making rational decisions and building public trust in science. Universities actively educate critically thinking graduates equipped with the skills necessary to navigate a complex world of information.

The Effects of Demographic Change on Tertiary Education Systems:

- Mergers and consolidations of higher education institutions aim to optimise resources and increase efficiency.
- Academic institutions are specialising their research offerings, focusing on narrower areas.

Interactions Between the R&I Ecosystem and Related Markets:

- There is a growing demand in the labour market for graduates with interdisciplinary skills.
- The transfer of knowledge and technology is becoming a key element of regional economic development.

The Impact on R&I Funding:

- Competition for financial resources stimulates interdisciplinary collaboration between research units.
- Investments in regional R&I infrastructure strengthen local innovation and competitiveness.

Socio-Spatial Implications:

- The network of research centres is becoming more dispersed beyond traditional metropolitan areas.
- The dispersion of research infrastructure contributes to a more balanced development of innovation across Europe.

4.5 Synthesis

These scenarios offer varying perspectives on how automation, research providers, and key demographic shifts (ageing, migration, fertility, etc.) might interact to shape the R&I landscape. They highlight potential challenges such as talent drain, ethical dilemmas, funding constraints, and geopolitical pressures, as well as opportunities for innovation, social inclusion, and strategic autonomy.

Building upon this scenario-building phase, the next step of the project included further workshops:

- **Implications Workshop** – aimed at analysing the specific implications of each scenario for the European R&I system across key dimensions such as education, funding, and socio-spatial impacts.
- **Simplified Roadmapping Workshop** – aimed at identifying and longlisting potential actions to mitigate challenges and leverage opportunities identified in the scenarios.
- **Wind-tunnelling Workshop** – aimed at future-proofing these actions by testing and refining policy options against the developed scenarios, ensuring their robustness and effectiveness under conditions of uncertainty.

5 IMPLICATIONS

5.1 Introduction

A series of interconnected workshops explored potential future scenarios, fostering a deeper understanding of their consequences. The ultimate goal was to propose robust actions to strengthen the resilience and adaptability of Europe's R&I system, ensuring that it remained dynamic and competitive. Each workshop built upon the outcomes of its predecessor, creating a cumulative understanding that enabled the progressive refinement of the analysis and the development of strategic responses.

The **Implications Workshop** aimed to systematically map the consequences of pre-developed demographic scenarios for the European R&I system. The core methodology used in this workshop was the **Futures Wheel**, selected for its ability to reveal both immediate, direct consequences and cascading, indirect effects.

Participants in the **Implications Workshop** were organised into four groups, each assigned one of the previously constructed demographic change scenarios. The objective for each group was to explore and document the potential implications arising from its assigned future. To structure the analysis, scenarios were examined through four predefined dimensions relevant to the R&I system: impacts on tertiary education systems, including student demographics and curricula; interactions between the R&I ecosystem and related markets, such as shifts in supply and demand; effects on R&I funding priorities and sources; and wider socio-spatial implications, including the geographical distribution of research hubs and talent.

The **Futures Wheel**, a structured brainstorming technique, served as the principal instrument for this exploration, enabling the systematic identification of primary, secondary, and tertiary consequences. The process began with each group placing its assigned scenario at the centre of the wheel. Participants then identified the immediate, direct impacts (primary implications) that the scenario would have across the four R&I dimensions, forming the first conceptual ring. Subsequently, for each primary implication, the groups identified follow-on effects (secondary implications) by considering what would happen next. This iterative process continued to identify third-order implications where relevant, fostering a granular understanding of ripple effects and interdependencies within each scenario. The collaborative approach ensured that a rich and diverse set of implications was generated, highlighting both potential opportunities and emerging challenges.

Following the **implication mapping**, the workshop concluded with a cross-scenario analysis conducted during a plenary session. This final step involved comparing the findings from all four groups to identify recurring implications—consequences that emerged across multiple scenarios. This qualitative assessment was essential in highlighting implications with the greatest potential significance and likelihood of occurrence. Overall, the process provided a synthesised understanding, transforming a general awareness of demographic change into a nuanced mapping of its potential impacts on the European R&I system.

5.2 Clustered Implications

5.2.1 Recurring Implications

These are the core themes and dynamics that appeared in more than one scenario, suggesting they are robust trends and fundamental pressures that the R&I system will almost certainly face, regardless of the specific future that unfolds.

Theme: Reshaping of Higher Education & the Talent Pipeline

– **Structural Disruption of Universities**

The traditional role and structure of universities/higher education institutes are consistently challenged, whether through consolidation and specialisation, privatisation, or a fundamental shift away from research.

– **The Rise of Lifelong Learning**

The imperative for continuous learning and adaptation for an ageing workforce is a powerful driver, demanding new models for upskilling and reskilling within the R&I ecosystem.

– **Intense Global Competition for Talent**

The R&I system is consistently defined by a heightened competition to attract and retain top research talent from a global pool.

Theme: R&I Funding and Priority-Setting Landscape

– **A Shift Towards Applied & Mission-Oriented Research and Innovation**

There is a powerful and recurring pull away from purely curiosity-driven research towards R&I that addresses specific commercial, political, or societal challenges.

– **The Influence of an Ageing Population on R&I Agendas**

The demographic reality of an ageing Europe consistently shapes R&I funding priorities, whether through a focus on age-tech, the "silver economy," or digital health solutions.

Theme: The Governance and Structure of Research and Innovation Systems

- **New Dynamics of Collaboration and Competition**

  Discussions within all the groups revolved around a reconfiguration of how R&I actors relate, pointing towards more intensified collaboration (especially academia-industry) and/or heightened competition for resources.

- **The Need for New Regulatory Frameworks**

  A consistent theme is the need for the R&I system to address complex governance issues, including intellectual property rights (IPR) and the need for better regulation of new technologies.

Theme: Socio-Spatial Dynamics

- **The Decentralisation and Regionalisation of R&I systems**

  The idea that innovation will move beyond traditional hubs and become more localised, specialised by region, or dispersed in a network is a strong recurring theme.

- **The Pursuit of Strategic Autonomy**

  A common driver for the R&I system is the geopolitical push for greater European strategic autonomy, influencing everything from infrastructure investment to research priorities.

Figure 8 Summary of recurring implications

Recurring Implications in R&I Systems

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Reshaping of Higher Education & the Talent Pipeline

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Intense Global Competition for Talent

The R&I system is consistently defined by a heightened competition to attract and retain top research talent from a global pool.

R&I Funding and Priority-Setting Landscape

A Shift Towards Applied & Mission-Oriented Research and Innovation

There is a powerful and recurring pull away from purely curiosity-driven research towards R&I that addresses specific commercial, political, or societal challenges.

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The demographic reality of an ageing Europe consistently shapes R&I funding priorities, whether through a focus on age-tech, the "silver economy," or digital health solutions.

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Socio-Spatial Dynamics

The Decentralisation and Regionalisation of R&I systems

The idea that innovation will move beyond traditional hubs and become more localised, specialised by region, or dispersed in a network is a strong recurring theme.

The Pursuit of Strategic Autonomy

A common driver for the R&I system is the geopolitical push for greater European strategic autonomy, influencing everything from infrastructure investment to research priorities.

Source: Study team

5.2.2 Exclusive Implications

The following table includes the unique, defining characteristics and outcomes tied to a single scenario. They represent the critical differentiators that emerge from specific strategic choices and truly distinguish one potential future from another.

Figure 9 Exclusive implications

Scenario 1: Corporate Ascendancy	Scenario 2: Inclusion and Purpose?	Scenario 3: Splinters & Stratification	Scenario 4: Hybrid Hubs
Formal degrees are fully devalued and systemically replaced by corporate-issued credentials.	Legal protections for researchers against undue political pressure are formally harmonised across the EU.	The ability to craft effective AI prompts becomes a new, highly valued strategic asset for securing R&I resources.	The EU defence budget becomes a significant driver for R&I funding priorities.
A cautious, security-focused, and strongly "human-led" approach to risk assessment is adopted for all R&I.	A system of participatory research and direct citizen engagement becomes a central feature of R&I governance.	A symbiotic partnership where governments issue clear technological challenges and corporations compete to provide solutions becomes the dominant innovation model.	R&I is framed as a shared, lifelong responsibility for all citizens, not just professional researchers.
A vast network of smaller, agile start-ups emerges with the specific purpose of servicing dominant corporations.	EU investment is strategically used to mitigate regional disparities as a core policy goal.	Economic isolationism becomes the primary driver of the R&I system, forcing blocs into resource independence.	Competition for physical space between IT infrastructure (data centres) and other societal needs becomes a critical socio-spatial challenge for the R&I system.
Progress is made specifically in profit-driven green technologies, as opposed to publicly-driven ones.	A "post-growth" paradigm emerges as a beacon of hope, influencing the direction of R&I.	A technologically literate populace is seen as a crucial strategic resource for powering the AI ecosystem.	The synergy between young researchers and AI capabilities is identified as the key driver of technological momentum.
The complete privatisation of HEIs, which are run as corporate divisions, fundamentally changes the R&I landscape.		Education evolves into a leisure pursuit for many, diminishing the value of formal credentials in the R&I system.	Universities/HEIs explicitly take on the new mission of shaping critical thinking to counter systemic mis-/disinformation.

6 CHALLENGES & OPPORTUNITIES

6.1 Introduction

The following analysis of challenges and opportunities for the European Research and Innovation (R&I) system is the result of a multi-stage synthesis and interpretation process. The primary objective was to move beyond the raw outputs of the foresight exercises to distil a set of actionable strategic insights. This was achieved by systematically building upon the initial workshop data through a structured analytical framework.

First, the verbatim implications generated during the futures wheel workshop provided a structured set of direct and downstream consequences for each scenario. Then the process shifted from a scenario-by-scenario review to a cross-cutting thematic analysis. All implications were examined collectively to identify overarching patterns, recurring themes, and significant points of divergence that transcended the individual scenarios. This qualitative synthesis allowed for the clustering of disparate ideas into larger, more meaningful conceptual themes, such as the transformation of higher education or the changing governance of R&I.

It is crucial to note that the implications identified in the foresight process are, in themselves, neutral; they do not carry an inherently negative or positive angle. A single future development can manifest as both a challenge and an opportunity depending on the strategic perspective applied and the goals one aims to achieve. The same trend can create risks for established institutions while simultaneously opening new pathways for innovation.

Therefore, the final and most critical step of this analysis was to deliberately view these synthesised themes through the specific strategic lens of the project. Each neutral theme was evaluated from two standpoints to determine its potential impact on the European R&I system. Its potential negative aspects were framed as **Challenges** - risks, barriers, or systemic problems that must be mitigated. Concurrently, its potential positive aspects were framed as **Opportunities** - strategic advantages, positive pathways, or areas for proactive investment. These were then organised under the four original workshop dimensions to ensure coherence and provide a clear framework for strategic discussion and policy development.

6.2 Dimension 1: How will demographic shifts reshape education?

6.2.1 Challenges for the R&I System

The Decline of the Traditional Public University Model

The European R&I system faces a fundamental challenge in the decline of the traditional public university, a trend driven by both institutional inertia and systemic erosion. This process is profoundly linked to transformations in the labour market, which are themselves spurred by demographic shifts. An ageing European population strains public finances through increased pension and healthcare costs, leading to dwindling state support for public research institutions and a crisis in public sector remuneration. This, in turn, directs top research talent towards better-paid, more dynamic careers in the private sector, which can offer more competitive conditions and hiring flexibility.

This demographic pressure leads to a twofold crisis for public universities. They often exhibit institutional inertia, with rigid structures ill-suited to a rapidly changing landscape, making them less competitive. Simultaneously, the lack of public funding and talent drain accelerates the erosion of their role as the bedrock of foundational research. As universities are increasingly privatised, run as corporate divisions, or become exclusively teaching institutions, the national research agenda risks being skewed towards proprietary, short-term goals. This ultimately starves the public R&I system of the foundational knowledge and diverse talent it needs to thrive in the long term.

Supporting Implications:

- The privatisation of higher education is complete; universities are run as corporate divisions.
- Universities are in a precarious position, with rigid structures ill-suited to the new landscape.
- Universities have largely transformed into educational institutions, no longer primary research engines.
- Fewer higher education institutions, leading to mergers.
- Loss of universal access to higher education.
- Private higher education institutions have more flexibility in hiring staff, making them more competitive.
- Changes in staff policies are occurring.

A Narrowing of the R&I Talent Pipeline

A powerful undercurrent across several future scenarios is the risk of the European R&I talent pipeline narrowing significantly, driven by a systemic shift towards market-driven education at the expense of holistic scientific training. This trend challenges the value placed on deep, formal scientific training, as traditional degrees like PhDs are devalued in favour of short-term, task-specific certifications. This shift is driven by a demand for job-specific skills, visible in futures where education models prioritise specialised skills over broad knowledge and industrial PhDs become the dominant model, which can disincentivise young people from pursuing long, rigorous research careers.

