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JRC SCIENCE FOR POLICY REPORT

Shaping & securing THE EU'S OPEN STRATEGIC AUTONOMY by 2040 and beyond

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Shaping & securing THE EU'S OPEN STRATEGIC AUTONOMY by 2040 and beyond

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Executive summary

The objective of this Science for Policy report is to present the results of the foresight process carried out on the future of open strategic autonomy. The report describes trends and emerging issues looking at 2040 and beyond in a systematic and systemic way. It informs the 2021 European Commission Strategic Foresight Agenda and it provides foresight analysis and knowledge to the 2021 Strategic Foresight Report. Desk research was carried out, including a literature review, policy analysis and syntheses of existing knowledge on the current state of the EU's open strategic autonomy and future possibilities in 2040 and beyond. Participatory foresight methods were employed to build collective intelligence on possible future developments, including the development of scenarios and an assessment of future policy options.

The importance of open strategic autonomy has been stressed in several Commission policy initiatives such as the trade policy review and update of the new industrial strategy[1]. The concept includes the ambition for the EU to assume greater responsibility for its own security, reduce one-sided dependencies in critical areas and strengthen its capacity to set and implement its own priorities. This concept has been brought to light by the Covid-19 pandemic, which has exposed vulnerabilities in Europe (e.g. disrupted medical supplies during the lockdown). Despite a variety of definitions, the literature indicates core features of open strategic autonomy that encompass notions of a ***current*** state of vulnerability, dependency and gradual dis-empowerment, in contrast to a ***future*** state of enhanced resilience, managed mutual interdependence and relative power.

This report presents foresight scenarios on the global standing of the EU in 2040, in relation to open strategic autonomy. The scenarios were derived in participatory workshops with experts and stakeholders. They point to ways for the EU to build preparedness through anticipation. A Delphi enquiry enabled the engagement of experts who assessed and ranked the identified 'forward-looking issues' in terms of their relevance for shaping and securing the EU's open strategic autonomy towards 2040.

Based on the results of the foresight process[2], this report outlines potential implications that could contribute to leveraging the EU's capacity to move towards open strategic autonomy by 2040 and beyond. It addresses current weaknesses and upcoming challenges, pointing to underlying opportunities and implementing-priorities that will be required to shape and guarantee open strategic autonomy. The implications outlined should be considered as a set, in order to ensure the establishment of a coherent policy framework. The results are presented in a systemic way across five different areas[3], i.e. geopolitics, technology, economy, environment and society.

Identified <u>geopolitical</u> trends and opportunities for the future of open strategic autonomy:

- *Increasing geopolitical competition* provides opportunities for strengthening strategic alliances and alignment with like-minded countries and international organisations. These

include the transatlantic partnerships, bilateral and multilateral fora. There is space for the EU to play a role in facilitating and triggering discussions on possible reforms of international institutions and organisations to better face current and future challenges. New and existing relations could be strengthened, for example inter-regional multilateral relations (e.g. with neighbourhood European countries, Africa, and the Middle East) by establishing win-win partnerships in ways that provide equal benefits to all involved parties.

- *Unclear evolution of the international order and hybrid threats* provide opportunities for an expansion of the EU's internal security and defence capacities. Political cohesion could provide the EU with greater influence and the ability to act jointly on defence and security matters, (for e.g. to ensure maritime, air space and outer space influence and cyber security) via diplomacy.

- *Shifts in the future global landscape of powers* calls for the EU to have a clear standing in relation to other important global players. This includes that the EU should define its approach toward the US-China rivalry, as well as its relationship with other emerging and developed global powers, whose future redistribution of geopolitical position is unclear (such as India, Africa, Russia and Latin America, as well as other Asian countries, e.g. Japan, Taiwan, South Korea).

- *Increasing global competition in standardisation* provides opportunities for strengthening the EU's power by using its accumulated excellence in the area, as well as by identifying and monitoring critical areas and technologies for future standardisation. It would give the EU a competitive advantage in terms of geopolitical power and positioning.

Identified <u>technological</u> trends and opportunities for the future of open strategic autonomy:

- *Increased competition in the area of digital technologies* provides opportunities to ensure the EU's digital technology sovereignty through increased efforts in research excellence and their translation into economic growth. This could be achieved through scaling up the EU's start-ups in innovation-friendly ecosystems, and by keeping and attracting talent to the EU with the strong support of education and job creation.

- *The pervasiveness of digital technologies in our lives* calls for a joint approach to their governance through international cooperation with like-minded democracies. Regulatory frameworks could be designed in a way that fosters innovation in line with EU values and standards set to leverage the EU's ability for leadership.

- *Safeguarding Science, Technology and Innovation systems* that could be disrupted in the years ahead, together with enhancing international partnerships and ensuring the competitiveness of researchers and the education system could be key for achieving digital sovereignty in the future.

Identified <u>economic</u> trends and opportunities for the future of open strategic autonomy:

- *Increasing global competition through the growth of emerging economies leads to a more fragmented economy*. This new economic landscape provides opportunities for

further leveraging the potential of the EU's Single Market, smart specialisation and broadening global connectivity and value chains.

- *Foreign powers might progressively utilise economic dependencies for geopolitical reasons and some global market players might become extremely powerful monopolies globally*. That requires strengthening the resilience of the EU's strategic economic assets and industries, from Intellectual Property Rights (IPR) to critical infrastructure, to avoid foreign control and rebalance economic power.
- *With the growing interdependence of the global economy and with major powers building on conflicting interests and values*, there is an opportunity for the EU to enhance its ability to set common economic objectives and act independently. The EU's capacity to act as a unified front would strengthen its position and enable it to safeguard its interests, such as global trade liberalisation and rules-based multilateral cooperation.
- *The international dominance of the US dollar in the financial system will be increasingly challenged.* This opens the opportunity to reinforce the international role of the euro to enhance the stability and resilience of the financial system and increase the EU's economic sovereignty.
- *The climate crisis and threat of ecosystems collapsing pose a growing risk of climate change-related economic losses and rising resource dependencies*. To increase the EU's economic resilience, a more inclusive and sustainable economic model (e.g. beyond GDP) would require further steps along the green and digital transition of the economy. The EU could profit from exporting a successful green and digital economic model to other world regions.

Identified <u>environmental</u> trends and opportunities for the future of open strategic autonomy:

- *Coordinated diplomatic efforts will be crucial to ensure that the green transition becomes a global effort.* Thus, there is a huge opportunity for the EU to keep its leading role in climate diplomacy. This also includes maintaining the EU's role as pace maker of the green transition and support to a global movement of responsible change.
- *Climate change already affects Europe negatively. Adaptation to climate change is one way to manage climate risks.* These efforts include the protection of critical assets from the negative impacts of climate change, such as flooding or droughts, and a strengthening of disaster prevention and coping mechanisms, capabilities and competencies.
- *The green transition offers the opportunity to become a leader in emerging green technology sectors.* Building on this opportunity, the green transition could become a catalyst

to modernise EU industry. Two possible opportunities are a continued pursue for renewable energy technology leadership and the implementation of a more circular economy. The latter would also reduce the dependency on imports of critical materials and goods.

- *As a frontrunner in climate action, domestic EU companies might have a competitive disadvantage because of higher environmental standards than other global players*. The industrial sector could be protected by implementing policy measures that can reduce the risk of carbon leakage and pave the way to industrial technology leadership at the same time. An example of such a measure is the Carbon Border Adjustment Mechanism that was proposed by the European Commission.[4]

Identified social trends and opportunities for the future of open strategic autonomy:

- *Increased polarisation in society and populism* show the need for participatory and inclusive governance that enables co-design and co-creation of policy solutions and services with citizens to enhance trust and legitimacy at all levels of governance. Strengthening democracy in the EU and the EU's position in the world by focusing on fundamental rights and values, could ensure fairness, justice and solidarity.
- *Digital skills and education are not equally offered across the EU regions*. For the EU workforce to remain competitive in the future, defining key areas for training and reskilling is needed. This would require further investment in modernising the education system and skills needed for the future (e.g. digital skills, critical and analytical thinking, problem solving) and avoid brain drain through innovative education and attractive work profiles.
- In the context of the twin transitions, the focus of policy design would need to ensure adequate and fair support to people and industries. Social interventions could be applied when needed for successful transitions, to optimise positive transformations and minimise negative disruptions in society (e.g. social safety nets).

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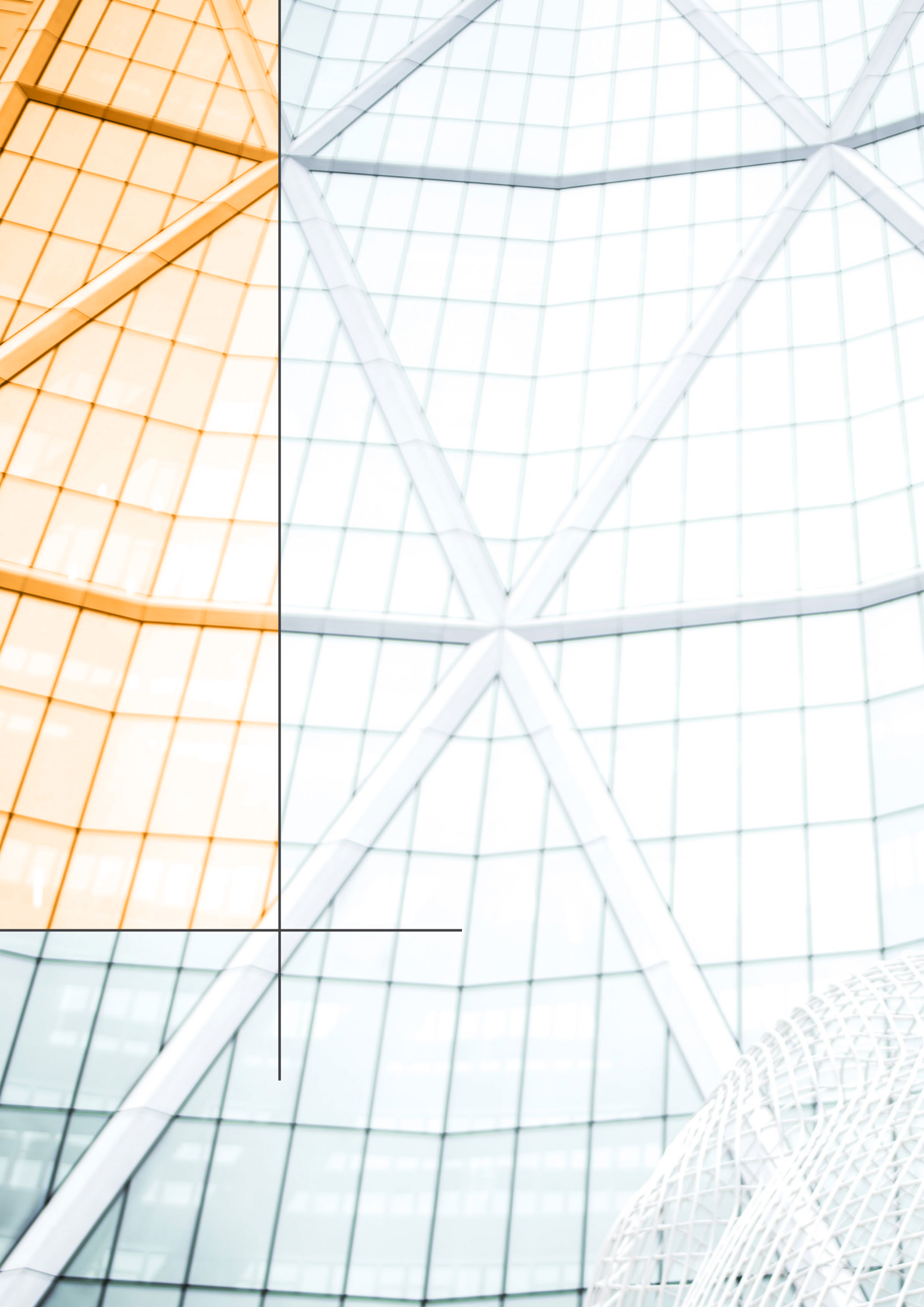
Table of Contents



Introduction

The Covid-19 crisis has brought to light the concept of open strategic autonomy. The crisis has underlined that to build a more resilient and 'future-proof' Europe, the EU should be more aware of its critical dependencies. This report describes trends and emerging issues, looking forward at how they could evolve over time, and looking at the opportunities and risks they entail. The process and results depicted in the present science for policy report underpins the European Commission's 2021 Strategic Foresight Report[5].

The concept of open strategic autonomy has emerged in a context of increasing global connectivity and multidimensional interdependence on the one hand, and assertive to aggressive competition on the other. Its core features include notions of a future state of enhanced resilience, managed mutual interdependence and relative power evolving from existing capacities, vulnerabilities, and dependencies.

While it originally focused on matters of security and defence, open strategic autonomy has expanded to encompass a wide range of policies[6]. It extends from geopolitics and economics (i.e. critical raw materials and supply chains) to law (i.e. regulation and standards), technology, environment and climate, social and governance (i.e. manipulation of data and misinformation). This extension has led to the indiscriminate use of a range of economic and technological tools to deliberately influence and at worse undermine rival political and economic systems.

Strengthening Europe's ability to play a more active role in the world is central to open strategic autonomy[7]. The results of the foresight process underline that open strategic autonomy does not amount to seeking protectionism or isolationism. It is rather about equipping the EU to manage interdependence in line with its interests and values, and to deal with growing geopolitical competition. Hence, it is 'a means to an end', or to attaining the EU's long-term objectives. A process rather than an end-point, and a dynamic rather than a rigid process[8].

In this report open strategic autonomy is understood as cutting across multiple policy areas. Policy instruments discussed and analysed can enhance Europe's resilience, reduce its dependencies and ensure safety and security. Open strategic autonomy can also be perceived as contributing to a more 'proactive' agenda to enable Europe's own choices through rule making and standard setting at the EU and multilateral level.

Open strategic autonomy is about equipping the EU to manage interdependence in line with its interests and values

This foresight analysis highlights the need for an increased coherence in the EU's open strategic autonomy related policies across domains and time horizons. These policies are those that can equip the EU with a stronger ability to manage interdependences in line with its interests and values. Cross-cutting policy narratives ought to be robust and co-created with all the relevant stakeholders. Indeed, there is a growing need for a more systematic engagement of the public to ensure that policy narratives are clear on what this concept means for European citizens.