The ultimate consequence is a critical skills gap within the R&I system. An overemphasis on vocational training risks marginalising disciplines crucial for developing creativity and critical thinking, such as the humanities and social sciences. This leads to a shortage of individuals trained in complex problem-solving, robust scientific methodology, and the theoretical foundations required for true scientific advancement. The result is a future R&I workforce that, while highly skilled in specific tasks, may lack the broader, more imaginative perspective required to maintain Europe's long-term innovative capacity and competitive edge.

Supporting Implications:

- The allure of academia has diminished for younger generations, who are drawn to more dynamic and immediately impactful careers.
- The tertiary education sector's transformation has resulted in a diminished emphasis on formal academic credentials within the R&I landscape.
- An overemphasis on STEM and profit-oriented research leads to a decline in humanities and social sciences.
- The education system is distorted, prioritising specialised skills over broad general knowledge.
- Formal academic qualifications decrease in importance compared to practical skills.
- There is a growing divergence between intra-European and extra-European student mobility dynamics.

6.2.2 Opportunities for the R&I System

Systematising Lifelong Learning to Create Agile Career Pathways

The demographic shift towards an older population in Europe presents a significant opportunity to systematise lifelong learning, bolstering the R&I system's human capital. In a future with a shrinking younger talent pool and longer careers, the continuous upskilling and reskilling of the existing workforce becomes an imperative for maintaining productivity and innovation. By building a formal framework for lifelong learning, the system can ensure its researchers remain at the cutting edge of new technologies like AI, evolving methodologies, and interdisciplinary approaches. This creates a more resilient and consistently innovative research community, capable of adapting to and leading future scientific transformations in a world where continuous adaptation is essential.

This emphasis on continuous learning enables the creation of more agile and diverse career pathways for researchers. A formalised system of lifelong learning naturally embraces flexible and modular credentials, which can gain prominence alongside traditional degrees and are often delivered through remote or personalised education programmes. This creates more varied entry and exit points into research careers, allowing for greater mobility between academia and industry. Such a system would be enriched by professionals with diverse experiences, fostering a more dynamic talent pool that is continuously updated with new skills and perspectives, making it better suited to the challenges and opportunities of a demographically changed Europe.

Supporting Implications:

- A significant push towards lifelong learning models for an ageing workforce.
- Increased access to personalised and flexible education programmes.
- Remote forms of education are becoming more prevalent.
- Flexible, modular credentials gain prominence over traditional degrees.
- Lifelong learning is institutionalised within corporations to keep the workforce productive.
- Having more opportunities for more personalised, student-centred learning.

Redefining the University's Societal Role as a Guardian of Public Interest

In a future shaped by demographic pressures, universities have an opportunity to reinforce their societal value by becoming crucial hubs for fostering critical thinking and scientific literacy. As states grapple with the fiscal burdens of an ageing population, they may cede R&I leadership to the private sector, leading to innovation driven by commercial rather than societal needs. This, combined with the "digital fatigue" and vulnerability to disinformation seen in parts of the population, creates a critical need for an engaged and discerning public. The university's role can therefore be elevated beyond simple education to that of a guarantor of the public interest, cultivating a populace capable of navigating a complex world of information and ensuring that technological advancement serves the broader community.

By actively embracing this role, universities can build a robust social licence for the entire R&I system. Fostering essential soft and interdisciplinary skills and promoting technological literacy creates a public that can resist misinformation and participate constructively in research processes. A technologically literate populace is not merely a passive beneficiary of innovation but becomes a crucial resource, capable of contributing to the R&I ecosystem and ensuring that the development of AI and other automated systems remains ethically grounded. This deep public trust is the foundation upon which long-term support for R&I funding depends, ensuring that progress is aligned with societal well-being in an increasingly automated world.

Supporting Implications:

- Universities shape critical thinking to counter misinformation.
- The development of soft and interdisciplinary skills is essential.
- A technologically literate populace is a crucial resource for the AI ecosystem.
- The EU R&I system emphasises participatory research and citizen engagement.

6.2.3 Recommended strategic actions

Reinvest in deep scientific education and training

Description: Strengthen PhD and postdoctoral programmes to combine academic excellence with interdisciplinary, creative, and critical thinking skills. This action counters the narrowing talent pipeline by ensuring the workforce retains the capacity for complex problem-solving beyond immediate market needs.

Responsible stake-holders	Resources needed	Level of urgency
National governments, universities & research organisations, EU institutions.	**Financial:** National/State-level financing, EU-level financing (e.g., Marie Skłodowska-Curie actions). **Non-financial:** Human capital (mentorship capacity), Institutional know-how.	Now or within 5 years. (Immediate action is required to prevent a generational skills gap).

Establish a European framework for lifelong learning in R&I

Description: Create a coordinated framework enabling modular upskilling and reskilling throughout research careers. This should include novel funding mechanisms, such as a "sabbatical re-training fund" modelled on pension contributions, to support mid-career transitions.

Responsible stake-holders	Resources needed	Level of urgency
National governments, EU institutions, private sector (industrial groups), universities.	Financial: Multi-source funding (public-private partnerships), tax incentives for corporate training.	Now or within 5 years.
	Non-financial: Political will to reform labour/education laws, digital infrastructure for micro-credentials.	

Allocation of funding for citizen science

Description: Ring-fence specific funding lines for citizen science and community-based research. This operationalises the university's role as a guardian of public interest by actively involving citizens in data collection and agenda-setting, thereby rebuilding trust in science.

Responsible stake-holders	Resources needed	Level of urgency
EU institutions, national funding agencies, regional authorities, civil society organisations (NGOs).	**Financial:** EU-level financing (Horizon Europe), philanthropic grants.	Medium-term (6–15 years).
	Non-financial: Public support, methodological expertise (know-how) in participatory research.	

6.3 Dimension 2: How will R&I funding be affected?

6.3.1 Challenges for the R&I System

Funding Instability and the Neglect of Basic Research

A persistent challenge to the European R&I system is the threat of underfunding basic, curiosity-driven research, a problem exacerbated by funding instability. Demographic pressures, particularly from an ageing population, place significant strain on public finances, which can lead to volatile and limited public funds for R&I. This politically and fiscally unstable environment discourages long-term investment and forces a focus away from ambitious, high-risk projects towards those with more immediate, predictable outcomes. It also makes it nearly impossible to build and maintain the large-scale research infrastructures that are the backbone of a modern R&I system.

This neglect of fundamental science risks "eating the seed corn" of innovation. An excessive focus on funding only applied R&I with immediate market applications means the pipeline of ideas that fuels future breakthroughs will eventually run dry. Without a constant stream of new knowledge from basic research, the entire R&I system becomes less innovative and more reliant on incremental improvements. This creates a critical long-term vulnerability, undermining Europe's ability to respond to grand societal challenges, from climate change to future health crises.

Supporting Implications:

- Decline in basic research and lack of foundational ideas for applied research.
- Less focus on basic research.
- Difficult balance between applied research (which is favoured) and curiosity driven research.
- Limited research on SDGs, other global issues => implications for the climate.
- Limited public funds.
- Shift from public to private R&I funding.
- Less funding available for R&I.
- R&I funding linked with companies' short-term interests.

The Fragmentation of Funding and Loss of Strategic Cohesion

The European R&I system is challenged by a structural fragmentation of its funding landscape, a direct result of demographically-strained public budgets. As fiscal pressures limit the state's role as the primary, central funder, a proliferation of diverse and uncoordinated funding models emerges. The system becomes reliant on a patchwork of corporate R&D budgets, private HEI investments, venture capital, and other private sources, each with its own goals and timelines. This shift from a coherent public funding strategy to a decentralised, private-led model creates significant new risks for the stability and strategic direction of European research.

This fragmentation leads to a chronic misallocation of capital and an inability to orchestrate a national response to societal challenges. Without a central steward, funding naturally flows towards areas with obvious, short-term commercial returns, leading to duplicated efforts and investment bubbles. Conversely, areas of critical public interest that lack immediate market applications—such as fundamental science, climate research, or pandemic preparedness—face systemic underfunding. The result is an inefficient and incoherent national funding portfolio that struggles to support long-term projects or address grand challenges effectively.

Supporting Implications:

- Fewer R&I actors in the public sector, less diversity overall.
- Corporations provide vast financial resources for R&I through their private HEIs.
- Funding priorities are strategically shifted towards age-related research and technologies that boost productivity.
- More focus on commercial impact when assessing projects for funding.
- Unstable political situation.

6.3.2 Opportunities for the R&I System

Building a Legitimate, Mission-Oriented R&I System

Focusing R&I funding on clear, ambitious missions provides an opportunity to mobilise the entire system towards common goals that address Europe's core demographic challenges. Rather than funding disparate projects, the system can direct its collective power towards large-scale objectives, such as achieving digital strategic autonomy or ensuring public health for an ageing society. For such missions to garner the necessary long-term political and financial support, especially when public trust in institutions is eroding, they must be deeply embedded within society. This creates a powerful opportunity to strengthen the social contract for R&I by involving citizens and other stakeholders in defining these missions from the outset.

This approach makes the R&I system more than the sum of its parts, enhancing both its effectiveness and its legitimacy. A mission-oriented framework, guided by participatory processes and citizen engagement, can break down silos between disciplines and foster radical collaboration between public and private actors. By ensuring the direction of innovation is aligned with societal values and needs, the resulting solutions are more likely to be widely accepted and adopted. This creates a virtuous cycle where a more democratic and inclusive R&I system builds public trust, which in turn secures the mandate to pursue the transformative breakthroughs Europe needs.

Supporting Implications:

- Focus of R&I funding to address societal challenges.
- R&I funding is strongly focused on clear EU political priorities.
- Governments issue clear technological challenges, and companies compete to provide solutions.
- Need for more transparency.
- The EU R&I system emphasises participatory research and citizen engagement.
- A more democratic and inclusive R&I system.

Creating a More Efficient and Dynamic R&I Funding Ecosystem

The new R&I landscape creates a clear opportunity to design a more efficient and dynamic funding ecosystem based on a strategic "division of labour". In this model, public and private capital are allocated to the roles they are best suited for. Scarce public funds can be precisely targeted to de-risk and support high-risk, long-term basic research—the foundational science that fuels future breakthroughs but is often avoided by the private sector. In parallel, private capital, with its focus on commercial viability, can be channelled towards closer-to-market R&D and scaling up innovations.

This strategic allocation is made more relevant and urgent by Europe's demographic and fiscal pressures. With public funds constrained by the needs of an ageing population, it is imperative to maximise the leverage of every public euro. Instead of viewing the rise of corporate-led R&I as solely a challenge, this division of labour harnesses it productively. This approach, supported by shared funding models for major infrastructure and novel schemes like crowdfunding, accelerates the path from the laboratory to the market while ensuring the long-term innovation pipeline remains secure.

Supporting Implications:

- The EU is actively experimenting with novel funding schemes.
- Shared funding models between government and industry have emerged to cover the immense costs of R&I infrastructure.
- More diversity in funding sources (crowdfunding etc.).
- Possible "division" of labour between public and private investment.

6.3.3 Recommended strategic actions

Mandate a fixed percentage for fundamental research

Description: Enact legislation or binding targets mandating that a fixed percentage of national and EU R&I budgets be dedicated exclusively to fundamental, non-applied research. This creates a "firewall" protecting long-term science from short-term economic fluctuations.

Responsible stakeholders	Resources needed	Level of urgency
National governments (parliaments/ministries of finance), EU institutions (European Commission)	**Financial:** National/state-level financing (budgetary allocation).	Now or within 5 years.
	Non-financial: Strong political will, regulatory frameworks (ERA Act).	

Obligation to publish national R&I roadmaps

Description: Include an obligation in the European Research Area (ERA) Act for Member States to publish transparent, multi-annual national R&I roadmaps. This ensures strategic alignment, reduces duplication across borders, and provides predictability for investors.

Responsible stake-holders	Resources needed	Level of urgency
European Commission (DG RTD), national governments.	**Financial:** Administrative funding for foresight and planning.	Now or within 5 years.
	Non-financial: Data and information access, coordination expertise.	

Create a European mission lab network

Description: Establish a network of regional "mission labs" where citizens, researchers, and policymakers co-design and test mission-driven innovations. These hubs act as the physical interface for the mission-oriented approach, ensuring local relevance and uptake.

Responsible stake-holders	Resources needed	Level of urgency
Regional & local Authorities, universities, EU institutions, civil society.	**Financial:** Structural funds (ESIF), Horizon Europe funding.	Medium-term (6–15 years).
	Non-financial: Public support, collaborative infrastructure (living labs).	

6.4 Dimension 3: What are the socio-spatial consequences?

6.4.1 Challenges for the R&I System

A Geographically Concentrated and Fragile R&I System

A major socio-spatial challenge is the tendency for R&I excellence to concentrate in a few "superstar" hubs, a trend which initiates a damaging "brain drain" from other areas. This creates a self-perpetuating cycle: dynamic regions with established infrastructure attract top research talent, including through direct recruitment by private companies. This depletes the local talent pools in peripheral regions, which in turn makes the central hubs even more attractive and further widens the innovation gap. This geographic inequality, where some regions become pronounced hubs for specific industries, challenges the goal of a cohesive European Research Area and makes it difficult to leverage the diverse demographic and intellectual potential of the entire continent.

This cycle makes the overall European R&I system brittle, inefficient, and vulnerable. While creating pockets of high performance, the concentration of resources leads to the chronic under-utilisation of talent in peripheral regions, while simultaneously intensifying competition for resources within the hubs. The constant loss of researchers and graduates depletes the capacity of peripheral regions to staff universities, start innovative companies, and attract R&D investment. Ultimately, this creates a deeply unbalanced system that is vulnerable to localised shocks and is unable to build the widely distributed capacity needed to tackle Europe's grand challenges.

Supporting Implications:

- Regional disparities.
- Focus on cities as innovation hubs.
- More centralisation of R&I.
- Regional specialisation becomes more pronounced, allowing specific geographic areas to become dynamic hubs.
- Less mobility for researchers and students.
- Private companies directly recruit international researchers through their own channels.
- Big challenge to correctly resource ageing care, highly skilled R&D talent.

Infrastructure Conflicts Limiting R&I Growth

A novel socio-spatial challenge arises from infrastructure conflicts, a problem directly rooted in Europe's demographic trajectory. As the population ages and the workforce shrinks, a strategic push towards automation and AI becomes essential to maintain productivity and compensate for labour shortages. This reliance on technology drives an enormous demand for new, energy- and land-intensive digital infrastructure, particularly the large-scale data centres required for modern R&I. This demand, born from a demographic imperative, creates new and intense competition not only for physical space but also for energy and other natural resources.

This technology-driven need for space and energy can directly constrain R&I growth, especially in dense areas. The demand for land for data centres can clash with other essential uses, such as housing for researchers or facilities for other scientific discovery. Furthermore, the significant energy consumption of advanced AI systems creates another layer of conflict. This high demand can lead to persistently high energy costs or even force a pragmatic rationing of AI use to only the most critical tasks, creating a new bottleneck for innovation. This may also create a spatial disconnect, where R&I infrastructure is built in remote areas with cheaper energy, while the economic benefits remain in established urban hubs.

Supporting Implications:

- The need for EU digital infrastructure requires also space for IT-infrastructure (eg. data centres) - which competes with housing and industry.
- Stronger competition for natural resources among companies.

6.4.2 Opportunities for the R&I System

A Geographically Balanced R&I Ecosystem Built on Regional Strengths

The challenges of over-concentration and brain drain create a clear opportunity to build a more distributed and resilient R&I system. This involves moving towards a polycentric "network of excellence" where strategic investments are made in the unique competencies of different regions ("smart specialisation"). Such a model allows Europe to leverage its diverse demographic assets, such as distinct talent pools in Central-Eastern Europe, and connect them through robust interregional partnerships and virtual mobility. By investing in regional R&I infrastructure outside of traditional metropolitan areas, this approach can foster a more balanced and equitable European Research Area.

This distributed network can be cultivated by fostering new R&I hubs from the ground up through community-led innovation. Supporting initiatives like citizen science and local living labs that focus on addressing specific local needs—many of which are driven by regional demographic realities like an ageing population or youth unemployment—can unleash the innovative potential of areas currently outside the mainstream. This approach helps create new, specialised R&I hubs that are deeply embedded in their local economic and social context. This not only leads to more relevant and sustainable solutions but also helps to reverse regional decline and build a more cohesive and integrated R&I system across the continent.

Supporting Implications:

- The R&I network is more dispersed beyond traditional cities, contributing to a more balanced development.
- There is a discernible push towards the decentralisation of research activities.
- Investments in regional R&I infrastructure strengthen local innovation and competitiveness.
- Interregional partnerships and virtual mobility create a resilient and interconnected R&I system.
- Focus on local needs and challenges.
- Stronger local communities.
- More regional focus on self-sustaining R&I and clusters focusing on strategic areas.

Leveraging R&I to Drive Cohesion and Strategic Autonomy

In a global landscape marked by instability, uncertainty and volatility of alliances, R&I investment emerges as a powerful tool for achieving Europe's broader geopolitical goals. As a response to technological crises and fragile supply chains, there is a clear push for the EU to strengthen cooperation and pursue greater strategic autonomy. This ambition aligns with the internal need to address regional disparities, which are often exacerbated by demographic trends like brain drain. The opportunity lies in using targeted R&I investment as a dual-purpose policy instrument, actively investing in education and infrastructure in less prosperous regions to both mitigate imbalances and build sovereign capabilities.

By strategically directing funds towards building R&I capacity in regions selected for their importance to strategic industries (e.g., digital infrastructure, green technologies, pharmaceuticals), Europe can create a virtuous circle of balanced development and strength. This approach enhances the EU's collective autonomy by fostering resource independence and building its own technological infrastructures. Simultaneously, it stimulates local innovation ecosystems, creating high-value jobs that can counteract regional population decline and promote cohesion. This alignment of R&I policy with industrial and cohesion policy allows for a more resilient and integrated European Research Area, where strategic strength is reinforced by equitable, continent-wide development.

Supporting Implications:

- The EU has strengthened cooperation, invested in its own digital infrastructure, and is pursuing strategic autonomy.
- The EU actively invests in education and infrastructure in less prosperous regions to mitigate regional disparities.
- Economic isolation has fostered higher levels of circularity and resource independence within each bloc.

6.4.3 Recommended strategic actions

Create a European network of regional innovation campuses (ENRIC)

Description: Develop a distributed ecosystem where peripheral regions host specialised innovation nodes focused on their unique local strengths (smart specialisation), connected digitally to central hubs.

Responsible stake-holders	Resources needed	Level of urgency
Regional & local authorities, universities, EU institutions (cohesion policy actors).	Financial: EU cohesion funds, regional/local-level financing.	Medium-term (6–15 years).
	Non-financial: Technological infrastructure, regional know-how.	

Establish a European strategic resilience lab network

Description: Launch cross-regional hubs specifically tasked with testing and scaling technologies critical to Europe's strategic autonomy (e.g., energy independence, defence dual-use), embedding these strategic assets in local economies to ensure security of supply.

Responsible stake-holders	Resources needed	Level of urgency
EU institutions, national governments, defence/strategic industries.	Financial: EU-level financing (STEP - Strategic Technologies for Europe Platform), public-private partnerships.	Now or within 5 years.
	Non-Financial: Strategic intelligence, political will.	

Innovation mobility guarantee

Description: Launch a "circular talent" programme that guarantees researchers and innovators positions in peripheral regions after periods abroad, or incentivises mobility to these regions, preventing permanent brain drain.

Responsible stake-holders	Resources needed	Level of urgency
EU institutions, national governments, universities.	**Financial:** EU-level financing (mobility grants), national top-ups.	Medium-term (6–15 years).
	Non-financial: Regulatory frameworks (portable pensions/benefits).	

6.5 Dimension 4: What will be the evolving relationship between R&I and the market?

6.5.1 Challenges for the R&I System

The Dominance of Market Logic in Defining R&I Value

A fundamental challenge to the R&I system is the risk of market logic becoming the primary arbiter of scientific and technological value. As the state's influence wanes due to demographic and fiscal pressures, powerful corporations emerge as the dominant players, naturally defining R&I success through the lens of market viability and short-term profitability. The entire innovation system is thus reoriented to service the demands of existing or emerging profitable markets, such as the "silver economy" created by an ageing population, fundamentally changing the relationship between research and society.

This "capture" by market logic transforms the pursuit of knowledge into a transactional process geared towards private wealth creation. The R&I system's vital role in addressing broader societal problems and generating public good is marginalised. Innovations that are scientifically significant but cannot be immediately commercialised are devalued and filtered out, while research with negative externalities but high profit potential is prioritised. This skews the relationship between R&I and the market, turning a potential engine for broad societal progress into a tool for narrow commercial gain.

Supporting Implications:

- Focus on commercially viable areas, loss of diversity in disciplines, loss of fundamental research.
- Innovation is cautious, profit-driven, and focused on security and risk assessment.
- Progress has been made in profit-driven green technologies.
- Limited research on SDGs, other global issues => implications for the climate.

Regulatory Lag Stifling or Enabling Harmful Innovation

The rapid pace of technological change, itself a response to demographic pressures, presents a major challenge for regulatory frameworks. The urgent need to deploy technologies like AI to compensate for a shrinking workforce can pressure governments to favour rapid innovation over cautious regulation. Simultaneously, the fiscal strain from an ageing population can diminish the state's capacity to develop the sophisticated, agile oversight needed for these complex technologies. This creates a high-stakes environment where governments may either be unable to keep pace with change or may deliberately create a permissive legal framework to stay competitive, leading to significant uncertainty.

This regulatory lag creates a dual threat for the R&I market and society. On the one hand, legal uncertainty can stifle investment and slow the adoption of beneficial innovations. On the other hand, and perhaps more dangerously, a lack of effective regulation can enable harmful outcomes. It can lead to the rise of monopolies controlled by a few tech conglomerates, the unethical instrumentalisation of human data, and the deployment of technologies that erode public trust. This risk is particularly acute when dealing with an ageing and potentially more vulnerable population, where the consequences of regulatory failure in areas like digital health or social care are especially severe.

Supporting Implications:

- Need for better regulation and stronger institutions.
- Will need to simplify the regulations around collaboration and knowledge transfer.
- IPR issues.
- Will need to be carefully managed. More comprehensive programming is required.

6.5.2 Opportunities for the R&I System

Pioneering Future Markets through Strategic R&I Collaboration

The profound societal and demographic shifts facing Europe create fertile ground for entirely new industries, presenting a major opportunity to pioneer and lead the global markets of the future. A prime example is the "silver economy," a substantial market for new goods and services emerging directly from the needs of an ageing population. To seize this opportunity, Europe can design a high-momentum innovation ecosystem built on intensified collaboration between academia and industry. This synergy acts as the engine for translating Europe's deep understanding of its own demographic challenges into a significant first-mover advantage on the world stage.

This collaborative ecosystem works by creating seamless pathways for knowledge transfer, joint appointments, and shared infrastructure, accelerating the journey from the laboratory to the market. It establishes a virtuous circle where market needs—such as for digital health and social care in an ageing society—pull research from academia, while industrial challenges push academic discovery toward new frontiers. By focusing this collaborative power on strategic areas like the green transition and AI-driven services, Europe can secure a long-term competitive advantage, shaping the standards and dominating the high-value markets of tomorrow.

Supporting Implications:

- Cooperation between academia and industry has intensified.
- Much better collaboration between EU industry groups will be required.
- A symbiotic, mutually beneficial partnership between governments and corporations allows for the rapid acceleration of technological development.
- Will need significant scaling of investment by EU companies in R&D.
- Innovation has focused on creating a significant "silver economy".
- Research is increasingly focusing on the needs of ageing societies.
- Immersive virtual entertainment platforms have been developed.
- A post-growth paradigm and a more reasonable use of new technologies are seen as beacons of hope.

AI-Driven R&I as a Catalyst for Market Leadership

The strategic integration of AI into the research process itself is a transformative market opportunity. By providing researchers with powerful AI tools, the European R&I system can unlock a step-change in productivity, allowing for the faster development of new materials, medicines, and technologies. This acceleration dramatically shortens innovation cycles, enabling European industries to bring novel products and services to the global market faster than their competitors. This "speed-to-market" capability, driven by the synergy between human creativity and AI, represents a powerful new lever for securing a first-mover advantage and establishing market dominance.

This AI-driven shift does more than just accelerate existing processes; it has the potential to reshape the market itself. By increasing the return on R&I investment, it can lower the traditionally high costs of discovery, potentially making cutting-edge innovation accessible to a wider range of companies beyond large corporations. Furthermore, the ability to craft effective AI prompts becomes a crucial strategic asset, creating a new, high-value market for sophisticated AI research tools and platforms. Mastering this new mode of innovation is therefore a direct route to market leadership, allowing European firms to out-compete rivals and define the next generation of high-tech industries.

Supporting Implications:

- Technological progress has gained momentum due to the synergy between the creativity of young researchers and AI capabilities.
- The ability to craft effective AI prompts has become a new, highly valued strategic asset.
- A technologically literate populace is a crucial resource for providing the novel data and intelligent prompting needed.

Cultivating a Market that Values and Rewards Socially-Conscious R&I

A significant market opportunity is emerging from shifting consumer and talent values, creating a commercial environment that actively rewards purpose-driven innovation. Demographic changes are a key driver of this trend; an older, more experienced consumer base, for instance, may be more sceptical of purely technological solutions and instead offer its loyalty—a direct market reward—to companies that demonstrate genuine ethical conduct and a focus on well-being. Similarly, in a competitive, demographically tightened labour market, top R&I talent is increasingly drawn to value-aligned companies, making a strong social mission a key advantage in securing the best human capital.

This market alignment translates into durable business advantages that go beyond reputation. By orienting their R&I towards societal demands and engaging in participatory research, companies can build significant brand equity and trust, which can justify premium pricing and secure greater market share. This focus can also unlock access to new pools of capital from socially responsible investors. Crucially, this approach mitigates business risk by earning a durable "social licence to operate." Companies seen as legitimate partners by society are more resilient to public backlash and regulatory shocks, ensuring their long-term profitability and success in a market that increasingly values more than just the bottom line.