This report outlines future opportunities to achieve and secure open strategic autonomy in Europe by 2040 and beyond based on the current state-of-play. Results presented in this report have emerged through the foresight process described below (Figure 1), which was employed to bring forward-looking evidence to the Commission's Strategic Foresight Agenda 2021[9]. The process ran between November 2020 and June 2021. The report begins by outlining the EU's existing strengths and weaknesses with regard to open strategic autonomy, as well chal-

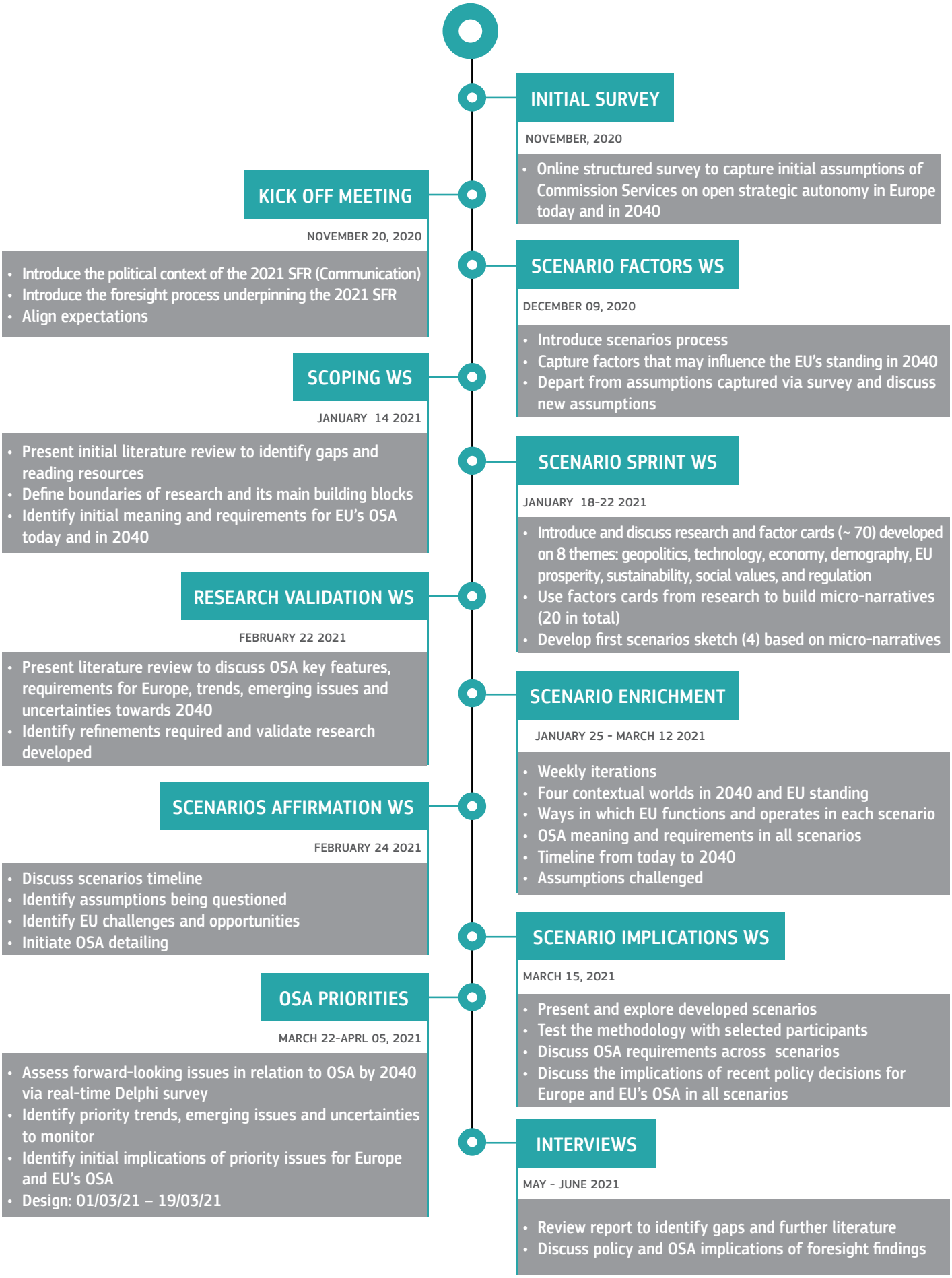


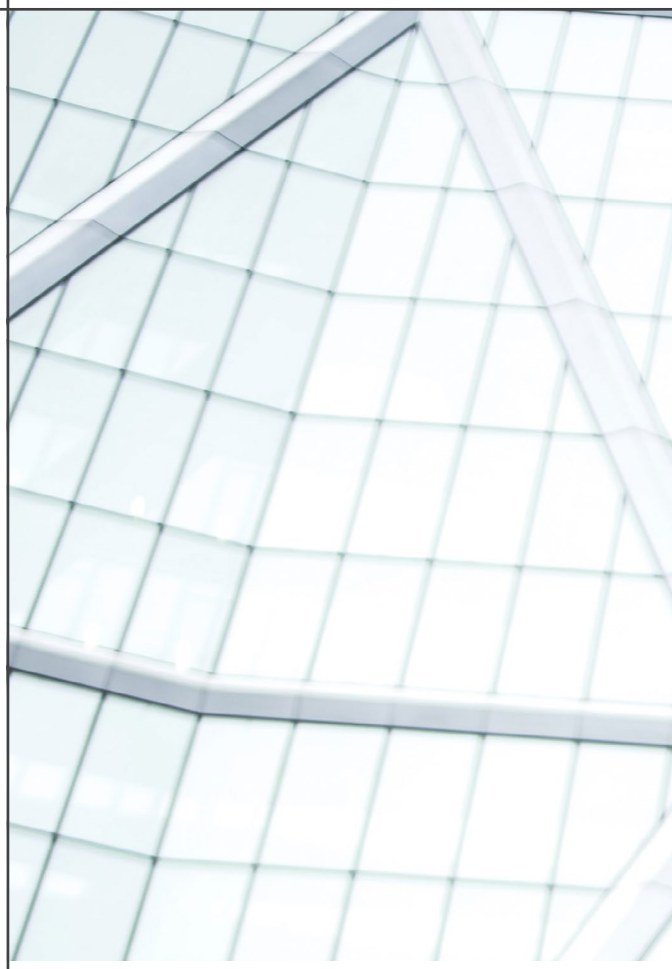
Figure 1: Foresight process employed

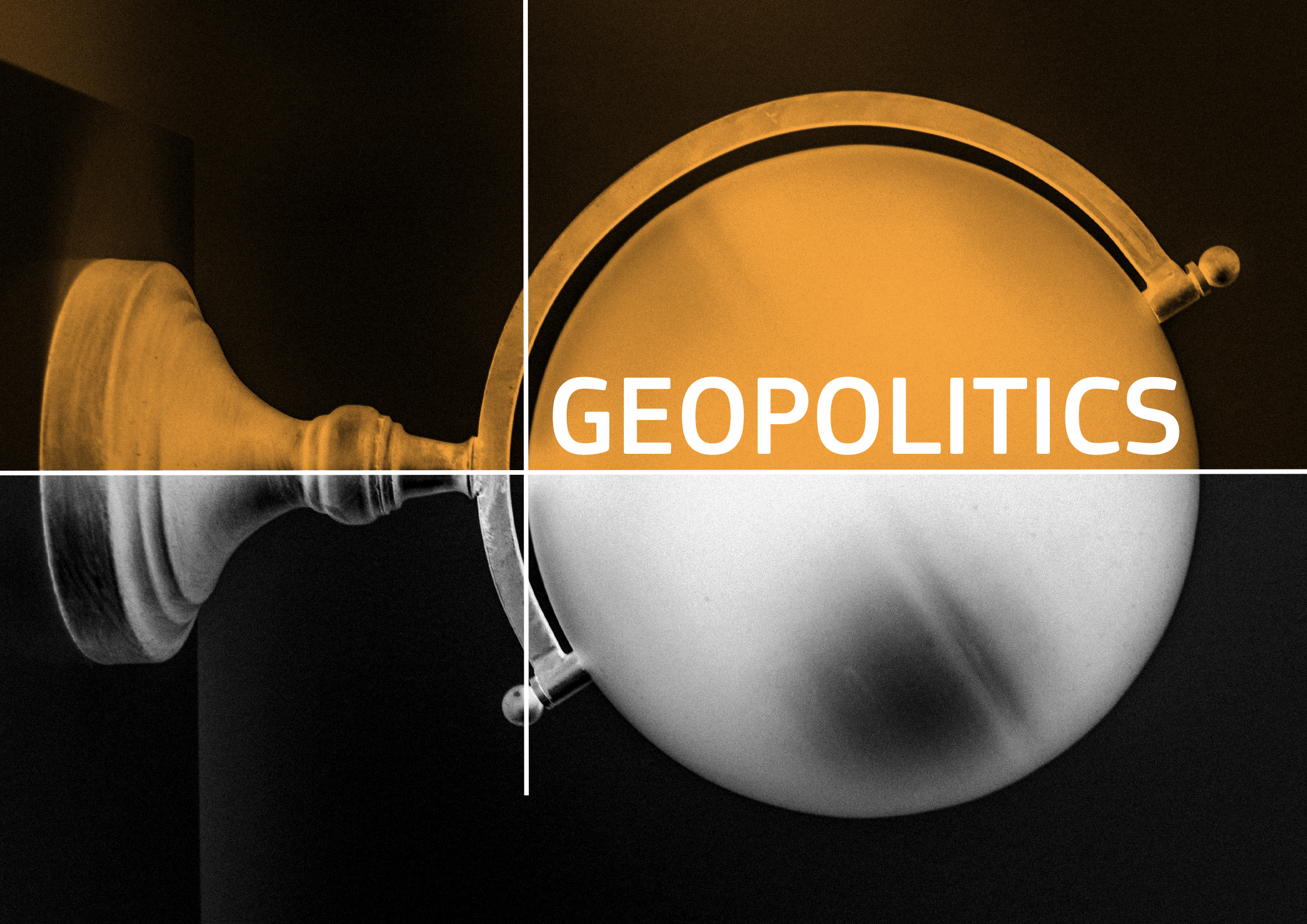
lenges and opportunities for maintaining it by 2040 and beyond. This analysis is based on desk research and debates carried out with experts from across Europe and relevant European Commission services. It reviews current evidence in terms of the EU's dependencies, vulnerabilities, risks, capacities and capabilities. It presents the key trends and emerging issues that are likely to shape the EU's open strategic autonomy in the future. The analysis was grouped and presented in five areas of open strategic autonomy: geopolitical (Chapter 2), technological (Chapter 3), economic (Chapter 4), environmental (Chapter 5) and social (Chapter 6). These five areas allow taking a systemic and holistic approach to this multifaceted concept.

To be better prepared for uncertain future developments, a scenario analysis describes possible futures of the global standing of the EU and open strategic autonomy in 2040. The set of four scenarios provide a framework that provide a way to investigate the meaning and relevance of the EU's open strategic autonomy in 2040 and beyond (Chapter 7). They bring forward four *plausible* futures and are meant to question our individual and collective assumptions about the past, present and future. These assumptions were gathered through an initial survey addressing EU Commission services and through dedicated workshops (Annex 1).

The report concludes with implications for leveraging the EU's capacity to ensure its open strategic autonomy by 2040 (Chapter 8). These implications highlight the ways in which the EU could use its existing strengths and develop further capacities, both by itself and through alliances. It also points to ways of addressing current weaknesses and upcoming challenges, seize underlying opportunities, and implement identified priorities required to shape and guarantee the EU's open strategic autonomy.

To be better prepared for uncertain future developments, a scenario analysis describes pos¬sible futures of the global standing of the EU and open strategic autonomy in 2040





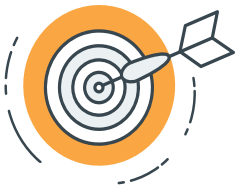
GEOPOLITICS

Geopolitics

This chapter describes the key elements that currently shape the geopolitical aspects of the EU's open strategic autonomy, both in the present and towards 2040. The infographic below depicts a summary of the EU's existing strengths that are key to addressing current weaknesses and upcoming challenges, as well as for seizing opportunities. Building on the EU's regulatory and standard-setting power, its active role in international partnerships and diplomacy and its governance model, is paramount for enabling the EU to leverage its global position and address emerging threats. This is both on its own and through strategic alliances in order to increase its soft power, security and defence capacity - which depend on a common EU geopolitical narrative, built upon a shared vision and set of priorities. We elaborate on these aspects in the subsequent sections.

AREAS FOR IMPROVEMENTS

- The EU needs to show clarity in terms of geopolitical objectives and priorities, and an associated common narrative
- The EU still needs to make progress regarding its military power, defence and security
- A combined analysis of current and future resource and infrastructure dependencies is key to clarify Europe's policy options



EXISTING STRENGTHS

- EU's regulatory and standard-setting power
- EU's openness and active role in multilateral and bilateral partnerships, and multi-dimensional diplomacy
- EU's rules-based and multi-level governance model offers the right framework to advance Open Strategic Autonomy

EMERGING CHALLENGES

- Increasing redistribution of power globally, with a multipolar international order, increased competition, a rising China, and an unclear US positioning
- Escalation of global rivalry and fragility, in particular the US-China conflict and a more fragile Africa, and tensions in the neighbourhood
- Expansion of threats to the EU (including hybrid warfare), its global positioning (including in its neighbourhood, in MENA, in space and in the Arctic), and its infrastructures

OPPORTUNITIES FOR EU'S OSA

- Leverage EU's soft power and position in the global standardisation competition
- Strengthen strategic partnerships with like-minded allies and emerging players, while fostering multilateral governance and rules-based international cooperation
- Advance EU's security and defence capacity by building a shared vision and set of priorities, and establishing action coordination

Current strengths and weaknesses

The EU has three key areas for improvement regarding its geopolitical stand. First, in the defence and security domain, coordinated priority setting is still required to guide cooperation and commitment by Member States. Second, a combined approach of current and forward-looking analysis is key to clarifying Europe's policy options. This is particularly important for resource and infrastructure dependencies and risks, as they can contribute to fine-tuning policy responses more effectively. Third, open strategic autonomy-related EU policies need to be framed around a common geopolitical narrative, which both global players and EU citizens can understand and relate to. Taking on and advancing a responsible global change agenda could provide this framing and a clear, coherent, and attractive common policy narrative.

Three EU geopolitical strengths provide the basis on which to develop the above-required improvements, to address upcoming challenges and seize their underlying opportunities. First, the EU strives to function as a role model in diplomacy deployment. The EU's science, vaccine and climate diplomacy, as well as development cooperation, are important examples of its openness and active role in multilateral and bilateral partnerships, and in multidimensional diplomacy. Second, the EU still exerts important regulatory and standard-setting power. This power derives from the significant size of the European market (450 Million consumers), its political will, and citizen support to set rules and standards for its consumer markets. The EU thereby influences both foreign governments and multinational corporations to comply with EU rules. Third, the EU's rule-based and multi-level governance model offers the right framework to advance open strategic autonomy via multilateral and rules-based cooperation grounded on effective and representative international institutions.