Supporting Implications:

- More focus on social innovation.
- A more inclusive R&I system.
- Research agendas are more frequently aligned with social demands.
- Emphasis on participatory research and citizen engagement.

6.5.3 Recommended strategic actions

Agile, multi-stakeholder regulatory networks

Description: Move from static, siloed agencies to agile regulatory networks involving innovators, ethicists, and civil society. These networks use foresight to draft "anticipatory regulation" for emerging technologies like AI.

Responsible stakeholders	Resources needed	Level of urgency
Regulatory bodies, industry representatives, civil society, researchers.	**Financial:** National/state-level financing.	Now or within 5 years.
	Non-financial: Foresight expertise, data access, trust/collaboration frameworks.	

Incentives for regional innovation clusters (future markets)

Description: Strengthen incentives for clusters focusing on demographically driven emerging markets (e.g., longevity, circular manufacturing). Use tax credits and matching grants to de-risk private investment in these high-social-impact sectors.

Responsible stake-holders	Resources needed	Level of urgency
National ministries of economy, regional development agencies, private investors/VCs.	Financial: Tax incentives, structural funds.	Now or within 5 years.
	Non-financial: Market intelligence, cluster management expertise.	

Investment in homegrown AI infrastructure

Description: Invest strategically in sovereign European AI models, datasets, and computing infrastructure that are auditable and aligned with European values. This prevents dependency on non-EU tech giants and ensures data sovereignty.

Responsible stake-holders	Resources needed	Level of urgency
EU institutions, national governments, consortiums of research institutions & tech companies.	**Financial:** Massive public-private investment (Euro HPC style).	Now or within 5 years.
	Non-financial: Technological infrastructure (computing power, data centres), technical talent.	

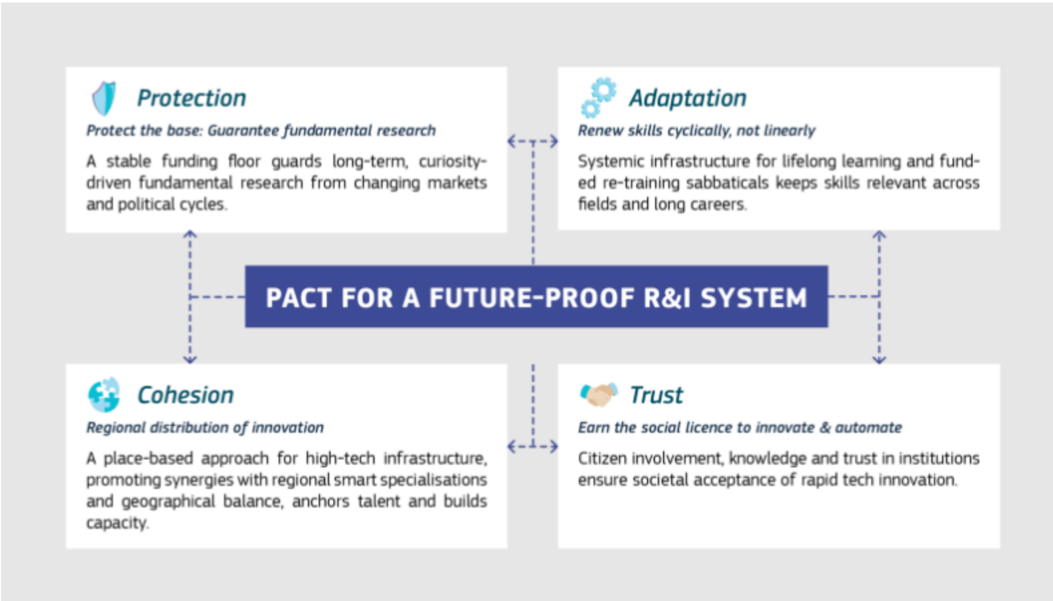
Purpose certification & disclosure framework

Description: Establish a mandatory European framework requiring large R&I organisations and corporations to verify and disclose the social and environmental impact of their innovation portfolios. This creates transparency and allows the market to reward responsible actors.

Responsible stake-holders	Resources needed	Level of urgency
EU institutions (for legislation), independent auditing bodies, industry associations.	**Financial:** Private sector compliance funding.	Medium-term (6–15 years).
	Non-Financial: Regulatory frameworks (reporting standards), data transparency.	

6.6 General Recommendations

The foresight process concludes that European R&I requires a structural overhaul, identifying four strategic mandates that represent the most robust and cross-cutting priorities for future-proofing the system. The process, encompassing scenario building, implications mapping, and the wind-tunnelling of potential actions, reveals that the accelerating demographic decline and geopolitical uncertainty demand a fundamental restructuring of the system's relationship with society, the market, and the state. This concluding analysis synthesises the core findings, identifying four strategic mandates that emerged as the most robust and cross-cutting priorities for future-proofing the European R&I ecosystem. These mandates represent actions that proved consistently effective across the full spectrum of contrasting scenarios, offering maximum resilience regardless of which future trajectory ultimately materialises.



The protection mandate calls for a legislative ring-fenced mechanism to establish a mandatory funding floor for fundamental research, insulating the "seed corn" of scientific inquiry from volatile budgetary cycles. The analysis reveals that the most critical vulnerability identified in scenarios defined by fiscal contraction or corporate dominance (such as Corporate ascendancy) is the swift erosion of long-term, curiosity-driven science. Expert validation consistently warned that without a legislative defence mechanism, funding will inevitably shift towards short-term, applied projects to plug immediate fiscal gaps caused by ageing populations and budget constraints. This mandate, which calls for national governments to establish a mandatory funding floor for fundamental research, is therefore not merely a financial plea but a structural defence mechanism. By insulating this "seed corn" of scientific inquiry, Europe ensures it retains the capacity to generate the radical, breakthrough ideas necessary to solve currently undefined future problems, rather than merely optimising solutions for problems that are already understood. Expert feedback highlighted a risk of "directionality creep," where even basic research funding is subtly pushed towards political missions; this mandate aims to structurally sever the link between demographic volatility and the freedom of scientific discovery.

The adaptation mandate requires a paradigm shift from the traditional R&I pipeline to a "cyclical" human capital model, implemented via a European framework for lifelong learning and dedicated sabbatical funds. The traditional "pipeline" model of human capital—educating the young to replace the old—is statistically untenable in a shrinking demographic context. The analysis dictates a paradigm shift to a "cyclical" model, recognising that if careers now span fifty years, the human capital base must be renewed multiple times to prevent mass skills obsolescence. The adaptation mandate calls for a European framework for lifelong learning (LLL) and dedicated sabbatical funds. This framework transforms continuous upskilling from a personal burden into a systemic infrastructure, akin to a pension scheme. By providing dedicated funds and guaranteed access to re-training sabbaticals, the R&I system gains the necessary agility to rapidly pivot researchers from declining or obsolete fields to emerging, strategic ones. Validation cautioned against conflating LLL with traditional academic degrees; the focus must be on agility, micro-credentials, and industrial placements, directly addressing the "skills gap" without relying on unsustainable demographic growth.

The cohesion mandate dictates that Europe must trade short-term efficiency for long-term distributed resilience by distributing high-tech infrastructure like regional innovation campuses to peripheral regions to anchor local talent. Centralised R&I "superstar" hubs, while offering local efficiency, are strategically brittle. In scenarios involving geopolitical uncertainty, supply chain fractures, or fragmented global systems (like Splinters and stratified R&I), concentrating R&I capacity in a few major cities leaves the wider continent vulnerable and exacerbates brain drain. The cohesion mandate dictates that Europe must trade some short-term efficiency for long-term distributed resilience. By deliberately distributing high-tech infrastructure - such as regional innovation campuses and resilience labs - to peripheral regions, the system anchors talent locally. This action converts regional diversity from a liability into a strategic asset for autonomy, turning "left-behind" places into specialised nodes, capable of leading in niche areas like the silver economy or green hydrogen. Experts emphasised that these new structures must not duplicate existing infrastructure but must have a distinct mission focused on regional smart specialisation.

The trust mandate ensures the system earns a "social licence to automate" by creating agile regulatory networks and integrating citizens through ring-fenced citizen science funding, thereby mitigating societal backlash against rapid technological acceleration. Demographic shortages will inevitably force Europe to automate its research and industry faster than many other global players. However, foresight workshops highlighted a high risk of societal backlash (as seen in Inclusion and social purpose) if this rapid technological acceleration is perceived as unethical or purely profit-driven. The trust mandate argues that R&I cannot proceed faster than the public's willingness to accept it. By creating agile regulatory networks that include ethicists and civil society, and by integrating citizens directly into the research process through ring-fenced citizen science funding, the system actively builds a "social licence." This reduces the cost of friction, prevents regulatory deadlock, and ensures that the inevitable deployment of AI and automation serves human needs. To be effective, citizen science must be elevated from a hobbyist activity to a rigorously funded and integrated component of university and research missions, acting as the necessary bridge between the research community and a potentially sceptical public.

The resilience of the future R&I system relies not on individual policies, but on the synergistic interplay between these four mandates. These four mandates are not silos; they are interconnected and mutually reinforcing. Sovereignty requires cohesion: Europe cannot achieve strategic autonomy if half its regions are drained of talent. adaptation requires trust: a workforce cannot be rapidly reskilled using algorithms they do not trust. And resilience requires a base: none of the applied innovations are possible without the long-term, curiosity-driven ideas protected by the protection mandate. Collectively, these strategic mandates provide a robust and validated roadmap for the European R&I system to convert demographic pressure from a vulnerability into a strategic opportunity.

Ultimately, these recommendations serve as the definitive answer to the structural dilemma posed in the Introduction: how to convert demographic pressure into a catalyst for a future-oriented R&I system. By implementing these mandates, policymakers move beyond adaptation, actively constructing a regenerative model capable of thriving in a new demographic reality. This decisive shift ensures that the demographic turn, rather than marking an era of decline, creates the foundation for a leaner, fairer, and more technologically advanced European Research Area, securing its competitiveness for the decades to come.

ANNEX 1 - METHODOLOGY

This annex recaps the methodological report (D1), which covered mainly the activities of Task 1, ultimately impacting the subsequent Tasks of the study. It included a description of the desk research, the identification of weak signals and trends, the development of a stakeholder database, and the refinement of the workshop series.

A1.1 Desk research

This section outlines the desk research conducted to identify conditions influencing the European R&I system in the context of demographic change. It clarifies the definitions of key terms and describes the methodological approach used to gather and analyse relevant information.

Key Terms

- Trends: A trend represents a general tendency or direction of development or change observed over time. It depicts a historical change up until the present, relying on measurable quantitative or qualitative data to illustrate the historical pattern. Trends should indicate a clear direction of change and be framed as statements of fact, avoiding any judgment on desirability. For example, "increasing automation of the economy" is a trend, supported by quantitative data like the number of operational industrial robots.
- Weak Signals of Change: Also known as emerging issues, weak signals are potential future developments that may currently appear fringe but could mature into critical mainstream issues. They might disrupt existing trends, accelerating or decelerating them, or become major trends in their own right. Examples include new technologies, public policy issues, or novel concepts.
- Uncertainties: Uncertainties are questions about the future, often inspired by the present but not anchored in it. They might concern the continuation or disruption of trends, changes in driving forces, or the occurrence of unexpected events.
- Drivers of Change: Drivers are influential forces that shape or transform a system, such as the R&I sector. They are variables that can affect a system in multiple ways, for example, by strengthening or weakening trends or producing new ones. Drivers can be identified using the PESTLE framework, which provides a macro-level perspective.
- Megatrends: Megatrends are large-scale, global shifts in behaviour or attitudes that have a long-term impact across multiple industries. They are slow to form but, once established, can influence a wide range of activities, processes, and perceptions for decades.

Desk Research Methodology

This research focused on identifying trends, weak signals of change, and uncertainties with a significant potential impact on European demography and the European R&I sector between 2025 and 2050. The aim was not to analyse all global trends but to specifically filter for those, relevant to demography and R&I within the European context. Both positive and negative trends were considered.

Weak signals/ trends identification

The research involved collecting information from diverse sources and analysing it according to specific criteria:

- Trend Description: A concise name and detailed description of the identified trend.
- Category: Classification of the trend according to the PESTLE framework.
- Time Scale: The longest possible time horizon for the trend's influence on R&I.
- Geographic Area: The geographic area impacted by the trend.
- Impact (Quantitative): Assessment of the trend's impact level on the European R&I system up to 2050.
- Impact (Qualitative): Description of the nature of the trend's impact (positive or negative) and how it might affect the R&I system.

Similar criteria were used to analyse weak signals, including their potential to disrupt existing trends and the EU's involvement in their emergence.

Each team member conducted independent research, with the understanding that some overlap in identified trends might occur. Individual inputs were documented separately, without modification or commentary on the contributions of other team members. Duplicates were identified and removed during subsequent analysis by the team.

Box 1 Examples of initially identified weak signals

Decrease of classic study fields

Every fourth new degree programme created since 2023 is still traditionally tailored to a single subject. The trend is towards specialised courses in digitalisation, sustainability and psychology, among others.

Source: https://www.che.de/2024/23-000-studienangebote-rekordwert-trotz-sinkender-studierendenzahlen/

The campus of the future requires new learning architectures

- New teaching needs more places for research-based and project-orientated learning and different forms of collaboration, fewer large lecture halls will be needed.
- Open labs: Structures within the campus or the space around (city) where experiments can take place visibly and invite passers-by to engage and discuss, offer new interdisciplinarity and innovative ideas.

Source: https://www.stifterverband.org/insights/bildung-kompetenzen/lernorte/der-campus-der-zukunft-braucht-neue-lernarchitekturen

Research for commercial aims provides backbone for research

Revenue from commercialised research in 2030 is sufficient to allow research to pay for itself. Universities have a clear understanding of what research lends itself to commercialisation, gain access to private equity capital and participate in rich innovation ecosystems, facilitated by venture studios.

Source: https://www.ey.com/en_gl/insights/education/are-universities-of-the-past-still-the-future

Science of the future is digital, interdisciplinary, societally beneficial

Young scientists consider interdisciplinarity, digital expertise, greater involvement of society and its needs in research projects combined with increased science communication to be particularly important for the science of the future

Source: https://www.dfg.de/de/aktuelles/neuigkeiten-themen/190912-yrw

Increasing role of AI in the economy

- **Development of AI** advances rapidly and is expected to reach $170 million in 2025.....
- The AI Commission believes that a total of SEK 750 million should be allocated to Swedish universities during the years 2025–2027. The aim is to provide **teachers with the opportunity to develop their skills in AI**, and to ensure that the content of the courses is future-proof.
- Invest in inter- and **multidisciplinary research with AI in focus** that can drive both disciplinary and AI research forward. By investing in multidisciplinary research in areas that are strategically important for Sweden, we can drive both AI research and research in areas that are important for Sweden forward, while generating concrete problems and data sets to work with.
- **Text-generating AI** will change scientific practice. AI text generation is seen as support for administrative processes but also support the creation of scientific texts. For the latter, new reflexive skills are needed

Sources:https://www.weizenbaum-institut.de/news/detail/chatgpt-in-der-wissenschaft/

https://www.regeringen.se/rapporter/2024/11/ai-kommissionens-fardplan-for-sverige/

A1.2 Stakeholder mapping

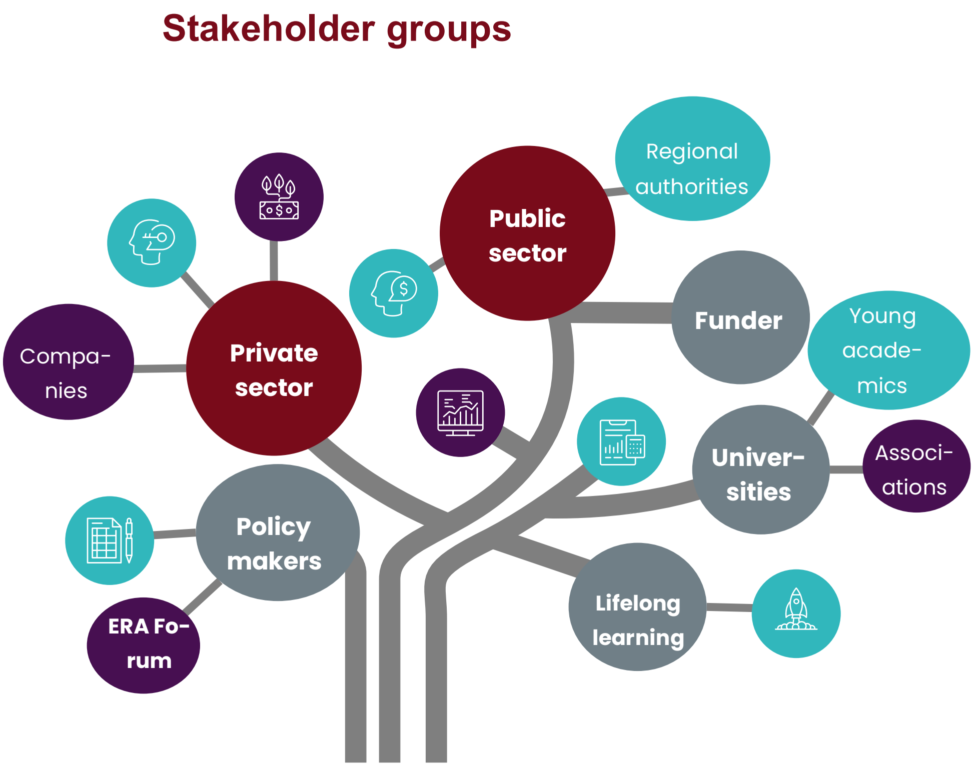
The stakeholder mapping served primarily two purposes:

- To identify relevant, potential participants for the workshops and other activities
- To search for weak signals for which stakeholder types or individual organisations are mentioned

The study team developed a simple database– covering a long-list of EU-level associations and networks, but also national ministries, rectors' conferences, and other national entities.
The structure of the information covered includes:

# ID	Full name	Organisation	Position in organisation	Type of stakeholder	Geographic location	Website	Email address

The stakeholders were further categorised by a range of types including the academic community, councils, funders, innovators, policy makers, research organisations, student organisations, university networks and others.



A1.3 Workshop concept/planning

This section outlines the concept and plan for a series of interconnected workshops designed to explore the impact of demographic change on the European R&I system and develop robust, future-proof actions. The workshops followed a progressive structure, with each session building upon the outcomes of the previous one.

The first workshop, the **Scenario Building Workshop**, aimed to collaboratively enrich initial scenario outlines. Approximately 20 stakeholders participated and were divided into four groups. Each group focused on expanding specific scenarios by adding details and considering various world dimensions within each scenario. This creative process leveraged desk research and, most importantly, the knowledge and beliefs of the stakeholders to develop detailed and comprehensive scenarios. The flow of this process involved gathering key trends, signals of change, and possible disruptions, all categorised by PESTLE. A "Rip van Winkle" survey was also conducted. From this information, the project team identified uncertainties, also categorised by PESTLE. A pre-workshop internal survey analysed the probability and impact of the most important uncertainties and signals or disruptions. This analysis determined the axes of a 2x2 matrix. During the workshop itself, the four groups, each based on a quadrant of the 2x2 matrix, selected three disruptions from a set of five and discussed the possibility of them materialising within their assigned scenario. Next, using the scenario framework, the groups were answering general PESTLE-based questions related to the remaining uncertainties identified in the "Rip van Winkle" survey and use these answers to further develop their scenarios. Then, the groups shifted their focus to the R&I sector within each scenario, answering sector-specific and R&I-related

questions about areas of focus, funding opportunities, and regional and global collaborations. Finally, all groups reconvened in a plenary session to present their scenarios.

The second workshop, the **Implications Workshop**, aimed to map the implications of the demographic change scenarios for the European R&I system across its key dimensions. This workshop was focused on the implications that may arise in various situations modelled in the scenarios and are therefore more likely to materialise in reality. Participants were divided into four groups, each tasked with exploring the implications of a specific scenario. These scenarios were analysed through the lens of predefined dimensions, namely: the effects of demographic change on tertiary education systems; interactions between the R&I ecosystem and related markets; the impact on R&I funding; and socio-spatial implications. Within their assigned scenario, participants collaboratively identified and documented implications, evaluating and building upon each other's contributions. This collaborative process allowed for the exploration of both first-order implications and subsequent implications. The workshop consisted of several exercises, including an introduction to the project, an introduction to the scenarios, brainstorming sessions for first, second, and third-order implications, an implications assessment, and a cross-scenario analysis. The workshop culminated in a plenary session where the groups were comparing their findings. This cross-scenario analysis focused on identifying recurring implications across multiple scenarios, highlighting those with the greatest significance and likelihood of occurrence, assessed qualitatively. This synthesis provided a foundation for the next task in the project.

In the second part of the project, the activities originally planned as separate **Roadmapping** and **Windtunnelling** workshops were consolidated into a comprehensive, asynchronous validation process. This process was conducted on a dedicated online platform, 4CF HalnyX, utilising features characteristic of the Delphi method. This digital structure allowed for the iterative refinement and testing of strategic recommendations in a systematic manner. The process consisted of three distinct phases.

The first phase aimed to generate a longlist of actions to mitigate challenges and utilise opportunities. Experts were presented with the challenges and opportunities identified in the previous stages of the project. Instead of working in subgroups, participants were asked to propose concrete and feasible strategic actions that would address these findings directly. This activity generated a comprehensive pool of potential strategic responses to the challenges facing the European R&I system.

Following the brainstorming phase, a prioritisation exercise was implemented. For each challenge and opportunity, experts were tasked with selecting the most important action from the generated pool. Crucially, participants assessed these actions in terms of required resources and stakeholder engagement, effectively covering the key operational layers (such as policy involvement and necessary actors) originally envisaged for the roadmapping sessions. This assessment led to the selection of a refined set of priority strategic actions.

The final phase aimed to future-proof the prioritised actions. In place of the originally planned role-playing immersion, experts performed a structured evaluation on the platform to test how well each priority action would perform and retain its effectiveness when applied across all four distinct future scenarios.

The goal of this phase was to ensure that the final recommendations were resilient and aligned with predefined desirable futures. Participants evaluated whether the actions offered value to the R&I system regardless of which future trajectory might materialise. This final step yielded the core set of validated, future-proof strategic recommendations.

A1.4 Data collection and analysis

The data collection and analysis in this study provided the basis for understanding how demographic change will impact Europe’s R&I systems by 2050. The analysis quantified key demographic trends and examined their effects on the availability of researchers. The focus was on presenting a descriptive statistical overview and identifying key trends to assess the implications of demographic change which help feed into the different scenarios studied. Yet, there are caveats in terms of definitions and available data.

Data Sources and Collection

Given DG RTDs key interest in researchers and in particular doctoral students and graduates and how they may be affected in the longer run, the study team took into account the statistical problems in terms of definitions and availability of data.

While a larger body of literature presents various issues associated with career steps such as Ph.D.'s and post-docs, or on the demand and supply of researchers in general or for specific disciplines (e.g., STEM), analyses capacities or mobility of researchers. In terms of data, the situation is more challenging. Data on doctoral students, doctoral graduates or post-doc employment and occupational pathways – is not systematically available.

Box 2 Measuring Human Resources

When speaking about the human resources involved in the innovation process and those that are measured by statistical data, there are two broad groups:

- R&D personnel including Researchers, Technicians and equivalent staff
- Human resources in Science & Technology (HRST)

The Frascati Manual (OECD 2002) contains definitions for both classifications by occupation as well as by the formal, educational level of qualification. The following definition for R&D personnel is based on occupations:

- *Researchers* are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned
- *Technicians and equivalent staff* are persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences or social sciences and humanities (OECD 2002).

The treatment of postgraduate students differs considerably between countries. The OECD suggests to treat them as researchers.

Human resources in Science & Technology follows a different definition. It is based on the International Standard Classification of Occupations (ISCO), a tool for organising jobs into a clearly defined set of groups according to the tasks and duties undertaken in the job. ISCO does not include a class such as 'researcher'.

The Canberra manual (OECD 1995) defines HRST as those persons:

- Having successfully completed education at the tertiary level in a science and technology field of study; or
- Not formally qualified as above but being employed in a science and technology occupation, where the above qualifications are normally required

This provides both a **definition by educational level as well as occupation**. Thus, one can distinguish between all HRST and HRSTC – the core HRST which is the part with a formal educational level and which is also referred to as 'knowledge workers'.

The availability of human resource data at regional level is heterogenic. Countries differ considerably in education policies and thus, comparisons of obtained skills or degrees, for example, require tedious efforts. Possibly due to the fact that educational attainment of 'researchers' is more straightforward and comparable, international statistical analysis tends to focus on 'researchers'.

For the data background, the study relied on official European data sources to ensure accuracy and consistency. The primary sources included:

- Eurostat EUROPOP Projections (2023-2024):[24] Long-term demographic forecasts covering fertility, mortality, migration, and ageing. This data is essential for assessing workforce size

24 Eurostat. (2024). Population projections in the EU – Alternative scenarios. European Commission. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_projections_in_the_EU#Alternative_scenarios

and structural changes in the population. This database provides different project based on our scenarios also.

– European Commission's 2024 Ageing Report:[25] Economic and labour market projections, focusing on employment rates, pension costs, and fiscal pressures that may influence R&I investment.

– Cedefop Skills Forecast:[26] Provides long-term projections on employment, labour force trends, and skill demand across EU-27 Member States and selected non-EU countries.

Analytical Methods

The study applied a structured analytical approach to assess the relationship between demographic change and R&I systems. The key methods included:

– **Descriptive Statistical Analysis**: Key demographic indicators were examined to track changes in population structure, fertility rates, and migration patterns over time. The analysis also assessed shifts in education and workforce composition, particularly trends in researcher availability and retention, to evaluate the sustainability of the R&I workforce.