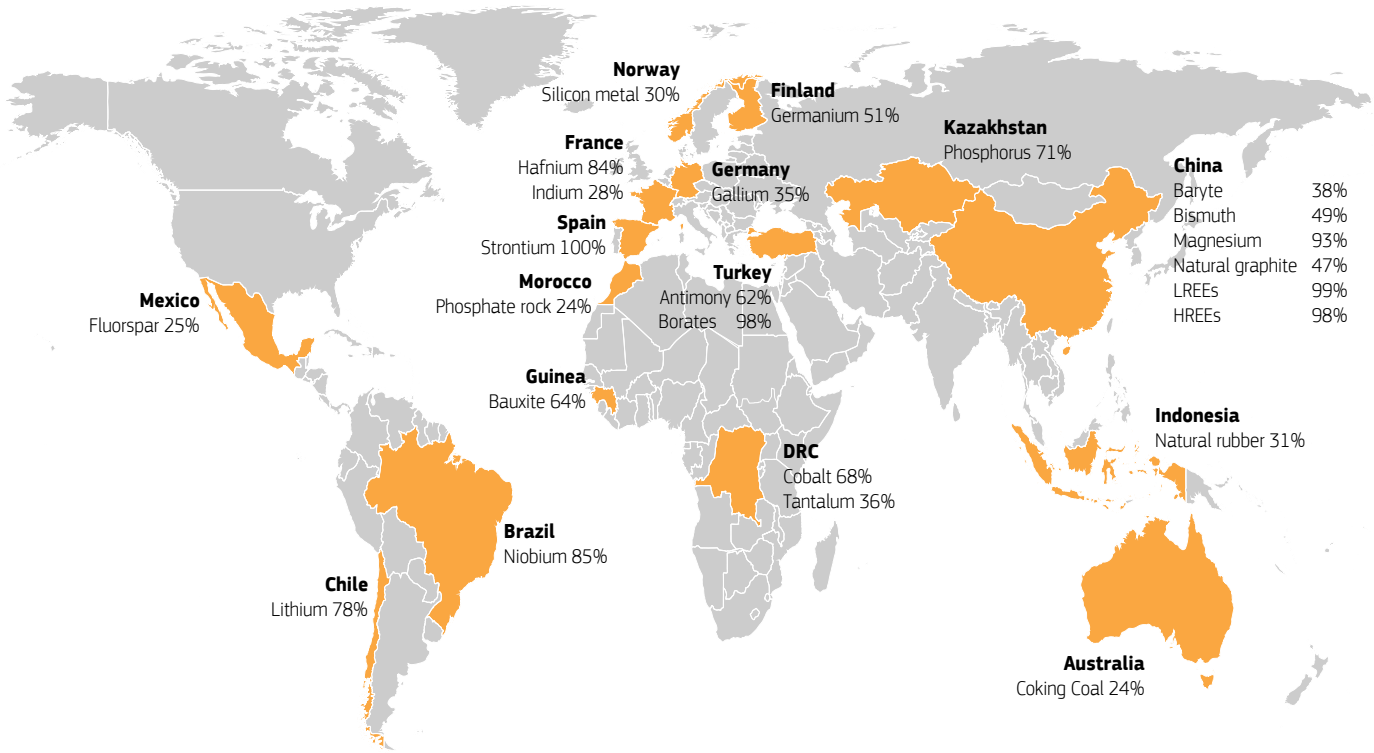
Need to advance the EU's military power, defence and security

Recently the EU has made some progress in defence and security. It has set up arrangements to enhance coordination and cooperation among Member States in developing their military capabilities and acquiring a stronger operational capacity. These include the Permanent Structured Cooperation, the Coordinated Annual Review on Defence and the European Defence Fund[10]. For the first time, it makes funding available under the EU budget to support joint research and capability development in the defence field. These arrangements are expected to be mutually reinforcing and to connect to the successive cycles of the Capability Development Process. Furthermore, the EU's Foreign Direct Investments (FDI) Screening Regulation has entered into force on the grounds of security concerns[11] and to preserve Europe's strategic interests while keeping the EU market open to investment[12]. Similarly, by fostering synergies among EU-funded instruments and facilitating civilian-space-defence cross fertilisation (spin-ins and pin-offs) it is possible to further develop the Single Market and improve EU citizens security[13]. However, the debate concerning the experience of the last few years points to the need for convergence and better priority-setting to guide cooperation and for more commitment by Member States, as well as for a quicker and united response[14].

The EU needs to improve its capacity on hybrid threats[15]. Currently, the EU's approach is mainly a reactive one to ongoing threats at EU borders, with a focus on Eastern and Southern territories. Countermeasures are focused primarily inwards, ranging from the digital economy to cyber, maritime, space and energy domains. These play a role in the security of the EU borders, its critical infrastructure and information flows. However, efforts to increase the EU's resilience and security, as well as to address vulnerabilities are still required. In this direction, the JRC has developed a conceptual framework together with the Centre of Excellence for Countering Hybrid Threats (Hybrid CoE) to facilitate the early detection of hybrid threats, the identification of gaps in preparedness and response, and the development of effective measures to counter this complex phenomenon[16]. Building trust and coordination among Member States, as well as the capacity to work systemically across policy domains in order to anticipate challenges and risks, is key for effective strategies and responses to hybrid threats.

The development of the EU Strategic Compass[17] 2020-2022 will foster a common strategic approach to the EU's security and defence policy and guide future EU work on development of EU Defence and security priorities and capacities. This two-year process, led by the European External Action Service under the responsibility of the EU high Representative for Foreign Affairs and Security Policy, aims to develop a 'Strategic Compass' for its security and defence policy. It offers a more strategic and evidence-based approach for providing guidance and direction on com-

Figure 2. Main EU suppliers of CRM



Source: European Commission, Study on the EU's list of Critical Raw Materials – Final Report (2020)

mon European security and defence policy, with a view to tangible results. It builds on the common analysis of the threats and challenges facing Europe carried out in 2020[18], towards shaping a common EU security and defence culture[19]. Threats include conventional to transnational threats, including hybrid threats. They also relate to pervasive and persistent instability and conflict in the immediate vicinity of the EU and beyond. Ultimately, the EU needs to increase its operational effectiveness, further develop its civilian and military capabilities and strengthen its resilience, while also looking at ways to work with partners more closely[20]. Europe should also focus on reinforcing its defence capacity whilst securing access to global commons (including cyber, maritime and space), and improving early warning systems and strategic foresight, beyond promoting technological sovereignty and innovation.

The EU has limited capability regarding military power, defence and security. The EU lacks the legal competence to act on behalf of the Member States in spite of its spending in defence and the size of its collective forces, which would make it a global power with one of the strongest militaries in the world[21]. This has left the EU dependent on the transatlantic partnership and NATO, and subject to the vagaries of an often-fragile relationship. The debate on open strategic autonomy has exposed different levels of ambition concerning Europe's role in security and defence matters[22]. Many argue that Europe's capacity to take more responsibility for its own security and that of others, in particular in the EU neighbourhood, is required for Europe to be able to advance its interests, values and agenda in a world of growing geopolitical struggles. At the same time, there are differences among Member States concerning the degree and implications of open strategic autonomy in defence.

Need for a combined actual and forward-looking analysis of EU dependencies and risks

The EU's one-sided dependencies in the supply of resources are a growing concern. These dependencies are evident in resources that are both rare and critical for the EU's current and future value chains. The resulting vulnerabilities are increasing due to the growing politicisation of critical raw materials (CRM) and supply chains. The Covid-19 pandemic has highlighted the EU's vulnerabilities in relation to vaccines, medicines and other critical crisis-related supplies, as already highlighted in the Commission's 2020 Strategic Foresight Report[23].

The Covid-19 pandemic exposed dependencies and vulnerabilities regarding the concentration of medical and other supply chains in China and India. Ongoing research highlights the fact that the intensity of globalisation is expanding the number of interdependencies, making the global trade system highly vulnerable to the propagation of failures and sudden collapse[24]. Apart from resilience concerns, this has also drawn attention to the less desirable direction and effects of exploitative practices powered by globalisation, including manipulation of foreign aid, labour, currencies, taxes, subsidies, tariffs and other trade barriers. Open

strategic autonomy marks a pushback on this exploitative form of globalisation and not a shutdown of globalisation in general. Indeed the effectiveness of such a pushback on exploitative forms of globalisation depends on the strength of the global partnerships the EU can forge with like-minded countries. Looking forward, the EU needs to invest in circularity[25], as well as research and innovation on substitute materials to manage and reduce its current reliance on the raw materials required for the twin digital and green transitions more effectively.

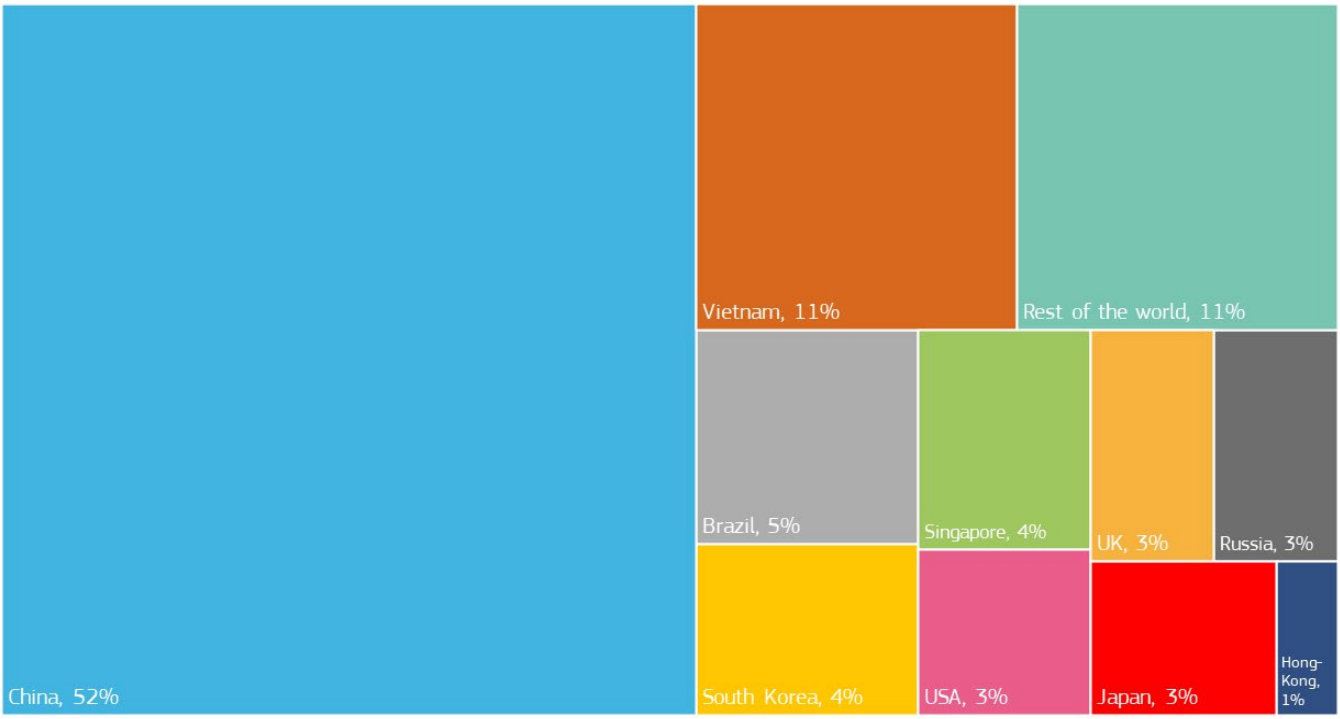
The EU's current approach to open strategic autonomy approach has focused on supply risk for key EU strategic sectors and related value chains. The attention has been on those rare minerals and raw materials with a high criticality rating and which pose the highest supply risk. Recent analysis[26] indicates that China is the largest global supplier accounting for 44% of critical raw materials (CRM) to the EU, while other countries account for the main share of specific CRM, including European countries (21%). Another report[27] comparing the significant strategic dependency of US, UK, Australia, New Zealand and Canada on China, identifies up to 831 categories of goods and 216 categories of goods to service critical infrastructures. It proposes that decoupling from China could take three forms: negative, positive or cooperative, but that further analysis is required to determine the extent of structural dependency.

Intermediate and final goods are an additional source of EU dependency. Intermediate goods are those used in final production, and their sourcing is scattered across the globe[28]. Overall, the three main foreign sources of EU import value, for the 137 products identified as highly dependent, are China[29], Vietnam and Brazil (Figure 2)[30]. "China represents around 52% of the total value of imports of the most foreign dependent products and it is among the top three suppliers for around 54% of these goods. In terms of stages of processing, around 16% of the products for which we depend on foreign countries are raw materials, around 57% are intermediate goods and around 27% are final goods". Out of the 137 highly critical products identified, 99 are related to raw and processed materials and chemicals. Overall, 34 products are more vulnerable and have a low potential for diversification and substitution with EU production. They include various raw materials and chemicals used in energy-intensive industries and health (including active pharmaceutical ingredients). The dependencies on imported energy products are important to consider in the context of the decarbonisation of EU industry, to which hydrogen should become a key contributor. Finally, the analysis in the report reveals that the EU has a high level of foreign dependency with respect to 17 products related to renewable energy production, green mobility (including batteries) and digital/electronics (including semiconductors, cloud and edge computing).

The 2020 Action Plan on critical raw materials identified that lowering dependences for strategic products will require a broader effort of trade diversification and partnerships[31]. Trade diversification is not simple. The same geopolitical shifts that are pushing the EU to secure supplies are making diversification harder. The EU may need to prepare for an erosion of critical supply security in the future. Hence, looking forward the EU will have to cope with three major factors that may shape its geopolitical environment. These are state fragility, economic coercion and climate change. Collectively, these three conspire to limit the number of available suppliers and partners for the EU's more sensitive dependences. A strategy of diversification may be applicable to raw materials or components, but not to other areas such as high-tech. Moreover, existing EU partnerships are a good foundation for diversification, as it is developing new resource partnerships, public procurement and sustained financial investments in critical areas[32]. Finally, novel ways to source resources, such as space mining[33] and seabed mining[34] are being explored.

Infrastructure is an area of concern regarding EU dependencies and exposure. Undersea internet cables are among the critical infrastructures that are becoming a focus of growing geopolitical competition[35] concerning who can build such internet infrastructure, and where. China and the US differ in their approaches, but both are racing ahead of the EU in their influence over internet infrastructures and those that depend on them. "*The EU lacks an all-encompassing strategy for the sector, and individual governments are still the key players. Building capacity to set industry standards would help European telecommunications companies win business abroad, and protect internet infrastructure against hostile powers*" [36] Moreover, connectivity together with the ability to engage with global partners is critical to exert influence in an interconnected world and, therefore, for open stra-

Figure 3: Share of EU imports value of dependent products



Source: European Commission based on BACI database (http://www.cepii.fr/cepii/en/bdd_modele/presentation.asp?id=37)

tegic autonomy. This can be done through networks (e.g. digital, energy, financial) [37].

Space and other critical infrastructure may also be at risk. Strategic autonomy in space relies on the safety and proper functioning of space and terrestrial infrastructure (e.g. satellites and ground stations), as well as supplies of technologies, components and materials. However, to understand EU dependencies in this area requires an overall strategy that maps out infrastructure linkages, identifies vulnerabilities and develops a plan of action to manage resilience. There are three key elements to protecting space-based infrastructures: situational awareness, technological advances and regulation[38]. Recently, the Commission proposed additional measures on critical EU infrastructures protection[39], which is included in the Commission work programme 2020[40], based on a review of the European Critical Infrastructures Directive[41]. It indicates that the current framework, mainly in the transport and energy sectors, is inadequate in the light of increasing interdependencies within, between and beyond these sectors. In addition, the evolving risks that they face, which may go beyond terrorism, man-made technological threats, climate change and natural disasters.