– **Trend Analysis**: Long-term demographic shifts were assessed to determine their implications for Europe's R&I workforce and innovation capacity. The analysis identified changes in population ageing, fertility rates, and migration, as well as variations in the size and composition of the R&I workforce.

Limitations and Considerations

While the study is based on reliable data sources and established methodologies, several factors introduced uncertainty. Migration patterns, policy changes, and economic fluctuations can significantly alter demographic projections, requiring ongoing monitoring. Additionally, demographic trends vary across EU Member States, meaning that their effects on R&I systems will not be uniform. As a result, any policy responses must account for regional differences and evolving labour market conditions.

25 European Commission (2024). The 2024 Ageing Report.

26 Cedefop. (2024). Skills Forecast – Future trends in the labour market. European Centre for the Development of Vocational Training

ANNEX 2 DATA

Table 7 Expenditure projections

	Pensions			Healthcare			Long-term care			Education			Total		
	2022	**Ch 22 - 45**	**Ch 22-70**	**2022**	**Ch 22 - 45**	**Ch 22-70**	**2022**	**Ch 22 - 45**	**Ch 22-70**	**2022**	**Ch 22 - 45**	**Ch 22-70**	**2022**	**Ch 22 - 45**	**Ch 22-70**
BE	12,7	1,9	3,5	6,1	0,4	0,6	2,3	0,9	1,7	5,6	-0,8	-0,8	26,8	2,4	5,1
BG	9,5	-0,1	0,1	4,5	0,4	0,2	0,5	0,1	0,2	3,7	-0,1	0,1	18,2	0,3	0,6
CZ	8,7	1,3	1,7	6,4	0,1	0,2	1,5	0,7	1,4	4,1	0,1	0,3	20,6	2,2	3,7
DK	8,3	0,0	-1,4	7,4	0,1	0,4	3,0	2,0	3,3	5,8	-0,5	-0,9	24,4	1,6	1,4
DE	10,2	0,8	1,2	8,0	0,0	0,1	1,9	0,5	0,5	4,3	0,2	0,2	24,3	1,5	2,0
EE	7,4	0,1	-0,7	5,1	0,4	0,6	0,4	0,4	0,7	3,9	-0,6	-0,6	16,8	0,3	0,0
IE	3,8	1,7	2,8	4,1	0,8	1,5	1,2	0,6	1,4	2,8	-0,6	-0,7	12,0	2,4	4,9
EL	14,5	-0,5	-2,5	5,4	0,6	0,6	0,1	0,0	0,0	3,4	-0,4	-0,5	23,4	-0,4	-2,4
ES	13,1	3,8	3,6	5,9	1,0	1,2	0,8	0,4	0,9	4,1	-0,7	-0,6	23,9	4,5	5,1
FR	14,4	-0,5	-0,9	8,8	0,1	0,3	1,9	0,4	0,7	4,8	-0,7	-0,9	29,9	-0,7	-0,7
HR	9,0	0,3	-0,2	5,8	0,4	0,7	0,5	0,1	0,1	3,4	-0,7	-0,7	18,8	0,1	-0,2
IT	15,6	0,9	-1,9	6,3	0,1	0,1	1,6	0,3	0,5	3,8	-0,6	-0,8	27,3	0,7	-2,0
CY	8,2	2,7	3,6	7,5	0,5	0,8	0,2	0,1	0,1	5,0	-0,4	-0,5	20,9	2,8	4,1
LV	7,2	-0,8	-1,7	6,0	-0,3	-0,3	0,5	0,2	0,3	3,6	-0,4	-0,2	17,2	-1,4	-1,9
LT	6,4	3,1	3,2	4,3	0,5	0,8	1,0	0,4	0,9	3,0	-0,4	-0,3	14,8	3,7	4,6
LU	9,2	2,6	8,3	3,9	0,7	1,2	1,1	0,5	1,6	3,0	-0,4	-0,4	17,2	3,4	10,7
HU	7,7	2,4	4,3	4,3	0,4	0,5	0,5	0,2	0,4	3,5	0,0	0,1	16,0	3,0	5,2
MT	6,2	-0,5	4,4	5,1	0,5	2,1	1,2	0,6	2,3	4,5	-0,7	-0,1	16,9	-0,2	8,6
NL	6,5	1,4	2,0	5,7	0,5	0,7	3,8	1,2	1,9	4,9	-0,7	-1,0	21,0	2,3	3,5
AT	13,7	0,5	0,4	7,8	0,8	1,1	1,6	0,8	1,5	4,6	-0,5	-0,4	27,7	1,6	2,6
PL	10,2	0,4	-0,2	4,4	0,7	1,1	0,5	0,4	0,9	3,9	-0,2	0,1	19,1	1,2	1,9
PT	12,2	2,9	-1,8	6,2	0,7	1,0	0,5	0,3	0,4	4,4	0,0	-0,1	23,3	4,0	-0,5
RO	8,5	2,1	-0,9	4,4	0,6	0,7	0,3	0,2	0,4	2,5	0,0	0,0	15,8	2,9	0,2
SI	9,8	3,0	3,8	7,0	0,7	0,8	1,0	0,6	1,0	4,3	-0,4	-0,3	22,1	3,8	5,4

	Pensions			Healthcare			Long-term care			Education			Total		
	2022	Ch 22 - 45	Ch 22-70	2022	Ch 22 - 45	Ch 22-70	2022	Ch 22 - 45	Ch 22-70	2022	Ch 22 - 45	Ch 22-70	2022	Ch 22 - 45	Ch 22-70
SK	8,5	2,7	2,8	5,7	1,3	1,6	1,0	0,7	1,4	3,7	0,1	0,3	19,0	4,9	6,1
FI	12,8	-0,4	1,4	6,2	0,4	0,6	2,1	1,1	1,8	5,3	-0,9	-1,1	26,4	0,1	2,7
SE	7,4	-0,4	-0,2	7,3	0,1	0,4	3,2	0,6	1,3	5,8	-0,5	-0,6	23,6	-0,3	0,8
EU	**11,4**	**0,7**	**0,4**	**6,9**	**0,2**	**0,4**	**1,7**	**0,5**	**0,8**	**4,4**	**-0,4**	**-0,5**	**24,4**	**1,0**	**1,2**

Source: European commission, EPC, 2024 Ageing Report. Economic and Budgetary Projections for the EU Member States (2022-2070)
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Table 8 Changes in components in total ageing costs

	Pensions			Healthcare			Long-term care			Education		
	2022	Ch 22 - 45	Ch 46-70	2022	Ch 22 - 45	Ch 46-70	2022	Ch 22 - 45	Ch 46-70	2022	Ch 22 - 45	Ch 22 - 45
BE	12,7	1,9	1,6	6,1	0,4	0,2	2,3	0,9	0,8	5,6	-0,8	0,0
BG	9,5	-0,1	0,3	4,5	0,4	-0,2	0,5	0,1	0,0	3,7	-0,1	0,2
CZ	8,7	1,3	0,4	6,4	0,1	0,2	1,5	0,7	0,7	4,1	0,1	0,2
DK	8,3	0,0	-1,5	7,4	0,1	0,3	3,0	2,0	1,3	5,8	-0,5	-0,4
DE	10,2	0,8	0,4	8,0	0,0	0,1	1,9	0,5	0,0	4,3	0,2	0,0
EE	7,4	0,1	-0,8	5,1	0,4	0,2	0,4	0,4	0,3	3,9	-0,6	0,0
IE	3,8	1,7	1,1	4,1	0,8	0,7	1,2	0,6	0,8	2,8	-0,6	0,0
EL	14,5	-0,5	-2,0	5,4	0,6	0,0	0,1	0,0	0,0	3,4	-0,4	-0,1
ES	13,1	3,8	-0,2	5,9	1,0	0,2	0,8	0,4	0,5	4,1	-0,7	0,1
FR	14,4	-0,5	-0,3	8,8	0,1	0,2	1,9	0,4	0,3	4,8	-0,7	-0,2
HR	9,0	0,3	-0,5	5,8	0,4	0,3	0,5	0,1	0,1	3,4	-0,7	0,0
IT	15,6	0,9	-2,8	6,3	0,1	0,0	1,6	0,3	0,2	3,8	-0,6	-0,2
CY	8,2	2,7	1,0	7,5	0,5	0,3	0,2	0,1	0,1	5,0	-0,4	-0,1
LV	7,2	-0,8	-0,9	6,0	-0,3	0,0	0,5	0,2	0,1	3,6	-0,4	0,2
LT	6,4	3,1	0,1	4,3	0,5	0,2	1,0	0,4	0,4	3,0	-0,4	0,2
LU	9,2	2,6	5,7	3,9	0,7	0,5	1,1	0,5	1,1	3,0	-0,4	0,0
HU	7,7	2,4	1,8	4,3	0,4	0,1	0,5	0,2	0,2	3,5	0,0	0,1
MT	6,2	-0,5	4,9	5,1	0,5	1,6	1,2	0,6	1,7	4,5	-0,7	0,6
NL	6,5	1,4	0,6	5,7	0,5	0,2	3,8	1,2	0,6	4,9	-0,7	-0,3

	Pensions			Healthcare			Long-term care			Education		
	2022	**Ch 22 - 45**	**Ch 46-70**	**2022**	**Ch 22 - 45**	**Ch 46-70**	**2022**	**Ch 22 - 45**	**Ch 46-70**	**2022**	**Ch 22 - 45**	**Ch 22 - 45**
AT	13,7	0,5	-0,1	7,8	0,8	0,3	1,6	0,8	0,7	4,6	-0,5	0,1
PL	10,2	0,4	-0,5	4,4	0,7	0,4	0,5	0,4	0,5	3,9	-0,2	0,3
PT	12,2	2,9	-4,7	6,2	0,7	0,3	0,5	0,3	0,1	4,4	0,0	0,0
RO	8,5	2,1	-3,0	4,4	0,6	0,1	0,3	0,2	0,2	2,5	0,0	0,0
SI	9,8	3,0	0,9	7,0	0,7	0,1	1,0	0,6	0,4	4,3	-0,4	0,2
SK	8,5	2,7	0,1	5,7	1,3	0,3	1,0	0,7	0,7	3,7	0,1	0,2
FI	12,8	-0,4	1,8	6,2	0,4	0,3	2,1	1,1	0,7	5,3	-0,9	-0,2
SE	7,4	-0,4	0,2	7,3	0,1	0,3	3,2	0,6	0,7	5,8	-0,5	-0,1
EU	11,4	0,7	-0,3	6,9	0,2	0,2	1,7	0,5	0,3	4,4	-0,4	0,0

Source: European commission, EPC, 2024 Ageing Report. Economic and Budgetary Projections for the EU Member States (2022-2070)

ANNEX 3 SURVEY RESULTS

A survey was conducted with a two-fold purpose:

1. To integrate a Rip van Winkle exercise
2. To obtain weak signals/trends from a broader range of people

A total of 53 individuals participated in the survey, with 21 respondents (40%) completing it in full. While the completion rate reflects the time and complexity required of the survey, the responses received represent a rich cross-section of expertise and geographic coverage.

The survey achieved broad geographical outreach, with the highest number of respondents from:

- *Germany (14)*
- *Belgium (11)*
- *Italy and Spain (4 each)*
- *Other European countries (4)*
- *Additional responses were recorded from Denmark, Finland, Ireland, Romania, Sweden, Latvia, Luxembourg, the Netherlands, and from two respondents based outside of Europe.*

Respondents represented a wide age range, though the majority (53%) were in the 31 - 40 age group, followed by:

- *31 – 40: 28 participants*
- *41–50: 12 participants*
- *20–30: 7 participants*
- *51–60: 5 participants*
- *Over 60: 1 participant*

The survey engaged a broad spectrum of roles:

- *Research scientists (22): Predominantly from the EU27, with some representation from Switzerland and the UK. The majority were aged 31 – 40 years.*
- *Policy makers (12): Mainly based in Germany and Belgium, with additional input from Romania. Most were between 31 and 50 years old.*
- *Stakeholder representatives (4): All based in Europe, with one located outside the EU27.*
- *Innovation actors (6): Spanning Italy, the UK, Ireland, and Belgium, primarily within the 31 - 50 age range.*
- *Other categories (including investors, R&I managers, students, academics, and foresight consultants): 5 individuals contributed insights from diverse professional perspectives.*

As part of the survey, respondents were also asked to indicate the sources that informed their identification of weak signals. This was a multiple-choice question, allowing for several selections. The responses revealed a diversity of sources:

- *Blogs were cited by two individuals, from the 31 - 40 and 41 - 50 age groups.*
- *Podcasts were selected by five respondents - four aged 31 - 40 and one aged 41 - 50.*
- *Reports or newspapers were mentioned by eight respondents, with representation across all age groups.*
- *Scientific publications were also selected by eight individuals, again spanning all age groups.*
- *Events were referenced by three respondents, with the exception of the 20 - 30 age group.*
- *Conferences were cited by five respondents from all age groups.*
- *Personal intuition was indicated by ten individuals, from all age groups except 20 - 30.*
- *Conversations with colleagues were the most commonly selected source, mentioned by eleven respondents across all age groups.*

Identified weak signals and trends

The identification of trends, weak signals, drivers, and uncertainties was based on a triangulated approach, drawing from desk research, exploratory interviews, and a stakeholder survey. The following sections present the findings from these activities, along with the initial thematic clustering used to inform the scenario development process.