A combined approach of current and forward-looking analysis is key to clarifying Europe's policy options. Such analysis for resource and infrastructure dependencies are important to fine-tune policy responses more effectively. A JRC foresight report on critical raw materials[42] ranks critical raw materials (CRM) in terms of importance, both in relation to their supply and their role in value chains. It indicates the extent to which these materials can be recycled and/or substituted, through innovation and technological advances. This type of ongoing analysis[43] constitutes an essential prerequisite for designing more robust approaches to open strategic autonomy. In this regard, important developments are underway with the setting up of the European CRM Observatory and the Raw Materials Scoreboard[44]. This type of work needs to be broadened, deepened and extended in scope, and time horizon. Future analyses will also need to take account of variables such as new (circular) industry and sustainable business models, technological advances, environmental concerns and market demand, among others.

The EU's active role in multilateral partnerships and multidimensional diplomacy

Multilateralism plays a key role in the EU's open strategic autonomy[45]. Multilateralism is a core element in the EU's foreign policy and identity and a cornerstone of its approach to peace and security. It is widely promoted by the EU to counter global threats, such as the proliferation of weapons of mass destruction, terrorism and global health crises - including the economic and humanitarian consequences of the coronavirus pandemic across the world[46]. Strategic partnerships and

multilateralism are two sides of the same coin, reinforcing one another and the EU's global standing. In addition, they are key to strengthening the EU's ability to shape multilateral norms, institutions and regimes in policy areas in which it yields more power, such as trade and regulations. Multilateralism also depends on cooperation between rivals and the ability to define the parameters for the governance of global public goods[47]. This is illustrated by the Joint Comprehensive Plan of Action (JCPOA)[48].

The EU is playing out its role through multilateral initiatives. In the case of global health policy in the COVID-19 pandemic, the EU together with the US, UK, and others are supporting equitable global access to vaccines through the World Health Organisation co-led COVAX initiative. The ongoing 'vaccine diplomacy' has implications for the EU's profile in and partnership with the Middle East and Africa. China and Russia have moved quickly to offer the vaccines they produce: China is supplying the Middle East and North Africa (MENA) and several African countries, and Russia has offered a number of doses to the African Union (AU). For China[49] this is also part of a larger approach – the Health Silk Road – which promotes China as a global health leader. The G7 recently committed to provide over two billion vaccine doses and to create appropriate frameworks to strengthen collective defences against threats to global health, including by shortening the cycle of vaccine development, as well as developing early warning systems and increased manufacturing capacity[50]. Through the COVAX initiative, the EU aims to facilitate access to a COVID-19 vaccine to millions of people in Africa, Asia, the Caribbean and the Pacific, and in Europe's eastern and southern neighbourhoods[51].

Science diplomacy is another key area for EU policy-making that links foreign policy and science policy. It refers to the EU's external engagement in science and technology (S&T), in particular international activities to tackle global challenges and to foster soft power capacities, thus improving the EU's external relations[52]. The debate includes the ways in which S&T can contribute to the EU's security[53]. It is composed of three forms of external science activities[54]:

1. science for diplomacy, or the use of science to advance diplomatic objectives;
2. diplomacy for science, or the use of diplomatic action to further scientific and technological progress; and
3. science in diplomacy, or the direct involvement of science, or scientific actors, in diplomatic processes[55].

EU science diplomacy activities have been fruitful worldwide. This is true in the Middle East, in the Americas, in Asia, in Africa and in its eastern neighbourhood[56]. Recently, the EU has launched its strategy for international cooperation on research and innovation in a changing world[57] with a view to strengthening its science diplomacy.

The EU's regulatory power

The EU still exerts important regulatory power. It derives from both the significant size of the European market (450 Million consumers)[58] and the political will (and citizen support) to set rules and standards for its consumer markets. The EU thereby influences foreign governments and multinational corporations who find it easier to comply with (unified) EU rules, rather than producing different products or services for different markets (and regulatory frameworks). The EU exerts this 'superpower' influence, not by imposing standards coercively, but via market forces[59]. However, it is important to keep in mind that EU regulatory power is strong relative to its rivals. Europe should strive to maintain and increase this power despite the fact that it may not prove to be easy to sustain. In fact, China has the market power, but currently lacks similar regulatory capacities and the US lacks the political will to use its power.

The EU's strong regulatory power has become particularly significant recently. This is due to the prolonged impact of the Covid-19 pandemic on the global economy and the change processes underway as a result. Rule-making and standard-setting[60] have acquired strategic relevance because of their instrumental value and use in providing direction to global change, as different models of capitalism – more market driven and more state driven – as well as sets of norms and values co-exist and compete on the global stage. This is even more important at a time when Europe, and the rest of the world, face two structural transitions – green and digital – that need steering and adequate governance frameworks. The Green Deal with the ambition to achieve zero net emissions of greenhouse gases by 2050 is set to unleash a torrent of new climate and energy legislation[61]. In the digital field, beyond the ICT Standardisation Priorities for the Digital Single Market[62], the EU digital strategy[63], the strategy for data[64] and the White Paper on AI[65] recognise the importance to adopt standards for the new generation of technology, and a strategy for standardisation has been announced[66].

The EU's rules-based and multi-level governance model

The EU is in a unique position to influence and further develop rules-based international cooperation with like-minded countries. The EU still holds an important role as an agenda-setter for new international norms and standards. The EU is increasing its profile as a global change leader on climate and green transitions, and as a gatekeeper on environmental and labour standards, as well as data governance and privacy. This will require the EU to work in close partnership with other global players and international institutions, and with like-minded countries[67]. The EU can call on its vast reserves of diplomacy, expertise in legislative, institutional and political reform, Research & Innovation (R&I) and scientific excellence as well as experience in consensus-building among EU27. Recent events have demonstrated that the EU has the opportunity to leverage its strengths, assets, confidence and political and public will to advance a responsible global change agenda.

A forward-looking rationale for the EU's open strategic autonomy is to reinvigorate multilateral and rules-based cooperation. This form of cooperation must have the foundation of effective and representative international institutions. The EU is best-placed to take on the role of responsible agenda-setter of international norms and standards, serve as live laboratory of multilateral based cooperation and multi-level governance, and be a powerful driver of responsible global change. By taking on this mission and multiple roles, the EU will be serving the global community and advancing progress on much needed global reforms and transitions. At the same, the EU will also be serving open strategic autonomy concerns and interests by developing an effective mechanism for exporting carefully constructed, economically and socially just policies, and European values, internationally.

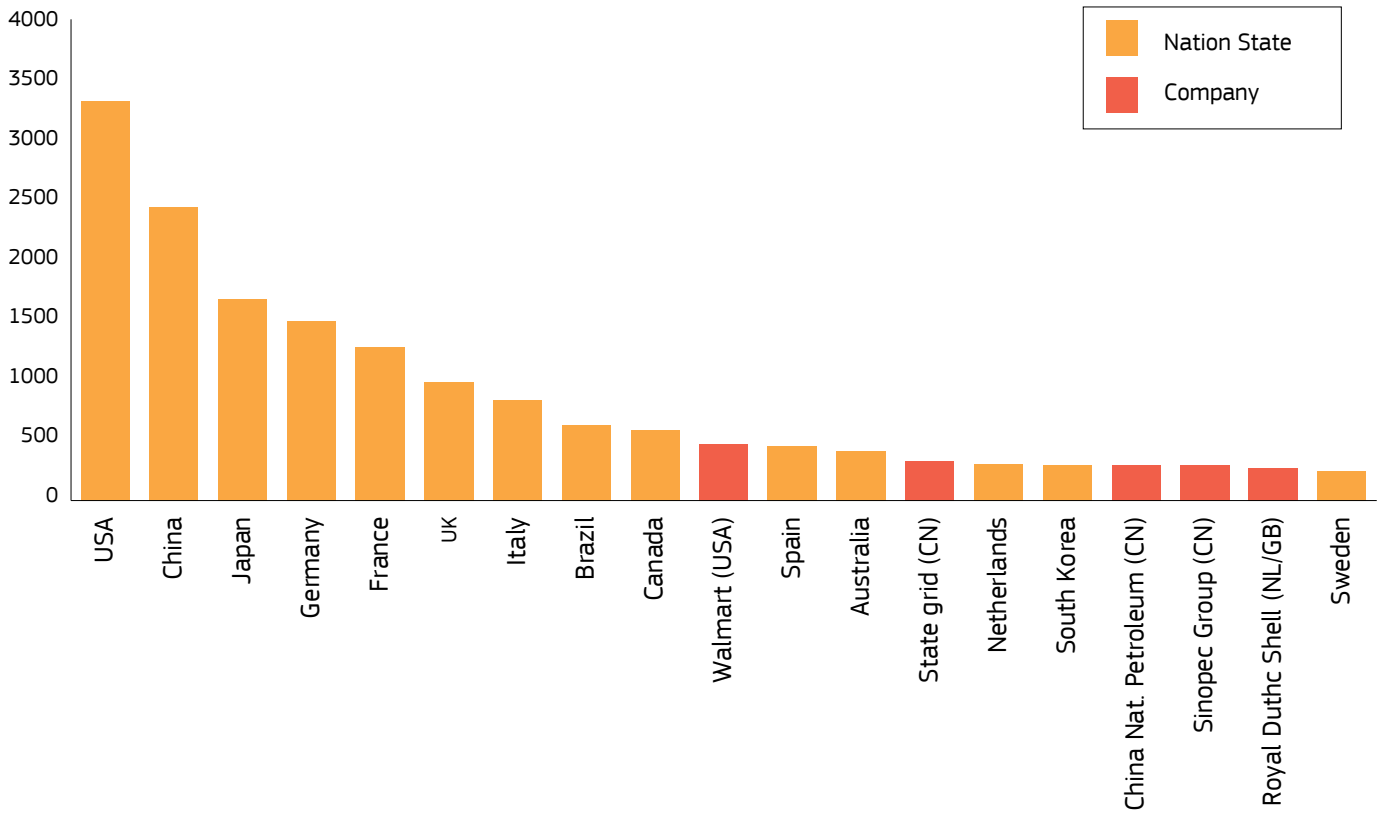
Future opportunities and challenges

Changes ahead are expected to present Europe with three key clusters of geopolitical challenges. First, significant change is foreseen on the geopolitical front with an increasing redistribution of global power. Major shifts are expected towards a more multipolar and contested international order, as well as the emergence and positioning of global powers, particularly in the East. The energy transition will further contribute to the redistribution of power globally. In addition, increased competition in standardisation will also contribute to the ways in which nations and regions will position themselves globally. The second key cluster relates to global rivalry and fragility that are likely to increase. These include tensions in European neighbouring regions, in the Western Balkans and MENA. At a global level, the US-China rivalry could define the geopolitical landscape in the near future. This could be aggravated by China's expanding influence worldwide. Moreover, Africa could have its existing fragilities expanded, to a point of being unable to reduce its overall poverty, thus threatening global sustainability. The third key cluster (of geopolitical challenges) is related to the multitude of threats the EU could face in respect to its global position. In addition, increasing hybrid warfare by Russia could potentially threaten the EU's security and its energy landscape.

> [An] active role in international partnerships and diplomacy and its governance model, is paramount for enabling the EU to leverage its global position and address emerging threats

These challenges present Europe with underlying opportunities. For instance, the evolution of the US's role globally could provide the EU with a like-minded ally on rules-based order and managing interdependence. Likewise, the EU can expand its influence and traction to advance partnerships in its neighbourhood and in MENA. Strengthening global alliances, establishing networks and partnerships, and using international institutions with a focus on critical areas and issues in which the EU can exert most influence will be key for securing open strategic autonomy while fostering mul-

Figure 4: Top 20 revenue generators



Source[73]: Data from Babic et al (2018) based on Forbes Fortune Global 500 list 2017 and CIA World Factbook 2017

tilateral governance and cooperation. The EU could also exploit its strengths in setting global standards more broadly to safeguard and advance its interests, particularly in advancing global green, digital and social transitions. In addition, the EU has the opportunity to leverage its soft power and position in the global competition for standardisation by identifying critical areas and technologies for future standardisation. Most importantly, currently the EU is in a good position to advance its defence and security capacity by building a shared vision and set of priorities, as well as establishing coordinated actions amongst Member States.

Increasingly multipolar and contested evolution of the international order

Multi-dimensional competition and deep interdependence are likely to be the two defining features of the international system over the long-term. This is based on current evolutions concerning the redistribution of power, the digital transformation and climate change. In this context, there seems to be three possible ways forward concerning the evolution of the international order:

1. The various forms of multipolarity will undermine rules-based cooperation, with nationalism on the rise, mutual trust among major powers undermined, international institutions side-lined, and globalisation splintering. In the absence of the will or capacity of a liberal hegemonic power, like the US, to preserve order, there is the potential for 'the jungle to grow back'[68], although recent commitments from both NATO's[69] and the G7's[70] representatives point towards increased unity and coordination among allies.

2. The progressive emergence of two distinct (political, security and technology) orders, centred on the US and China, with a relatively thin layer of common norms, which allows for a degree of economic exchange and cooperation on shared challenges, such as climate change[71].

3. Major powers will need to both compete and cooperate on different issues, because they face both the 'problems of anarchy' (such as hegemonic struggles or spheres of influence) and the 'problems of modernity' (the impact of science, technologies, climate change and trans-national challenges)[72]. From this standpoint, the rules-based order would not necessarily fall down, rather it would (arguably) just become more fragmented – a trend that is already at play. A variety of non-mutually exclusive formats for cooperation could operate, including:

   - Coalitions of like-minded countries (such as liberal democracies);

- Larger and more inclusive multilateral structures dealing with shared challenges like the proliferation of weapons of mass destruction, the climate crises, or health; and
- A vast range of formats and networks, including non-state (including firms) and sub-state actors, such as cities, providing the fabric for international cooperation, for example on issues of sustainable development and connectivity. It is important to highlight that the interplay between state and corporate powers largely shape international relations[74]. Figure 4 shows the states or companies that occupy the top rankings, with the US first, followed by China and Japan (the Eurozone ranks first with more than EUR4,687 billion if treated as a single political entity)[75]. In combination with the increasing nationalist and protectionist backlash in large parts of the world, this could lead to a revival of global rivalries with states using corporations to help achieve geopolitical goals in an increasingly hostile environment, and powerful corporations using strategies that are more aggressive to extract profits in response[76].

China's expanding influence worldwide

The EU has developed international partnerships for geopolitical purposes, but is falling behind China recently regarding its global position. The EU uses its development role to support less advanced countries worldwide, to secure its global position and promote its values and the rule of law together with poverty reduction and sustainable development. However, the EU has gradually been losing the limelight in this role with China's launch and expansion in 2014 of the Belt and Road Initiative (BRI), which combines economic and development cooperation with geopolitical and geostrategic security goals. "China increasingly sees its flagship foreign policy project as a tool for restructuring global governance and a vector for promoting a new form of globalisation"[77].

China is using the Belt and Road Initiative to enhance its influence worldwide, including its military and security presence. China has set up 'strategic bases' of military and/or security interest in Africa and installed intelligence surveillance technologies and capacities, including facial recognition technologies[78]. This, combined with other tactics, including debt entrapment, is jeopardising not only the autonomy of the African countries concerned, but it is also influencing the EU's autonomy and value system. For example, there is concern that by exporting surveillance technologies, China is exporting more than just the technologies, and is providing African governments the means to use these against political opponents and activists, going against EU democratic ideals. This highlights the potential threat of 'digital or algorithmic colonialism' based on foreign-developed AI, integrated in mass products used by Africans[79]. However, the BRI goes beyond Africa and to specific sectors such as infrastructure, space and digital. It also encompasses Latin America, the South Pacific and the Arctic, with all countries being potentially impacted by it. Moreover, beyond the economic sectors that are a potential target of the BRI, it goes further to include global governance and non-material dimensions in its underlying strategy[80].

China is relocating production to Africa. China-Africa trade has grown about 20 fold in the last two decades. There are signals that it is set to grow further, as China makes plans to further increase its foothold. With labour intensive industry in China losing competitiveness through rising labour costs, an option for them could be to relocate production to African countries. Ethiopia started an ambitious 'industrial parks programme' to attract investors in the light manufacturing industry. However, the competitive advantage of wage level offered by Africa is similar to some Southeast Asian countries[81].

China's influence in Africa is growing[82]. Chinese firms are turning to African technology ventures and ambitious China-Africa joint cooperation projects on ocean science, green agriculture, energy technology cooperation and geo-science cooperation, which are signals of investing in joint expertise[83]. However, China might become an obstacle to African industrialisation, as China dominates the sectors in which newly industrialised economies, like African ones, might want to enter with tremendous advantages of scale[84].

China's influence in Africa extends to security affairs, which increases concerns globally due to trade becoming both a product and a tool of security policies. At the political level, besides the regular meetings of the Forum for China-Africa Cooperation (FOCAC) established in 2000, recent initiatives point to a growing focus on security affairs. This illustrates that China is "weaponising trade and investments strategies as instruments of geopolitics"[85]. At the same time the

"geopoliticisation of European trade and investment policy" has emerged more prominently. These developments characterise "the external face of economic statecraft whereby trade policies come to be embedded in power rivalries", thus being "a policy space where geo-economics is both a product and a tool of security policies"[86].

China's global influence goes beyond the Belt and Road Initiative, including hybrid threats. Currently, the dynamics in the Indo-Pacific region have given rise to intense geopolitical competition[87], adding to increasing pressure on trade and supply chains, as well as in tensions in technological, political and security areas. Across the Indo-Pacific, China has more economic influence, whereas the US has more diplomatic and military weight. However, economic development is valued above security concerns and with this China sees an opportunity to expand its power by fostering regional integration and dependence, limiting the role of outside powers, and bringing Southeast Asia under its leadership[88]. Beyond a strategy for the Indo-Pacific region[89], the EU will need to build alliances[90] in order to contribute to stability and prosperity in the region. Finally, China's tactics near the South China Sea illustrate new confrontational strategies at sea, with attempts at creating a de facto exclusive maritime zone through the use of non-military hybrid tactics[91].

Shifting economic power from North to East

Economic power is shifting from the US and the EU (North) to China and India (East). Shifts in global economic power are expected to complement the geopolitical power shifts as US-China relations evolve. China and India are expected to become the two largest economies by 2050[92].

Current trends indicate that the EU will continue to lose its economic standing. Europe's ambition to take global leadership in green and digital transitions could position it strongly in an emerging lucrative market. However, it is not clear if this will suffice to stop the declining economic trend overall. Thirty years ago the EU accounted for 25% of the world's wealth, which is projected to go down to 11% by 2040 compared to China (22%) and the US (14%)[93] by 2040.

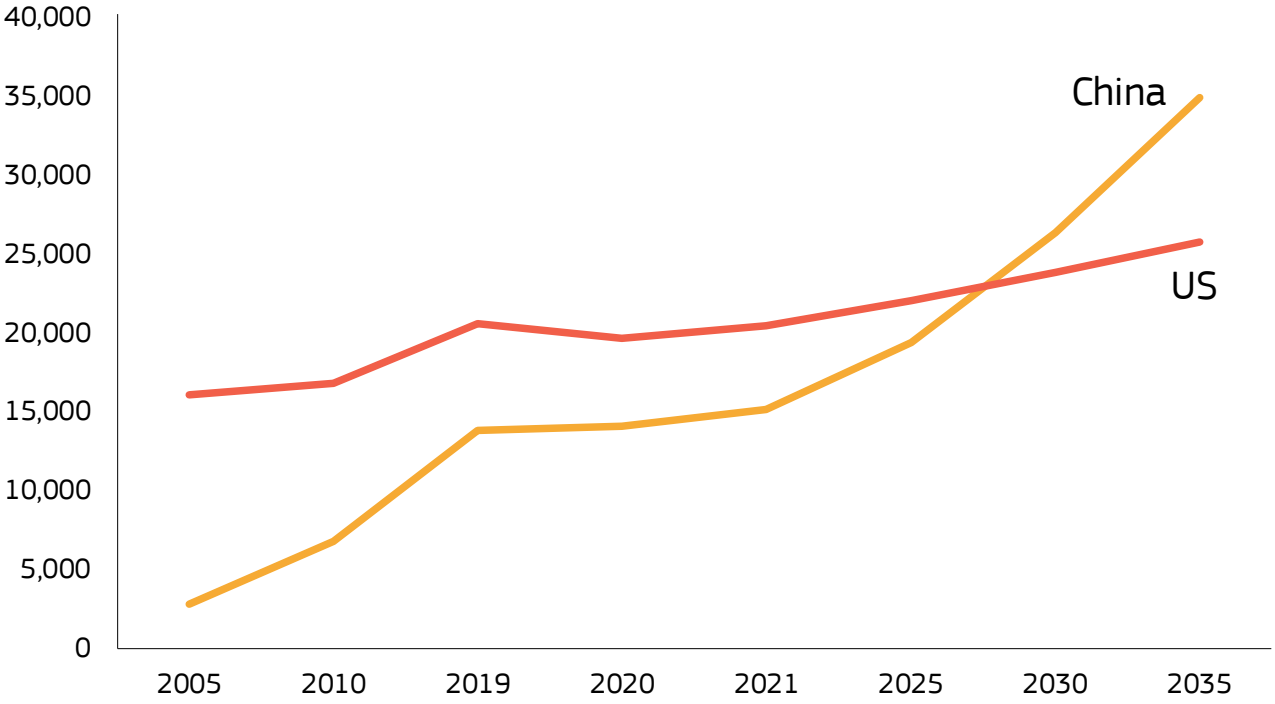
The global landscape will evolve with developing countries shifting from being 'policy takers' to 'policy shapers' at international level. The E7 countries (China, India, Indonesia, Russia, Brazil, Mexico and Turkey) are projected to account for 41% of GDP by 2040 and to reduce poverty, thus exerting more influence on global economic institutions and rule-setting[94]. A key decider will be the combination of alliances, (economic, technological and geopolitical), which are likely to emerge within G7 and E7 countries and between them. New geo-economic political alliances are likely to give rise to other new alliances in response to efforts to build global economic power.

Widening redistribution of power due to the energy transition

Demand for coal, oil and gas is expected to drastically drop between today and 2050. This will progressively decrease prices and lead to a considerable redistribution of economic wealth and power. With a global fossil fuel import bill standing at about EUR 1.6 trillion in 2015[95], importers will benefit from a reduction in energy import costs. For example, reaching climate neutrality is expected to reduce the EU's energy import dependence from 54% in 2018 to 20% in 2050[96, 97]. On the other hand, fossil fuel exporters will lose a large source of both revenue and influence. Among the exporters, those with the least diversified economies and/or the weakest governance frameworks, such as various countries in the MENA region[98] and Africa, stand to be the most affected. Some Gulf producers like Saudi Arabia and United Arab Emirates may be less drastically impacted than others, given their large financial means, and ongoing or envisaged efforts to diversify their economies[99] by focusing on an innovation strategy within a number of sectors[100].

Three categories of countries will gain influence from the energy transition. These include those countries with a large capacity to generate and export renewable power, those endowed with the minerals that are necessary for green technologies, and those leading technological innovation in renewable energy[101]. The concentration of the supply of some of the raw materials central to enabling the green transition has raised concerns about new import dependencies. Deliberate political decisions by exporters, conflict or instability in the countries or areas where resources are extracted, natural disasters or pandemics are some of the potential sources of supply chain disruption. Technological innovation that enables material substitution could decrease import reliance in the future.

Figure 5 Development of US and Chinese economies 2005 to 2035, GDP in billion US dollar (constant prices)[102]



Source: CEBR

Increasing global competition in standardisation

China and the EU are increasingly challenging the US leadership in standardisation. Standardisation has historically served as a key lever in state rivalry for economic and trade dominance[103]. China is laying out their China Standards 2035 plan to define the next generation of technologies that they could roll out through the 140 countries along the Belt and Road Initiative[104]. The EU is challenging standards on cars, chemicals, food and data privacy. In the digital age, all three powers are battling to gain 'first mover' advantage in standard setting, thereby benefiting their own companies, businesses and technologies, and shaping the global digital economy[105].

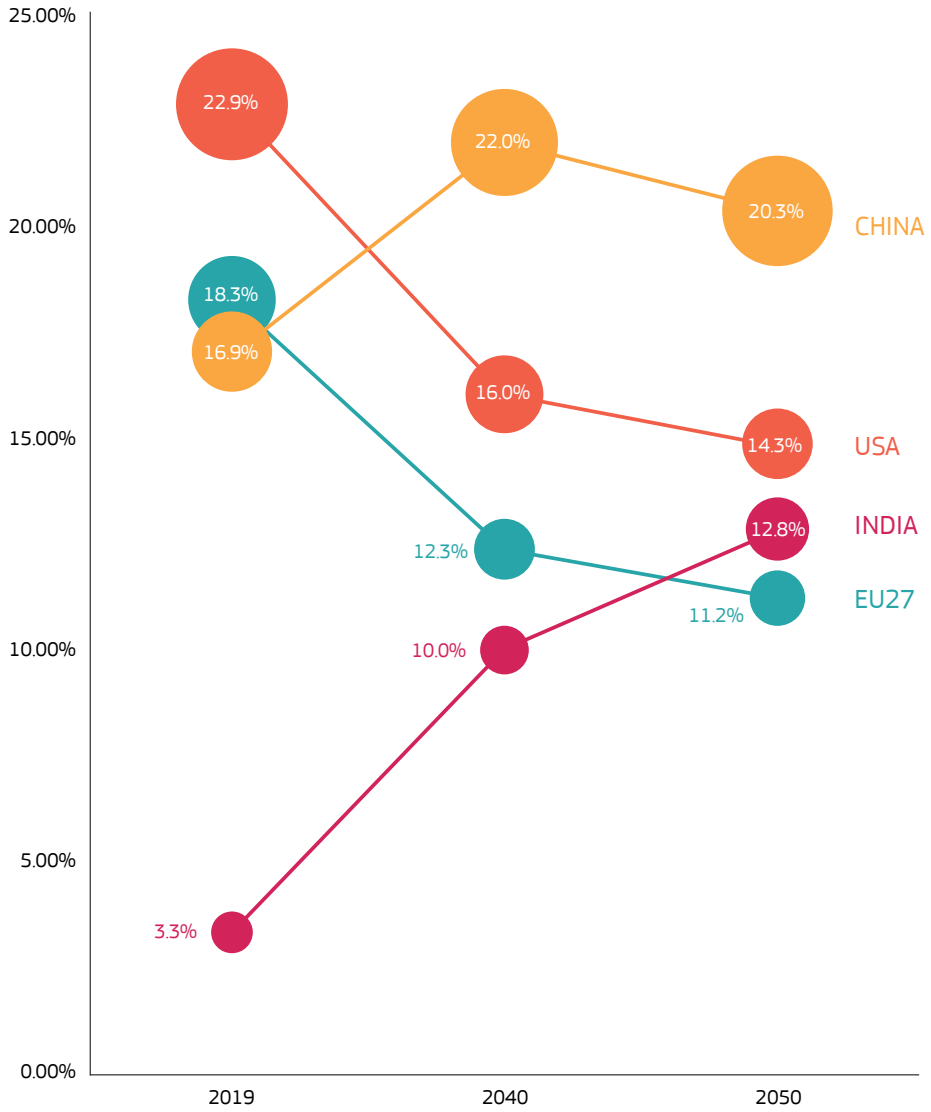
The rules and standards the EU sets in the single market are the basis for global standards, underpinning the EU's global regulatory power. To further increase the EU's standardisation power and use it as an opportunity to seize future benefits, it is important to identify critical technologies and other relevant areas where Europe could get a competitive advantage by being first in setting future standards. This is key to gain first mover advantage against the US and China, and thereby benefit EU's companies, businesses and technologies. Key sectors might include those of the green and digital transitions, including transport, construction and energy[106].

Emerging US-China rivalry

The US-China rivalry is likely to become a defining feature of the international landscape. The shape it will evolve into is still unclear. Strictly speaking, this presupposes the progressive emergence of two blocs opposing each other across the board, including with regards to political/ideological, economic, technological, and security dimensions. From this standpoint, a new Cold war may be even more dangerous than the previous one, given the potential impact of cyber-capabilities and threats on the balance of power.

The US-China relationship could amount to some form of 'cooperative rivalry' in the near future. In other words, a relationship that manages competition to avert conflict[107]. Despite a lot of technological decoupling, the economies of the US and China will remain too interconnected to split. In addition, it is unclear whether the US and China will be prepared to accept the costs and risks of all-out confrontation, as opposed to advancing their relative position through a mix of more assertive and more accommodating measures. In this case, trans-national challenges, including climate change, pandemics and weapons of mass destruction proliferation, will feature higher on the international agenda, thus threatening both the US and China, and requiring at least some degree of cooperation among them.

Figure 6 Shift on global share of GDP of major powers 2019, 2040 and 2050 (based on GDP at current prices and current US dollar)



Source: JRC calculation based on OECD scenarios for the world economy to 2060[108]

Open Strategic Autonomy is chiefly about Europe's ability to set its own priorities and course of action. As China's power grows, the debate may intensify within Europe concerning the correlation between advancing open strategic autonomy and shaping a common transatlantic agenda in the face of the new superpower (Figures 5 and 6). There is of course, no guarantee that these projections will be realised, and also that economic power does not directly convert into other dimensions of power. However, within a couple of decades the power differential between China and the EU may be considerable.