In the survey the most frequently cited weak signals relate to technology-driven change (16 mentions by 10 different respondents) and open-science, ethics and trust (11 mentions by 8 respondents).
Examples:

- *"AI is altering the skill sets required in academia. Some universities are already embedding AI literacy into training, while others are reconsidering traditional research roles."*
- *"Trust in science will become the next goal to better academia (the next 'open science')."*

Strategic and political foresight is increasingly shaping the future of the European R&I system, which is evolving towards a more decentralised, networked, and cross-border model of collaboration.

Examples:

- *"Transition from institutional support to innovation towards networking and supra-institutional multi-stakeholder structures and initiatives."*
- *"Digitally enabled research cooperation and sophisticated communication tools increase the geographical immobility among researchers."*

There is a growing emphasis on strengthening public - private collaboration, not only as a response to (foreseen) limited public funding, but also as a strategic means of staying resilient and adaptive in the face of rapid technological change.
Examples:

- *"In many countries, stagnating or declining national research funding is pushing universities to seek alternative funding sources through industry collaborations, international partnerships, and philanthropic support."*
- *"Some universities strategically work together with large companies. This can accelerate the transfer. But it can also strengthen the power of single companies in the R&I system."*

The evolving political landscape, particularly shifts in the United States, underscores the need for more agile and anticipatory collaboration within the EU. Timely, coordinated efforts will be essential to secure positive outcomes for European R&I in a highly competitive global environment.
Examples:

- *"Policy initiatives now happening in the US may provide a very easy and swift way for the EU to pick up research talent – if there is willingness to invest and to move quickly to attract people who want to move."*
- *"Rising fear of 'sensitive' words – With the growing censorship of scientific research in the US, there are some tendencies to 'comply in advance' because of fear of losing funding."*

Questions from the future

The following brings together the questions from the future of the Rip van Winkle exercise. Several questions were put by different people – in sometimes slightly different terms but in essence on the topic. The following tables exclude the almost duplicates. The grouping under the different headings was done by the study team.

Society and politics

- Does the European Union still exist?
- Has the European Union less MS than in 2025?
- Do we still live in a democracy?
- Do people in 2050 live in peace and freedom?
- Do people in 2050 work together across borders?
- Have we overcome the nation-state as the organisational principle for the world?
- Have democratic values and civic freedoms been destroyed in the name of technological progress?
- Is the world fairer?
- Has prostitution been successfully abolished?
- Do people fight for water and food?
- Do people still prefer to live in cities?
- Do people still work Mon–Fri, 8h a day?
- Has digitalisation considerably reduced our working hours below about 40 hours a week?
- Has digitisation continued to concentrate wealth and power?
- Does people still own cars?
- Do people still benefit from public services in health, education etc.?
- Has the Universal Basic Income been introduced globally?
- Is capitalism still the dominant economic system in the Global North?

R&I

- Was Europe able to avoid war and invest heavily in R&I to improve people's livelihoods?
- Is science among the Top 3 main concerns of citizens?
- Are the United States still a major player in international R&I?
- Does the public sector still fund research?
- Is the EU still funding research?
- Is Research in 2050 financed by private money?
- Are there still universities doing research?
- Are there some universities that are funded at transnational level?
- Are the universities in the US still the most prestigious / well-funded?
- Do member states invest more money in research on average than in 2025?
- Is there sufficient mutual trust to enable free and open scientific dialogue between researchers internationally?
- Has the influence of economic and business interests grown stronger in research funding and output?
- Is the distinct value of blue-sky research recognised as opposed to more applied or innovation-oriented research?
- Will it be more easy to be an innovator and commercialise my inventions?
- Will I be well-off if I become a scientist?
- What have been the major game-changing innovations of the past 25 years?
- Has the reproducibility crisis been solved?
- Has AI-generated fake data ruined scientific research?
- Is the peer-review system still in use?
- Are academic publishers still profiting from research work?
- Are we capable of communicating research results in a fair, ethical and responsible way to society?
- Are Research questions in 2050 set by citizens?
- Does research use experimental spaces?
- Can research use personal data without data protection?
- Did research improve the quality of life for a large part of society?
- Besides digital technologies, were there other major technologies that drove R&I?
- Were there innovations that truly disrupted industry?

Future of technology

- Has AI replaced researchers' work by 2050?
- Has AI taken over 50% of knowledge work?
- Has Artificial General Intelligence AGI been developed
- Is AGI a threat to humanity?
- Has the explosion of super-intelligence already occurred based on the accelerated development of AI
- Is AI a public good?
- Is private research goals aligned with citizens' needs?
- Can AI tell right from wrong?
- Is there AI factualness?
- Is generative AI capable of producing credible research outputs?
- Does AI really create jobs?
- Were many jobs taken over through AI? [Wurden viele Jobs von der KI übernommen?]
- Are smartphones replaced by multi-functionally programmable wearable plasmas?
- Is there a new way to interact with computers and smartphones?

Health and wellbeing

- Has a virus decreased the population in Europe?
- Is a 70-year-old person as healthy in 2050 as 70-year-olds were in 2025?
- Does R&I contribute to our health span?
- Do people live considerably longer than in 2025?
- Can cancer be cured?
- Gibt es durch revolutionäre Forschung Heilmethoden für alle möglichen Krankheiten?
- Does everyone have adequate access to clean drinking water?
- Have women completely transferred birth-giving to robot-supported laboratory environments?

• Is technology embedded in our minds through micro-chips? • Has a quantum computer been built? • Has the EU established a permanent operation of its extra-terrestrial stations on at least two planets? • Does humanity live in space?	• Is health research still funded on a project-related basis?

Climate change

- Have we managed to stabilise global warming at the 2 degrees goal?
- Is climate change the main concern No 1?
- Has humanity sufficiently addressed the climate emergency?
- Have we managed to stave off climate change?
- Do we already live in a climate-friendly world?
- Did climate change affect the quality of air people breathe?
- Is 'climate mitigation' a major force of economic activities?
- Has a solution been found to tackle microplastics pollution?
- Has desertification been controlled?
- Did efforts to rewild devastated ecosystems succeed?
- Are renewable energies able to cover needs, including in industries like aviation or steel production?
- Has the world transitioned to renewable energy as its main energy source?

ANNEX 4 STORIES FROM THE FUTURE

Scenario 1

Persona 1:
The start-up founder
Vera Novak, CEO of SensoHealth

Preparing a pitch inspired by family struggles
The holo-screen in Vera's private office within the OmniCorp Innovation Hub, a sleek glass box loaned to her by the venture fund, glowed an insistent red. Her pitch deck for the Series B funding was due in twenty minutes. Her company, SensoHealth, had developed a sensor system for elderly care that was genuinely revolutionary—a perfect, market-ready solution for the relentless expansion of the "silver economy." In an ageing Europe, with its shrinking care workforce, her technology wasn't just innovative; it was essential. She had started the company with a small team of fellow public university graduates in a cramped, rented workshop, fuelled by lukewarm coffee and a shared belief that they could create something for the public good. The idea had crystallised during a frustrating video call with her father, who was struggling to manage her mother's care in an understaffed public facility two regions away. She had seen the exhaustion in his eyes, a weariness shared by millions.

Funding requires stripping open-source access
The contract waiting on her datapad was the real challenge. The lead venture director from OmniCorp, a man who had never visited a public care facility, was demanding she strip, the open-source interoperability API from the final product. That API, the result of months of collaborative work, was the one remaining lifeline that would allow underfunded public nursing homes—like the one her own mother was in—to integrate her system affordably. It was the soul of her original mission, the very reason she had started this venture.

Weighing personal wealth against public mission
Vera glanced at the projected revenue figures, the numbers shimmering with promises of security and influence. If she signed the proprietary-only contract, OmniCorp guaranteed the kind of resources that would cement her success and personal wealth. She could finally afford the premium private care her mother deserved, moving her out of the struggling public system entirely. If she refused, the funding would collapse, leaving her to fight for scraps. She wasn't just selling a product; she was choosing a side in the socio-economic divide that defined her era. With a single signature, she could secure her own family's comfort by reinforcing the two-tiered system that left so many others behind. The moral pivot was happening now, a choice between the societal need that had inspired her and the personal salvation that commercial viability offered.

Persona 2:
The researcher
Dr. Elias Vance, Senior AI Scientist at BioGene HEI

Aligning research with corporate goals for family
Dr. Vance meticulously reviewed his quarterly performance report for the BioGene Higher Education Institution. The evaluation was, as always, rigorous, a seamless blend of academic review and corporate audit designed to ensure loyalty to the corporation's strategic goals. It was the bedrock of the company's system for capturing and controlling human capital, a constant, low-grade pressure to align his curiosity with the company's bottom line. Here, he had access to unlimited computational power, to labs the failing public system could only dream of. He remembered his last visit to his old university department; the equipment looked ancient, the faculty weary, their conversation circling around budget cuts rather than scientific breakthroughs. He justified his choices as the only way to provide for his family in a world where the public safety net was threadbare.

Perpetuating a system that traps his daughter
Today's report required him to reclassify his latest sequencing breakthrough. The discovery, with profound theoretical implications, was now to become an exclusive proprietary asset for BioGene's new line of anti-ageing pharmaceuticals. He felt the familiar, internal friction. He was using his expertise not for public science, but for a commercial interest. This choice was made painfully clear last week when his daughter, a bright teenager, had asked him about applying to public universities. He'd had to gently steer her towards the Bio-Gene HEI prep track, knowing it was her only real path to a secure future. He was perpetuating the very system that had trapped him. The corporate structure forced the best young researchers to either conform or face a marginalised career. Elias signed the reclassification form, the smooth surface of the datapad cool beneath his fingers. It was the price of his position, a silent compromise made not just for himself, but for his daughter's future.

Persona 3:
The R&I official
Anya Petrova, Ministry of research governance

Negotiating as a manager of declining public science
Anya sat in a bare government office, the paint peeling slightly near the window, preparing for a negotiation with representatives from the five tech conglomerates that now ran the continent. Her job was no longer about directing research or fostering innovation, but about managing the decline of public science. The state's R&I budget was a fraction of its former self, gutted by the ever-growing, non-discretionary demands of an ageing population—pensions and healthcare had long since taken priority. The vibrant posters from past science fairs that once lined the hallway had been taken down, leaving faint rectangles on the walls like ghosts of a more optimistic era. Her own public servant's pension felt less like a guarantee and more like a hopeful fiction.

Begging for data while subsidising state failures
The agenda today was to negotiate for access to a tiny subset of demographic data collected and owned by a private HEI. She needed it to inform a new, minimalist public health initiative for the elderly, but she had to beg for the raw material. She knew the corporations only dominated because the state had retreated, weakened by fiscal pressures. She felt this retreat personally; her ageing father's pension barely covered his rent, and she supplemented his income from her own stagnant salary. She was fighting for public services at work while privately subsidising the state's failure at home. As the negotiation began, the lead corporate liaison listened with a patient smile, his posture relaxed, his power understated but absolute. Anya, stripped of real power, made her case for "public good access," a concept that rang hollow when the funding, the labs, and the research itself were entirely out of their control. She was a custodian of a fading legacy, fighting to save small fragments of public integrity in a system that had already moved on, her arguments met with polite deflections and carefully worded conditions.

Scenario 2

Persona 1:
The start-up founder
Javier Cruz, Founder of LocalLoop Diagnostics

Seeking grant funding for a precarious start-up
Javier stood before the Regional Health Council, the fluorescent lights of the community hall humming overhead. This meeting was the final hurdle for the social mandate grant that kept his company afloat. His micro-diagnostic technology was decentralised, built on principles of societal well-being rather than relentless growth. His mission alignment frequently put him in conflict with the pursuit of market stability. He survived on a fragile mosaic of purpose-driven funding—public grants and peer crowdfunding—which made his existence precarious. His motivation was deeply personal; he'd watched his own grandfather, a proud, intelligent man, become increasingly isolated and fall victim to a sophisticated disinformation scam that had cost him his savings. That experience had ignited Javier's passion for creating technology that empowers, rather than exploits, the vulnerable.

Facing community distrust in AI technology
A council member, an older woman with sharp, sceptical eyes who represented the digitally fatigued, challenged him directly. "We appreciate the intention, Mr. Cruz, but we simply do not trust your AI. We have seen too many promises. We are tired of being experimental subjects for technology we don't understand, especially when all our institutions seem to be failing us."

Pivoting to an ethical defence to build trust
The sentiment, a mix of weariness and defiance, hung in the air. This pervasive digital scepticism threatened his entire financial stability. Javier had to pivot his defence away from the technology's effectiveness and toward its ethical framework. He spoke not of algorithms, but of his grandfather, of the community co-design sessions he had held, of the transparent data policies they had written together. He had to painstakingly prove that his work served the common good because he had seen, firsthand, the cost of technology without trust. He knew that his success today depended less on his code and more on his ability to build a fragile bridge of trust with a generation that had every reason to be wary.