This ongoing power shift to the East will affect the position and role of the US in unpredictable ways. Linear projections concerning the respective power assets of the US and China are subject to discontinuities (from technological breakthroughs to pandemics) and to the impact of political choices. The ways in which resources are used (unilaterally or multilaterally, through coercion or persuasion) is at least as important as the amount of available assets[109]. Equally relevant is the difference between potential power (power that is available) and usable power (power that can actually be wielded)[110]. Internal and external constraints are going to affect US foreign policy and its margin of manoeuvre to a larger extent than they have in the past.

The ways in which the US will define and pursue its core interests in a multipolar and contested environment remains uncertain. Critical variables in the medium to long-term include: the US's ability to re-

main at the forefront of technological innovation, the pace and quality of economic growth (including consequences for the middle class), the implications of the fast-raising public debt (including for the defence budgets and military engagements worldwide), prospects for domestic political polarisation and its impact on US foreign policy, and the evolution of the power of others, notably China, relative to that of the US.

Three potential evolutions of the US's global role are possible. These different alternatives, and related developments, will chart different plausible (and non-mutually exclusive) courses for the future of US foreign policy.

1. The first is a reaffirmation of the US's global leadership following its orchestration of the response to the challenges posed by China. From this standpoint, US global engagement is essential to support the liberal international order, which should be a core interest of the US. The US has the power to exert global leadership and that includes working closely with allies and like-minded partners, which multiplies America's influence[111]. Recent developments at the G7[112] and NATO[113] summits point in this direction.

2. The second possible development in the medium- to long-term is a level of retrenchment. The costs of US military over-reach and involvement in unstable regions and countries outweigh the benefits and the US should focus on other core threats and challenges, including the rise of China, reduce its commitments abroad and rely on its allies to carry more of the military and defence burden[114].

3. The third possibility is that of a recalibration of the US global position. Some argue that the US should move beyond the dichotomy of restoration and retrenchment and think about different ways of projecting its leadership, including a focus on domestic renewal, an emphasis on working with allies and others, and giving more attention to large transnational challenges[115].

Various elements of continuity can be detected in the evolution of US foreign policy over the last decade. These appear relevant to the decade to come as well, and beyond. These consist of a more delimited definition of core US national interests, with a growing focus on the domestic political and economic implications of foreign and trade policy decisions and a reluctance to intervene militarily in regional crises that do not pose a direct threat to the US. It emphasises that allies take a much bigger share of the burden for their own security, as well as a shift in strategic priorities towards dealing with the challenges posed by a rising China.

Growing fragility of Africa and geopolitical rivalry in MENA[116]

Africa faces a major challenge to convert long-term demographic growth prospects into a positive factor of economic growth and development. Africa's population is projected to expand from 1.2 billion to 1.8 billion between 2017 and 2035 - at which time about half of the population would be under the age of 21. Based on pre-pandemic development patterns, and in the absence of major investments in human capital and infrastructures, demographic growth would likely compound poverty. By this estimate, the number of those living in extreme poverty in Africa would grow by 170m between 2016 and 2035, even though by then they would represent a smaller share of the overall population[117].

The pandemic could undo several years of development progress in Africa[118]. The prospect of successive waves of infections - due to a late rollout of vaccinations – threatens Africa's recovery from the pandemic[119]. Depending on different projections, the African economy could be between EUR 288 billion and EUR 531 billion smaller by 2030, compared to pre-pandemic forecasts, and an additional 38 to 75 million people may fall into extreme poverty in the next ten years. Economic recession followed by sluggish growth, would drastically reduce the fiscal space (i.e. flexibility of government spending) of African countries, including their capacity to deliver basic public services such as health. On average, African governments are already spending 30% of their revenues on servicing debt (up from 20% before the pandemic) and debt payments are expected to pose a major challenge in coming years[120]. Based on these forecasts, Africa will drift even further away from fulfilling most of the 2030 Sustainable Development Goals.

The Covid-19 pandemic threatens the positive transformations of the African continent to date. Africa seemed to be embarking on a decade of unprecedented economic growth, sustained by the creation of the African Continental Free Trade Area (AfCFTA), widespread diffusion of technological innovation, hopes of democratic transitions, and the continent's new prominence in global geopolitics. African countries were

progressing towards increased regional cooperation, social inclusion and governance capacity. The EU and the African Union (AU) were moving steadily towards the definition of a new joint strategy. However, with the pandemic, violence and conflicts have increased, progress in trade integration has been threatened due to border measures and travel restrictions, and democratisation and the rule of law has been jeopardised in some countries. This indicates that Africa has entered its first recession in 25 years[121]. Looking forward, the evolution of Africa in the post-COVID-19 world will depend on the strategic assertiveness of African countries and their capacity to translate this into a collective African voice shaping global order[122].

Africa has various global players exerting economic or political influence and creating new patterns of multipolar competition[123]. The EU is likely to face adverse competition on a number of economic and geopolitical fronts. It can also embrace opportunities for enriched international cooperation with Africa, reinforcing multilateralism and shaping a more sustainable future. In spite of having common denominators among EU Member States on Africa, its growing importance for many individual Member States could amplify intra-EU competition. This could further undermine the EU's credibility and effectiveness in the African continent in relation to other global actors, beyond reducing the EU's overall ground in the continent due to the lack of a coordinated approach. The potential for the EU to lose momentum could be exacerbated, because growing multipolar competition in the region enables African countries to choose their best allies and most profitable deals. At the same time, these can fuel anti-Western rhetoric in a battle of strategic narratives and potential regime changes, especially by Russia, Turkey and China. Furthermore, Russia is moving as one of the fastest growing trade partners for sub-Saharan Africa, since both have an alignment of strategic narratives. Russia is delivering 'political technology' services, economic benefits, and relatively cheap arms. The lack of normative conditionality, the presence of Russian-supported disinformation networks and the expansion of quasi-private military companies, risks undermining EU interests, objectives and values in the African region[124].

Africa's growing fragilities and challenges ahead are manifold[125]. Climate change and increased pressure on resources could hinder cooperation and integration of African countries, and impact food production, infrastructure, trade and livelihoods. Digital inequalities persist. A slow adoption of cyber regulation and the absence of a joint marketplace may lead to catastrophic economic consequences. Increasing conflicts, armed violence and organised crime, may lead to increased insecurity as well as undermining the implementation and gains of the AfCTA. Reduced economic growth is leading to an increasing inability for Africa to reduce the size of its informal sector (i.e. the black market) and its unemployment, as well as to generate new jobs. Increasing urbanisation coupled with a lack of urban planning and industrial development risks the fragmentation of urban centres and the rise of dysfunctional cities that may become hotbeds of protests, riots and conflicts. Decreased integration may undermine the delivery of public services, thus jeopardising human development and growth. Diminished rates of electrification may erode universal access to energy and affect various sectors. The increased wealth of a few among the population could potentially lead to militarisation. The inability to capitalise upon the potential of Africa's maritime domain could exacerbate threats to the continent's security and prosperity. However, if appropriately addressed, these challenges could be turned into opportunities to sustain a free trade area, have improved security, meet sustainability needs, or act as enablers for growth.

External powers are increasingly becoming a key factor in shaping the future of the Middle East and the North Africa (MENA) region. In a multipolar landscape, regional powers such as the Gulf countries, or Egypt, can be expected to hedge their bets. While game-changing events cannot be ruled out, current trends point to the US engaging in the MENA more selectively, retreating from the role of ultimate arbiter of regional geopolitics, while prioritising vital interests, such as preventing a nuclear arms race. Russia has been highly effective in projecting its influence in the region in recent years, dictated mainly by economic and diplomatic mandates, as well as political-military opportunities[126]. It can be expected to remain an important player in certain geographical areas, such as the Eastern Mediterranean, but its resources are limited to sustaining its geopolitical ambitions. It is likely that China will continue to expand its diplomatic, political and economic footprint in the MENA region, though it is not clear to what extent it will become more involved in managing conflicts and crises there. China is already the largest individual investor in the region. Its trade with the Middle East was 16 times larger in 2018 than in 2000. Approximately 40% of China's oil imports come

from the region, and China is expected to play a major role in the MENA's digital and energy transitions, providing infrastructure and technology[127].

Impacts of COVID-19 could de-stabilise the MENA region. This could increase domestic friction in MENA countries as poverty grows, living conditions deteriorate and societies see little capacity and/or willingness by governments to introduce much-needed reforms. The region could then become highly dependent on external influences.

The EU has an opportunity to exert considerable influence and traction to advance partnerships in MENA. The EU's current influence in MENA is weak, with implications ranging from displacement to extremism and terrorism. Nevertheless, the EU has the potential to exert greater influence in the region by acting in a more coordinated manner and focusing its efforts on specific areas. These include supporting security and deploying military presence in the region where necessary (i.e. decoupling from US leadership), expanding its diplomatic influence (i.e. providing mediation, reconstruction assistance and support to the development of accountable institutions), as well as leveraging economic (i.e. trade and aid) and political influence (i.e. EU assertive coalitions in partnership with the European External Action Service (EEAS) and coherent policy positions) concurrently[128]. Ultimately, the EU has the opportunity to balance its current focus on migration and counter-terrorism with steps towards lasting regional stability, by reinforcing sustainable governance systems, thereby using the economic and political assets at its disposal. The EU can advance its influence further through international and global institutions. Other opportunities include advancing responsible global changes, such as achieving the SDGs. To do so the EU will need to build worldwide alliances and use international institutions, establish networks and partnerships, and focus on critical areas where it can exert the most influence.

Increasing geopolitical rivalry in the Western Balkans

The Western Balkans countries are exposed to growing geopolitical competition in the region[129]. Despite being at the heart of Europe, Russia has been pursuing a strategy of influence as part of its wider competition with the West[130], and China has increased its economic presence there, while also developing other vectors of long-term engagement[131]. In this context, the evolution of the accession process to the EU will be a fundamental variable for the future of the region[132]. Despite some recent positive steps, a sense of fatigue has affected mutual perceptions in recent years, amid stagnating reforms. Among other initiatives, spurring substantial economic investment and better integration of the region in the EU's supply chains would improve economic prospects and promote intra-regional cooperation. Similar would be to devise the necessary means to effectively support a green agenda and energy transition in the Western Balkans, spreading EU norms in the Energy Community, and helping the region becoming less dependent on Russian gas[133].

Broadening projection of hybrid warfare by Russia

Russia is likely to continue to project its influence in Europe. Competition between Russia and the EU/NATO is very unlikely to subside in the near future, since that would require substantial shifts in the foreign policy priorities of both sides. In this context, Russia's influence in Eastern Europe, the Baltics and across the whole of Europe could take place by leveraging economic and energy relations, mobilising links with local political and economic actors and using the full toolbox of hybrid warfare (i.e. a combination of conventional and unconventional tools of warfare)[134]. Russia could continue to increase polarisation, deterring trust in democracy through disinformation and support for extremist movements[135, 136]. Moreover, Russia is likely to attempt to shape the digital revolution to reinforce its authoritarian political system, as well as to use its military engagement abroad as part of its strategy to assert its great power status claim[137].

The Eastern Partnership includes an increasingly heterogeneous group of countries[138]. They cover the EU Member States and post-Soviet states of Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine. Whether their trajectories will converge or diverge over the long-term will depend on their domestic developments and on the balance of influence between Russia and the EU/NATO[139]. From this standpoint, the severe challenges facing Russia's economic growth could be an important variable. Russia may become a less relevant economic partner for some countries in the shared neighbourhood, whether in terms of trade or remittances. Several factors may re-define the regional energy landscape and progressively lower dependency on Russia in the long-term. These include alternative supply routes from the Caspian Sea through the Caucasus to Europe, the development of interconnectors between EU Member States and Eastern neighbours, the availability

of Liquefied Natural Gas (LNG) and the transition to renewable energy.

Increasing threats to the EU global positioning

Space is a priority area for open strategic autonomy. Europe has scored remarkable achievements, such as the Galileo and Copernicus Space Programmes. Currently, space is used for countless civil and military applications and it is an increasingly contested and congested political and in the technological arena[140]. It is a domain of growing international economic and security competition, with the US, China and Russia carrying out major investments for both national security concerns and economic competitiveness[141]. The combination of cheaper commercial launchers and the rise of private companies with an interest in space, earth-based technological shifts (such as 5G and 6G), and the rise of new space powers (such as China, India and the United Arab Emirates) gives EU Member States reason to consider beyond economics, to the geopolitical importance of space[142]. Moreover, the 'weaponisation' of space by EU rivals is a trend that is increasingly supported by new technologies such as Anti-Satellite Weapons. Therefore, maintaining a sustainable presence in the space race is key for Europe, as this has consequences for the future of the EU's communications, Earth observation and manufacturing[143], as well as security.

Space weaponisation, congestion and disruption are the three interconnected geopolitical trends that should concern the EU[144]. A coherent strategic EU space approach is still needed[145]. Dependency on foreign technology and infrastructures in this domain would hamper technological sovereignty, undermine economic competitiveness and prevent the EU from acquiring a stronger degree of open strategic autonomy in security and defence issues. Electronic warfare and cyber threats challenge the functioning of EU space capacities, as evidenced by the increasing use of anti-satellite weapons (i.e. space-to-space and ground-to-space)[146]. Hence, a renewed investment is required through adequate financial means, focusing on key areas of technological innovation and dealing with geopolitical competition in space[147].

The EU's forthcoming Strategic Compass[148] on security and defence is an opportunity to better link space and defence, to the evolving EU's space strategy. The Permanent Structured Cooperation and the European Defence Fund are already being mobilised to finance and develop space capabilities for EU security and defence. Existing tools such as Copernicus and Galileo Space Programmes are also being used for a range of security-related tasks such as search and rescue, border management, and even Common Security and Defence Policy missions and operations. The new EU Space Programme[149] worth €13.2 billion will support the European launcher industry to promote new propulsion technologies and it will use the new CASSINI initiative to invest €1 billion in space start-ups and innovation, beyond giving the EU autonomy over space tracking technology standards. In order to capitalise on these steps forward, it remains a priority to better link space and defence, as well as to ensure political coordination to meet the threats of the next 5-10 years[150].

The military capacity of various actors is growing[151]. This contributes to further instability at global level and further threatens the multilateral system that is already under pressure. Zones of instability and conflict in different regions close to the EU and beyond is likely to persist, and may even grow in the coming decade. This will contribute to further deterioration of multilateralism due increased fragilities of some states, inter-state tensions, and action of non-state actors that are likely to strengthen their hybrid tools, including disruptive technologies, information operations and both military (e.g. terrorism) and non-military influence.

Cyberspace is developing as a contested domain in which malicious activities constitute a threat to the EU[152]. The EU has an interest in ensuring a free, open, secure and stable cyberspace. Beyond terrorism and criminal networks, the internet is increasingly used for national security purposes by both state and non-state actors. Cyber-attacks are complex to apprehend, anticipate and react to, and they are difficult to attribute to any responsible person or group. The growing fragmentation and state control of cyberspace is undermining democracy, freedom, the multilateral rules-based order and multi-stakeholder governance of the internet. Cyberspace is also characterised by a concentration of private actors that manage cyber platforms and concentrate large amounts of personal data. In a variety of ways, the developments in cyberspace are shaping the geopolitical context.

Three trends depict the changes in the security domain triggered by the cyber realm[153]. First, an increase in the disruptive use of AI displays the ways in which the cyber realm has created new tools for disruptive use, where cyberattacks supported by AI are likely to emerge against critical infrastructure. Second, the ex-

pansion of the role of cyber during times of crisis leading to unexpected events and cascading effects, such as happened during COVID-19 with disinformation inciting attacks against infrastructure. Third, a growth in dependency between policy and technology shows the ways in which cyber has affected the relationship between the public and the private sector, with a renewed requirement for dialogue between policy and technology firms to avoid an erosion the basic principles of democratic principles and liberal economies.

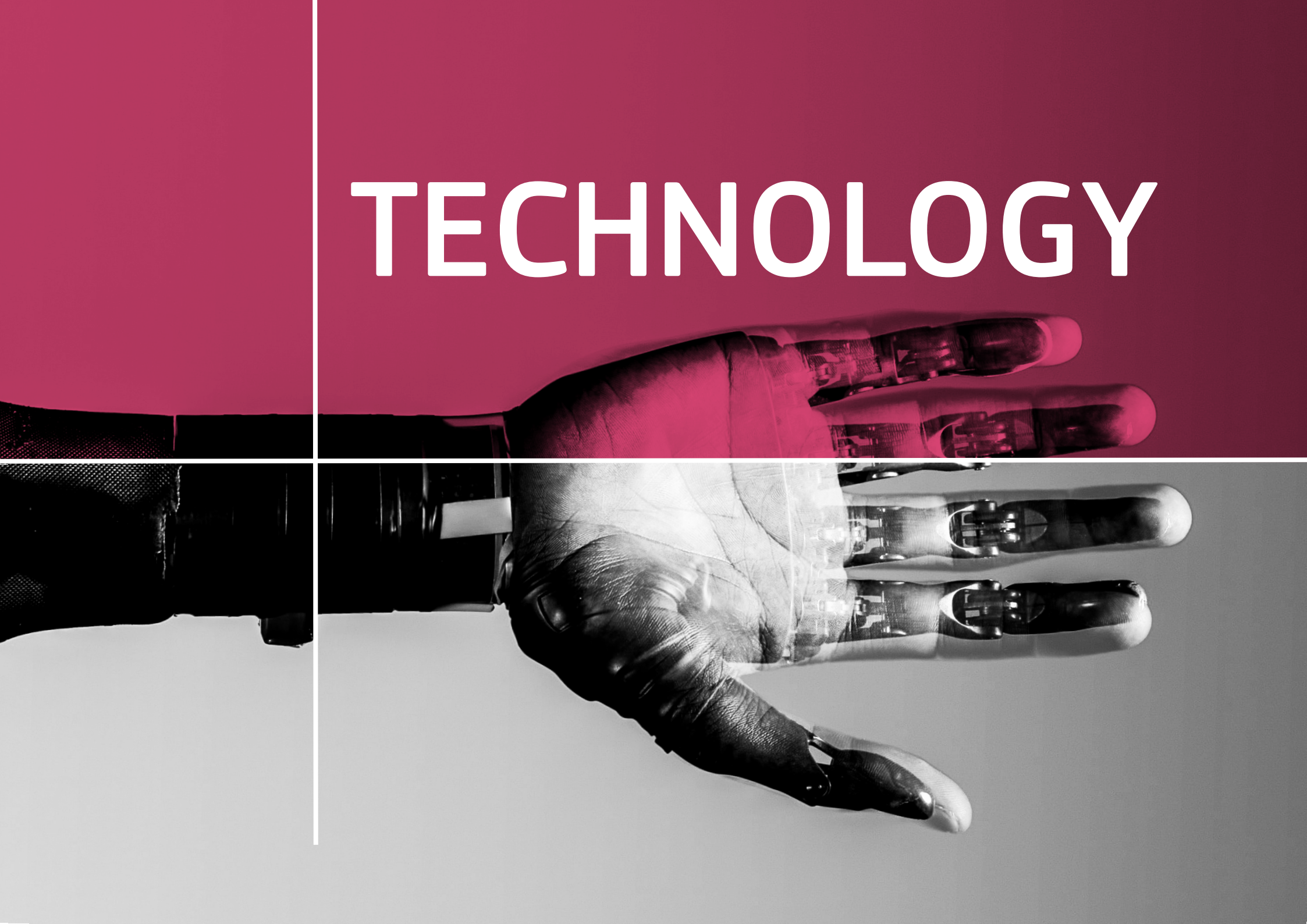
The Arctic is increasingly becoming an area of geopolitical importance. A number of players see new strategic and economic opportunities in the region. The US is ramping up its presence in the Arctic as is Russia on its own Arctic provinces, and China's Arctic interests are also growing. With the update of the EU's current Arctic policy, the EU is readying itself for the reins of power with a more precise and efficient approach. Such renewal of interest needs to respond to two major changes that affect the region and pose challenges to the role of the EU in the Arctic: accelerated climate change and increased geoeconomic and geopolitical competition[154]. It is the fastest warming region on earth. Climate change is accelerating the melting of polar ice with larger chunks of the Arctic becoming accessible both in terms of access to untapped natural resources and to maritime routes. Also, competition for the Arctic between the US, Russia and China are exposing the region to 'spill-over' effects from competition in Europe and the Indo-Pacific[155]. These are accentuated by the erosion of the rules-based international order and the advancement of military capabilities in the region, especially from Russia[156].

The Arctic will be a strategic stress test for EU defence and for the transatlantic partnership. China is expanding its economic, research and maritime presence in the Arctic. Chinese participation in Russian Arctic military exercises has increased global concern. Sino-Russian cooperation is largely energy and commercially driven at present, but could extend to military cooperation, which would be detrimental to European and transatlantic interests. European Arctic countries and the EU should strengthen multilateral cooperation, particularly through the Arctic Council. Ultimately, strategic rivalry will subject European defence and the transatlantic partnership to an Arctic stress test, including a role for NATO in the region [157]. Action and policy renewal are therefore key for Europe's future access to fish, minerals (including rare earths), oil, gas and trade routes in the Arctic, as well as to increase influence in the region and to do its part to improve life (for indigenous people) and to combat climate change in the region.

The Sino-Russian normative partnership poses three key challenges for the EU[158]. First, it contests the liberal foundations of current multilateral institutions, aiming to redefine and re-interpret international norms to reflect shared principles, worldviews and threat perceptions. Second, both countries often violate existing international norms, even those they promote, based on the shared conviction that the international order is dominated by the US and the West, thus reflecting values that cannot be considered universal. Third, they challenge the EU and its values via propaganda, disinformation and manipulation. Both countries seek state sovereignty through international joint perceptions on human rights, international security norms and measures, and cyber-governance, which extends their cooperation in the political, economic and security realms. China is already working with Russia to fill gaps in its military capabilities, accelerate its technological innovation and complement its efforts to undermine the US and West leadership[159]. The mutual benefits their actions will generate is likely to amplify their global influence and have an impact on defence, democracy and human rights[160].

Against this backdrop of diverse threats to the EU global position, a shared EU vision is key to advancing the EU's open strategic autonomy. A strategic approach to positioning the EU in the world entails building coordination and cohesion within the EU, as well as the convergence of Member States around a shared security and geopolitical vision. A subsequent step is an agreed set of priorities shared by all stakeholders. Strengthening the EU's resilience and ensuring its access to global commons requires investments in maritime, space and cyber, including civil-military exercises, protecting maritime infrastructure[161], and building further capacities in line with such a shared vision. Reinforcing Europe's ability to build strategic alliances is also critical to addressing threats to the EU's geopolitical positioning and space infrastructure[162], as well as to deter un-attributable attacks, which are the hallmark of hybrid warfare[163]. Finally, such a vision is key for the EU to invest in strategic alliances on security and defence and being clear on what it wants to achieve with specific partners[164].

TECHNOLOGY



Technology

Technological sovereignty is at the heart of the EU's debate on open strategic autonomy. The notion of 'technological sovereignty' has emerged as a means of promoting the notion of European leadership and open strategic autonomy in the digital field. It is mostly oriented towards R&I and the development of digital technologies with the goal to be at the forefront. In this context, 'digital sovereignty' refers to the EU's ability to act independently in the digital world and being conducive to foster digital innovation. In this very dynamic field, current strengths and weaknesses overlap with future opportunities and challenges. This section provides a short summary of the EU's strengths, weaknesses, challenges and opportunities infographic below and then discusses each of them in detail.

AREAS FOR IMPROVEMENTS

- Digital infrastructure and platforms (e.g. cloud computing infrastructures and video-conference platforms)
- Technology transfer
- Enhancement of technological edge and support for its industrial base, as R&D performance shifts to Asia
- Digital race in which Europe is behind China and the US

EXISTING STRENGTHS

- Research and innovation
- Technology standardisation and regulation that align with EU values and fundamental rights.
- Robotics

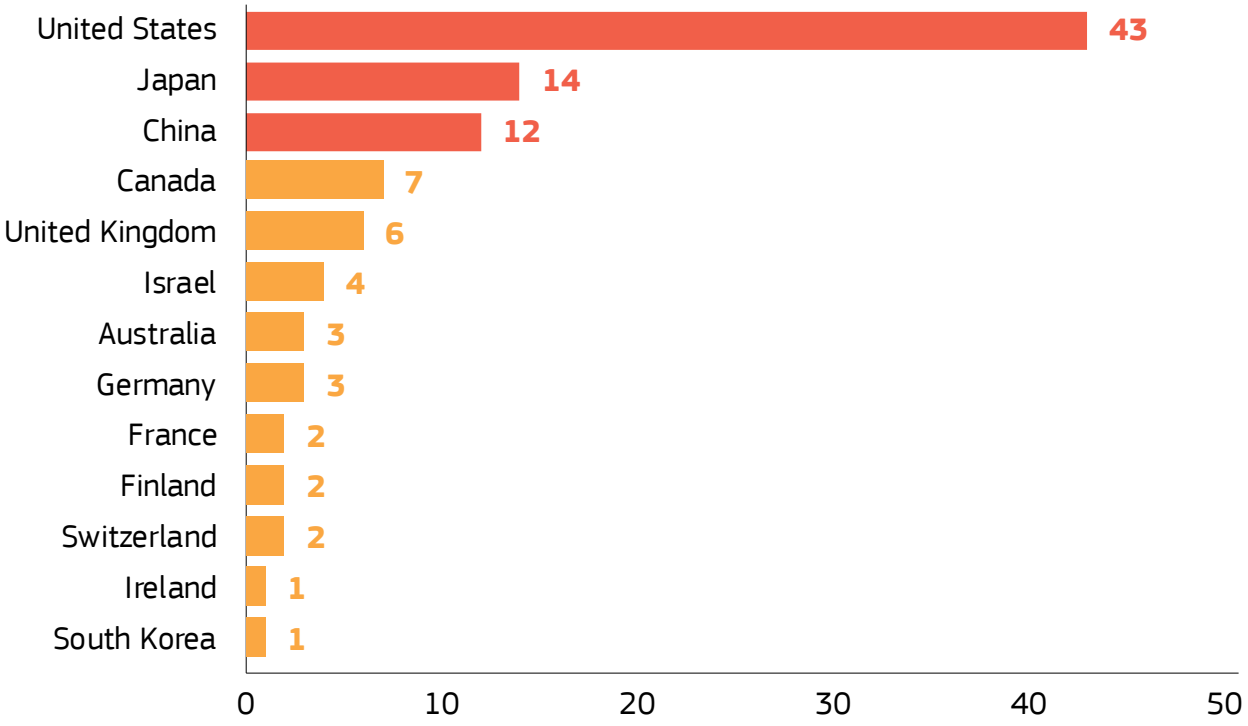
EMERGING CHALLENGES

- Hyperconnectivity driving industry convergence is intensifying global competition and posing a challenge for Europe
- Societal and ethical challenges are being brought forward, including fairness and bias in machine learning, human dignity and autonomy, impact on humans via recommendations and nudging, safety and liability .
- Attracting talent and preventing brain drain through encouraging and investing in research and innovation

OPPORTUNITIES FOR EU'S OSA

- Open source and open standards as an opportunity to lead the development of digital technologies and to create and maintain its own, independent digital approach and stay in control of its processes, its information and its technology
- Targeted investments in edge computing, digital technologies and infrastructure to ensure having EU fundamental rights and values embedded in technologies
- Better quality and efficiency of public services available to all citizens
- Digital innovation and deep tech for the development of cutting-edge technologies

Figure 7. Leading 100 companies filling quantum computing patent applications in 2020



Source: statista

Current strengths and weaknesses

Digital Race and Investment in Research and Innovation

The EU has been traditionally strong in industrial research and development (R&D). The investment in technological R&D in the EU has been increasing for 10 years consecutively[165]. EU companies increased R&D by 5.6% in 2019. This growth is driven by the automobile, ICT and health sectors. Two EU economies (Germany and France) were among the top five R&D performers within OECD countries in 2019. While the EU has strong capacities in research, the translation of research outputs into the economy and European industry need to be strengthened, to meet its goal of increasing competitiveness. As detailed in the European Commission's Industrial strategy, this could be achieved through Common Industrial Technology Roadmaps. These roadmaps will link EU and national support programmes, allow for cutting-edge research and innovation, create synergies between research and industry and strengthen EU industrial ecosystems[166].

The EU has a strong tradition in quantum research, which began with the creation of quantum physics in the first decades of the twentieth century. Current and future uses of quantum technology[167] include building a functioning quantum computer, developing ultra-secure communication systems, or making major advances in quantum-sensing technologies. Its market size is estimated to reach 6 billion euro globally by 2027[168]. Currently, there is a global race to create and conquer the market of key quantum technologies of the future, led by the US, Japan and China. For example, the US is investing more than EUR 1 billion in the period 2019 – 2028 and China is building a EUR 9 billion National Laboratory for Quantum Information Sciences[169]. Figure 7 gives an overview of the filled quantum computing patent applications in 2020.

The European Commission has launched Quantum Technologies Flagship Initiative. Its aim is to address some of the unsolvable research challenges so far (for example, developing ultra-secure communication systems or making major advances in quantum sensing technologies) and create world-leading knowledge-based industry in Europe. This initiative,

launched in 2018 provides more than €1 billion in funding for the technology to ensure its potential is fully exploited, with €152 million invested in the period 2018-2021[170].

EU Member States are also investing separately in quantum computing[171]. For example, in June 2021, Germany launched its first quantum computer jointly produced by IBM and Fraunhofer Gesellschaft[172].

Quantum computing and its potential are attracting top IT companies[173]. The US's IBM and Microsoft lead in the number of patents related to hardware and software in quantum computing. Japanese Toshiba and Chinese Huawei, together with Chinese State Grid Corporation and Hengtong group lead in the number of patents in quantum communication and cryptography.[174] Through a coordinated effort between European research programs, the EU Member States and the private sector, the EU aims to develop a so-called quantum web, where quantum computers, simulators and sensors are interconnected via quantum communication networks with the goal to strengthen its technological sovereignty.