Persona 2:
The researcher
Professor Lena Kovač, Head of Digital Ethics, Public University

Facing distrust from elderly research participants
Professor Kovač facilitated a participatory research session, the air in the room thick with a mixture of stale coffee and palpable tension. Her job was to rebuild public trust by designing ethical AI frameworks for healthcare. Her central challenge involved overcoming the populist distrust and digital fatigue of the elderly citizens sitting around her table. They were not abstract subjects; they were individuals with names and histories of being let down by systems that promised progress. She needed their input to validate her governance model, but they openly questioned her motives. "Another expert to tell us what's good for us," one man muttered, just loud enough to be heard. "Then you'll take our stories and sell them to some company."

A political attack creates intergenerational conflict
Suddenly, her device buzzed with a silent, urgent vibration. It was a message from her younger sister, a single mother struggling with precarious gig work, containing a link to a social media post. A junior minister, part of the younger generation of leaders, had just publicly criticised Lena's work, suggesting her funding should be redirected from "appeasing reluctant seniors" to more "dynamic, high-impact youth projects" like job retraining programmes. Her sister's message was blunt: "Is he right? Is my future being sacrificed for theirs?" The tweet

put her work squarely in the political crosshairs, framing it as an intergenerational conflict that was now playing out in her own family. Lena now had to navigate this political friction in real-time while trying to maintain the trust of the people in front of her. She faced the formidable task of defending her vital social science work—meant to ensure that technology benefited all age groups—against the political challenge of resource allocation, knowing that if she failed, she would be failing both the elders in the room and the generation of her own sister.

Persona 3:
The R&I official
Marc Dubois, EU R&I policy coordinator

Grappling with the productivity paradox
Marc was in a high-stakes meeting, the holographic draft of the new ethical AI framework hovering over the table. He privately grappled with the post-growth productivity paradox. He championed societal well-being and democratic science, yet the shrinking workforce and the fiscal pressure from an ageing population demanded constant productivity gains just to keep the lights on. The ghosts of unfunded pensions haunted every policy decision. He and his partner had been discussing having children for years, but kept putting it off, worried about the economic uncertainty and the heavy tax burden required to support the older generation. The need for productivity augmentation was not just a policy problem; it was the reason his own family’s future felt so uncertain.

Choosing between public trust and urgent innovation
The draft proposed strict new transparency requirements for algorithms used in the workplace—a necessity for public trust. A colleague from the economic directorate, a pragmatist, immediately pushed back, her voice sharp with urgency. "These regulations are too slow! We need fast, automated systems to compensate for the labour deficit now. The ethical tightrope is one thing, but we can't afford to stifle the innovation required to maintain our social contract." Marc faced a fundamental decision: where to draw the line between public trust and the critical need for innovation. He realised his job was fundamentally about intergenerational fairness: ensuring the technological solutions he implemented today didn't create new burdens for tomorrow’s children—children he himself hoped to have. Every clause he debated felt like a choice between the world they wanted and the world they could afford.

Scenario 3

Persona 1:
The start-up founder
Kazimierz Marek, Head of Secure AI Systems, European Federation

Innovation crippled by market isolation
Kazimierz was hunched over his terminal, the low hum of the secure server room a constant companion. He was meticulously crafting the AI prompt for the government's latest technological tender. His business, focused on secure AI solutions, existed entirely within the fragmented, closed market of the European Federation Splinternet, a reality dictated by past geopolitical shocks and severe migration controls. The pace of his innovation was crippled by this isolation. He felt less like a founder and more like a high-tech artisan, working with a limited palette of tools in a walled garden, while rumours of vast, untended jungles of data and talent existed just beyond his reach. This isolation was profoundly personal; his fiancée, a brilliant materials scientist from a non-European Federation bloc, was stuck in a years-long visa process, the severe migration controls preventing them from living together. Her expertise was exactly what his hardware team needed, but she was locked out, a daily reminder of their enforced separation.

High costs and security threats in a closed market
He was paying exorbitant fees to license a specific dataset—the only one approved for use within the European Federation. Closed borders prevented him from accessing global talent and data, increasing the cost and risk of duplicating research already done elsewhere. Simultaneously, a frantic message flashed on his secondary screen from his security chief: a sophisticated phishing attempt, with the digital signature of a competing bloc, was targeting their tender submission. Kazimierz had to pull two of his best AI specialists from R&D to work on security defence, a painful reallocation of resources that set their primary project back by a week. His success depended not on global market scaling, but on his ability to win competitive, government-steered tenders while navigating the structural inefficiencies of a closed, high-risk market and the constant, draining threat of espionage, a fight he felt both in his lab and in his empty home.

Persona 2:
The researcher
Dr. Sabine Reuter, Corporate Data Scientist, PharmaCorp

Discovering a data bias with personal consequences
Dr. Reuter stared at a diagnostic output from her proprietary AI agent. The AI, tasked with accelerating drug discovery for an age-related condition, showed an uncanny, statistically undeniable bias favouring one specific genetic marker predominant in the European Federation's ageing, native-born population. Sabine knew exactly why: the AI's learning capabilities were deeply imprinted by the limited, controlled data sets harvested exclusively from the closed European Federation Splinternet. Her core ethical conflict was the scientific compromise forced by geopolitical isolation. The issue had become terrifyingly personal last month when her cousin, whose ancestry traced to a region outside the primary data pool, received a confusing preliminary diagnosis for a neurological condition from a similar AI system. The doctors were struggling to interpret the results, a direct consequence of the biased data she knew was baked into the system.

Validating a biased AI that may cause harm
The corporate and governmental mandate was clear: rapid, short-term solutions for the immediate demographic problem. She lacked the support of marginalised social sciences or ethical oversight, leaving her in an ethical vacuum to manage the consequences of her biased AI systems. Sabine's task today was to "validate" the AI's findings for the next corporate pipeline stage, fully aware that she was contributing to a technologically powerful, yet ethically and scientifically confined, system that could one day provide ineffective solutions, or

even misdiagnoses, to anyone outside the narrow data parameters—potentially even her own family members. She was trapped in the Biased AI Cage, where the cost of isolation undermined the objectivity of science itself.

Persona 3:
The R&I official
Nikolai Volkov, European Federation strategic planning official

Managing the paradox of needing talent while enforcing closed borders
Nikolai chaired a crisis meeting on resource allocation, the faces of his department heads looking grim on the secure holo-conference screen. He was constantly navigating the tension between steering national R&D through AI prompt tenders—his main lever of control—and enforcing the severe migration controls necessary for political stability. The ageing population demanded immediate technological compensation for labour shortages, but the closed borders denied him the influx of young, skilled talent he desperately needed. It was a self-inflicted wound he was forced to manage every day, a paradox at the heart of their national strategy. He felt it keenly when he spoke to his son, a bright university student whose entire graduating class was facing a predictable, albeit secure, future within the European Federation's national tech sector, with no option to seek experience or contribute innovation beyond the bloc's digital and physical walls. Their talent was desperately needed, but their professional world was rigidly defined.

Trading a public service for a high-priority AI project
The conflict today was about the high resource demands of advanced AI. A major state task, crucial for maintaining their technological parity with other blocs, required immediate expansion of computational clusters, demanding an immense, immediate surge of energy and water. Nikolai had to divert those resources, which meant indefinitely pausing a public transport automation project that would have served his own ageing parents in a remote region. They had been looking forward to the service, a small promise of mobility in their declining years, and he knew they would be disappointed. He was constantly balancing the urgency of a technological catch-up against the socio-economic fallout of resource scarcity and restricted borders. His policy action was not about growth; it was about control. He was trading public services that would help his own family for highly focused, efficient technological power, all to manage the stability of a demographically imbalanced, isolated bloc.

Scenario 4

Persona 1:
The start-up founder
Elena Stoica, Founder of GreenGrid Tech

Balancing collaboration with a local mandate
Elena simultaneously managed three video conferences from her regional hub office in Cluj-Napoca. Her startup focused on green digital technology, aligned with the EU's strategic goal of digital independence and ecological transformation. She was constantly balancing maximising synergistic collaboration across the distributed network with adhering to her company's local mandate for regional production. She had founded her company in her home region specifically to counteract the brain drain that had seen most of her childhood friends, including her own sister, leave for the West a decade ago. Her commitment to local production was a commitment to building a future where people like her sister could one day come home.

Mediating a conflict to protect regional goals
On one screen, a renowned Professor Novák from an established Western HEI, a titan in his field, was clashing with Dr. Popescu, a talented young researcher from her own emerging Central-Eastern European (CEE) partner institution, over the production methodology. Elena needed Novák's deep-seated expertise and Popescu's innovative, young talent pool—the interregional partnership was crucial for counteracting internal brain drain and achieving collective gain. Yet, the Western partner was pushing for a centralised production model that violated Elena's commitment to building a local, regionalised supply chain. Elena had to mediate the conflict, gently reminding the professor of the strategic value of dispersed manufacturing in a fragile world, while encouraging her young compatriot to integrate the proven quality controls from the West. Her daily success hinged on her ability to integrate dispersed expertise and balance scaling the business (synergy) with the political imperative of local mandates.

Persona 2:
The researcher
Dr. Stefan Lind, Specialist in Human-AI Synergy, Regional Centre

Efficient virtual collaboration comes at a personal cost
Dr. Lind sat in his specialised regional centre in Odense, running a complex human-AI simulation for port logistics optimisation. His progress was driven by seamless virtual collaboration with researchers hundreds of kilometres away in Hamburg and Rotterdam, a core feature of the EU's dispersed excellence strategy. The intense specialisation, forced by resource optimisation and declining student numbers, ensured excellent funding and deep expertise, but it had also shaped his personal life. His partner was a leading neuroscientist at another specialised hub in Finland. They had built a life together across the EU's sovereign cloud, raising their young daughter through a patchwork of high-presence video calls and carefully scheduled monthly visits. The efficiency of virtual life came at a constant, personal cost.

Hyper-specialisation hinders broader discovery
Today, he faced a critical data inconsistency error reported by his AI co-researcher, an anomaly it couldn't resolve, flagging a potential flaw in their underlying assumptions. He needed to physically consult a foundational academic paper on fluid dynamics from a public library, but it had since been digitised and restricted to internal university archives. The virtual system, designed for efficiency, had inadvertently cut him off from the kind of serendipitous, cross-disciplinary discovery that once fostered broader critical thinking. He felt a pang of frustration, the same feeling he got when a video call with his daughter would lag at a crucial moment. While the system valued his ability to verify data and mitigate disinformation, the specialisation pressure meant his

knowledge was intensely focused, creating a constant tension between the hyper-efficiency of virtual mobility and the intellectual and personal constraints of a life lived through a screen.

Persona 3:
The R&I official
Inès Moreau, EU policy coordinator for regional R&I

Reviewing hub proposals to manage demographic shifts
Inès reviewed the final three proposals for the next major R&I infrastructure hub investment, the future of a billion-euro initiative resting on her recommendation. Her mission was to use R&I funding as a powerful tool for demographic crisis management and achieving EU strategic autonomy. She constantly sought to maintain the investment balance: strategically dispersing infrastructure and facilitating internal talent flow while mitigating existing regional disparities. Her own family's history was a quiet testament to these forces; her parents had left a struggling region in southern Europe for a prosperous one in the North decades ago, a move that had given her opportunities but had left them disconnected from their roots, with only annual visits possible.

The demographic crisis becomes a personal reality
As she deliberated, a notification chimed on her husband's datapad, which he had left on the kitchen counter that morning. It was an official notice, impersonal and unavoidable: he had been selected for the mandatory three-month rotation in a geriatric care facility, slated to begin in six weeks, in a struggling rural area. The message landed with a quiet thud in her meticulously organised life. Her husband, a data architect working on complex EU-wide systems, would soon be on the front lines, assisting with basic care, living the very reality of the demographic crisis she spent her days strategising about. She immediately began to calculate the logistical and emotional fallout: managing their home, their shared responsibilities, and the strain of his absence. The policy was designed as an impartial civic duty, a great equaliser, and now its fairness was no longer an abstract concept but a deeply personal, disruptive reality.

Facing a politically fraught choice between regional proposals
Now, as she looked at Proposal A, which offered the largest immediate economic return in an already prosperous Western hub, she felt a profound unease that went beyond mere strategy. It was the safe, predictable choice, reinforcing the path her own parents had taken, but it risked a further concentration of innovation capacity, potentially worsening the very care shortages and regional isolation that would soon define her husband's life for three months. Proposal B, a joint venture from Estonia and Latvia, suggested a location in a demographically struggling region with high youth outmigration, a risky but highly strategic move for regional cohesion. It represented the kind of opportunity that might have allowed her parents to stay, and offered a lifeline to regions desperately needing investment and care infrastructure. The choice was politically fraught, representing the constant tension between achieving collective EU gain and addressing localised economic and demographic imbalances. Inès had to select the proposal that would most effectively strengthen the resilient, distributed European R&I fabric, actively promoting talent circulation and mitigating internal brain drain—a decision now imbued with the weight of her husband's impending service.

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