European industries can increase their global technological leadership though public and private investment in R&I. Private-public partnerships will be key for the future. While global corporate R&D continues to increase, many of the future R&I funding programmes for digital technologies will boost the green transformation and EU competitiveness. Synergies between relevant EU programmes can also help EU achieve its technological sovereignty, as well as spin-offs and spin-ins. Scaling up and transition from research to industry (tech transfer) is key for the EU to benefit from long-term systematic investment in quantum computing[175].

EU companies show a diversified and strong technological and industrial base[176]. However, the EU should keep investing in R&D so that it does not lose ground towards its competitors. The global concentration of R&D performance continues to shift from the US and EU to China, followed by other South Asian and East-Southeast Asian states, which collectively accounted for 42% of global R&D expenditures (up from 25% in 2000), higher than the United States (25%) and the EU (20%). With these regions continuing to record substantially faster-than-average R&D growth rates, this remaking of the global geography of R&D is unlikely to slow down soon[177].

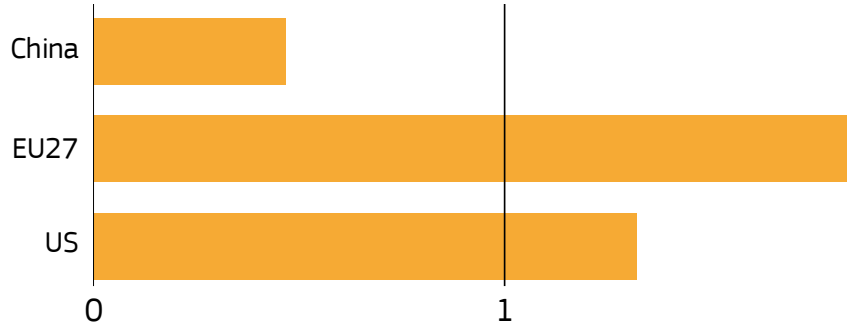
A sovereign EU Tech Fund has recently been proposed. Leaders of 32 EU 'unicorns' (i.e. start-ups worth over $1 billion) proposed that the European Commission come up with new European Moonshots, focused on software and hardware start-ups, deep tech and green tech start-ups,[178] and co-create flagships that will lead to the rise of a European innovation ecosystem. This would further secure EU innovation and technological leadership on a global scale. They also proposed a technological sovereignty fund worth EUR 100 billion for the EU to keep pace with other countries in the digital race. The fund would be based on a long-term, equity-based focus.

Robotics and automation

The rapid increase in the use of robots in our homes and at work, in hospitals and industrial environments, shows that this technology is and will remain an important element of current and future European society. The robotics market is increasingly driven by the development of novel and improved products in areas such as manufacturing, search, rescue and retrieval, inspection and monitoring, surgery and healthcare, homes and cars, transport and logistics, agriculture, and many more[179]. Applications of robotics include health, ageing population, environment, security, service markets, ICT, automotive and other sectors with automated production.

Europe is strong in the area of robotics. It holds a comparative advantage in comparison with other world regions. The EU produces "more than a quarter of the world's industrial and professional service robots (e.g. for precision farming, security, health, logistics)"[180]. The European robotics research excellence is the payback from the allocation of 700€ million for research up to 2020, through the Robotics Public Private Partnership (SPARC, the partnership for robotics in EU), and further private investments that reach 2.8€ billion in total[181].

Figure 8. The Revealed Comparative Advantage indicator[182]: EU specialisation in the area of Robotics, in comparison with the world average specialisation in that area[183]



Values above 1 indicate that a country is relatively specialised in this topic and has a revealed comparative advantage

EU setting rules and standards in digital technologies

Digital standardisation is key to leveraging the EU's ability for leadership in digital technologies, or in the digital domain. This is important in order to shape the global digital economy and ensure the safety and reliability of AI systems for the future. In this area, US leadership is being increasingly challenged by China (in AI) and by the EU (data privacy).

Governance, regulation and standardisation of digital technologies will be a critical factor to maximise digital opportunities, while reducing the challenges or threats[184] that they pose in parallel. This requires careful and innovative forms of regulation that do not stifle, but steer innovation. The EU needs to both generate innovation and frame technological applications in accordance with its economic and social model and its values. This is the foundation that will carry more weight in multilateral efforts to regulate new technologies. Through responsible governance, citizens' rights and freedoms will be protected. The translation of values and norms into the design and operation of AI systems (i.e. "privacy by design") should be a part of regulatory frameworks. Next to regulation, the setting and defining of standards is needed to verify, validate and monitor AI systems and assess long-term ethical implications[185].

The EU's Digital Strategy highlights the importance of setting rules and standards that align with EU values. The Strategy includes two important legislative proposals: the AI Act and Data Governance Act. The AI Act is based on the need for EU to ensure the development of secure, trustworthy and ethical AI as a tool for people and for increasing human well-being. The legislation will ensure a well-functioning internal market, while assessing both potential benefits and risks[186]. The Data Governance Act recently proposed by the European Commission will continue to support the establishment of common European data spaces that comply with fundamental rights.

Through the involvement in the World Trade Organisation Joint Statement initiative negotiations on e-commerce, the EU is engaged in shaping global rules on digital trade[187]. The EU's General Data Protection Regulation has also shown the potential of the EU to set global standards in the area of digital technologies. In fact, since its implementation in 2018, it has been already used as a model for privacy legislation across the world.

Open and multilateral technological standards are needed. The EU is working on implementing technical standards worldwide for the deployment of AI systems that are compliant with new EU regulations. It is important to have diverse stakeholders working on setting such standards in a number of areas, such as training of data, record keeping, information provision, transparency[188]. It is crucial that the EU ensures its values and ethical guidelines are taken into account in international AI standardisation[189].

It is essential for Europe to ensure information systems interoperability through standardisation. Standardisation is among the 'key interoperability enablers', necessary for the efficient and effective delivery of public services across EU administrations[190]. Interoperability is key for making maximum use of data and it is placed at heart of the European digital strategy[191]. A reinforced interoperability strategy between EU governments has been scheduled for the end of 2021. It will ensure coordination and set common standards for secure and borderless public sector data flows and services. Such standardisation will allow for the de-

ployment of interoperable technologies respecting EU's rules. It will promote EU's approach and interests on the global stage. Without interoperability, the EU will miss the opportunity to lead the global digital technologies' market.

Technological standards could also play a significant role in the development of industry 5.0. Industry 5.0 complements the existing Industry 4.0 'techno-economic vision' and approach of the Commission. The goal of industry 5.0[192] is to use research and innovation to build a more sustainable, human-centric and resilient industry. It goes beyond digitalisation for profit (industry 4.0) and points to the need to achieve benefits for all of society and to reduce generational and digitalisation divides and respect planetary boundaries. This could contribute to a more environmentally friendly, efficient industry, including in the ICT sector, as well as to the wellbeing of workers - who industry 5.0 puts at the centre of the production process.

Future opportunities and challenges

Open source software

Open source software has the potential to become an important element of the EU's technological landscape. Open source software is computer code that is made publicly accessible by design. The Open Source Software Strategy (2020-2023) of the European Commission serves as a tool to achieve digital transformation[193]. There are four main advantages of open source technologies:

1. innovation (based on the decentralised process of code production and the large community of developers that contribute to it);
2. transparency (offering the possibility to update and modify source code, or test for relevance for other use);
3. lower cost (free download and less costly); and
4. longevity (it has higher chances not to be abandoned and instead to be taken over by the community to ensure its relevance for future applications)[194].

Open source has been providing a significant economic impact to the EU's GDP. The economic impact of Open Source Software on the EU economy was estimated to be between EUR 65 and EUR 95 billion in 2018. A 10% increase of code contributions would generate around EUR 100 billion in additional EU GDP per year and around 1,000 more ICT start-ups per year in the EU[195]. Boosting its uptake is key for availing of the large opportunities that it can provide.

Open source software provides an opportunity for the EU to lead the development of digital technologies. It can contribute strongly towards European digital sovereignty (i.e. EU's ability to act independently in the digital world)[196]. Open source can give EU a chance to create and maintain its own, independent digital approach and stay in control of its processes, its information and its technology[197]. This is because it enables incremental innovation and technical solutions through the sharing of knowledge and skills, the use and reuse of software by small enterprises, thus increasing security and avoiding vendor lock-in.

The convergence of open source with AI has a high innovation potential. This could be important for both the public and private sectors. In the context of open government and open data, it could stimulate economic activities. The open data market size is estimated at €184 billion and forecasted to reach between €199.51 and €334.21 billion in 2025[198]. At the same time, it can lead to enhanced transparency and trust by citizens. European governments have affirmed the importance of open source software in public sector works, by incorporating it in their political and legal frameworks (24 out of 27 EU MS), as a part of broader digitalisation initiatives[199]. However, for the moment, many open-source projects have been funded and sustained by some of the US digital giant companies, such as Microsoft, Google, Facebook, Apple[200].

There are several key benefits of open source investments related to European digital sovereignty. They include improved access to source code, supporting open standards and consequently interoperability, labour saving costs and independence from proprietary providers of software[201]. The Berlin declaration signed in December 2020

reaffirms open source software as a facilitator for deploying digital tools and capacities in the public sector as well as interoperability[202]. In connection to the use of open source, legal, technical, risk management and ethical challenges need to be taken into account as well[203].

Open source software is not the same as open standards. Open standards are a set or a framework "of specification that has been approved by a recognized organization"[204]. Open standards have many benefits, including interoperability of different technology systems (that sustains the growth of software and hardware industries), enhanced data exchange, better data protection, fostering innovation (by providing a technological base) and transparency, ensuring economic growth[205].

Open source software combined with open standards can produce social and economic benefits. Open source developers have the preference to use open standards. Open source software can support market adoption of open standards. At the same time, the transparency on which open source software is based can improve trust in interoperability[206].

Accelerating digital transformation

The acceleration of the digital transformation will profoundly affect economics, politics, security and international affairs in the coming decades. The mainstreaming of digital technologies and AI will boost economic growth but also favour some countries and regions over others. Through impacting a range of sectors and services, AI could boost global GDP by 14%, or EUR 13 trillion by 2030, with the biggest gains in China (+26%) and North America (+14.5%), whereas EU's GDP would be increased by between 10 and 11%[207]. Additional potential for savings has been estimated. For example, e-Health solutions could bring savings, while increasing the quality of and access to healthcare[208].

The majority of firms will have adopted three key digital technologies by 2030. These are big data analytics, Internet of Things (IoT), and AI (machine learning)[209]. This could lead to increased productivity worldwide. In the EU, it is expected that the cumulative additional GDP contribution of new digital technologies could amount to €2.2 trillion in the EU, which represents an increase of 14.1% compared to 2017[210]. The increasingly strategic use of AI in the public and private sectors, including in the functioning of key public services, highlights the importance of factoring in AI and related technologies (or their potential) in critical industries and in green and digital transitions[211]. In the case of IoT[212], there is often the need to introduce edge computing architectures. An effective implementation of AI includes reinforced connectivity through radio spectrum coordination, 5G mobile networks and optical fibres, next generation clouds, satellite and cybersecurity technologies.

Raising the investment level of private and public actors in digital technologies will be essential to support innovation. The EU and Member States will need to contribute about €75 billion per year for ICT investment in the next decade[213]. AI attracts rapidly growing investments, with global spending expected to jump from EUR 31 billion in 2019 to about EUR 81 billion in 2023[214].

The new initiative "Digital compass"[215] identifies main goals that Europe should reach in order to achieve the EU's vision for digital future that empowers people and businesses. These goals include digitally skilled population and professionals, secure infrastructures, digital transformation of businesses and digitalisation of public services. The Compass will be aligned with the newly created JRC Digital Resilience Dashboard[216].

Europe will reinforce its innovation capacity through technologies at the interface between defence, space and civil uses, such as cloud, processors, cyber, quantum and artificial intelligence. The Commission's Action Plan on synergies between civil, defence and space industries[217] is an important step to ensure that EU will have the necessary capabilities to enhance both its own resilience and innovation. The goal for the Action Plan, together with the European Defence Fund is to further enhance EU's technological edge and support its industrial base.

Europe needs to invest in developing its own capacities in areas such as 5G and 6G, supercomputing, edge computing, and cloud infrastructure. A foundation for an open data infrastructure, based on European values and characterised by openness, transparency and connection between EU Member States is needed. Several promising European start-ups and

scale-ups (e.g. Livestorm, Hopin, Wonder, Teooh, Whereby) are already working on the development of such platforms[218].

Edge computing[219] can offer solutions that are secure and distributed at or near the edge of a computing network. The increasing number of IoT devices, that is doubling every five years, creates cyber-security risks[220]. Together with the growth of the use of cloud computing (which had been 'exploding' and which has grown even more due to the COVID-19 pandemic), common solutions are needed in the form of hyperscale cloud providers that can develop solutions to distribute their cloud capabilities closer to the edge. However, it is estimated that by the end of 2023, only 20% of edge computing platforms will be managed by hyperscale cloud providers, (compared to less than 1% in 2020)[221].

Europe needs scalable computing infrastructures. Data virtualisation[222] and cloud computing tools and services that can manage and analyse big data in short amounts of time, are a growing market currently dominated by US companies (Google cloud, AWS, IBM cloud, Microsoft Azure). With the rising number of connected devices in the Internet of Things, it is estimated that 80% of data will be processed close to the user, in edge computing.

Europe's reliance on the digital infrastructure and economy during the COVID-19 pandemic highlighted the need for sustained investments and domestic capabilities that can increase its strategic autonomy. The pandemic has shown the fundamental value of digital collaborative and communication platforms for social welfare, work, education, communication, as well as the functioning of the economy. The lack of a European collaborative platform and the dependency on non-European platforms meant that citizens had to rely on foreign platforms and had to share data with them. This pointed to gaps in European technological sovereignty[223]. This influence of non-EU tech companies has become a concern for EU policy-makers, especially with regard to their impact on EU privacy and data protection and on the establishment of a secure and safe digital environment, but also with regard to the EU's data economy and innovation potential.

Cloud and edge computing can contribute to the increase of Europe's data sovereignty[224]. Europe can profit from the creation of synergies and European networks. A European Alliance on Industrial Data, Edge and Cloud will enable the development of Joint investments in cross-border cloud infrastructures and services to build the next generation cloud supply; European marketplaces for cloud services, EU Cloud Rulebook for cloud services. They will ensure that EU's standards, rules, and best practices for cloud and edge computing use are applied. Cloud computing and edge computing could contribute to achieving the sustainability goals of the European Green Deal (e.g. in farming, mobility, buildings and manufacturing). Alongside regulation, investing in edge computing is key for the EU.

Key Digital Technologies

The EU is currently heavily reliant on core and fundamental technologies sourced from outside its borders. The EU is lagging behind on crucial technological infrastructure such as semiconductors and superfast telecoms networks. Reasserting its computing power, having control over data, and securing connectivity are key for technological sovereignty of the EU. This can be achieved for example, by doubling semiconductor chip production in the EU, providing safe data storage and robust internet platforms.

Key Digital Technologies are electronic and photonic components, and the software that defines how they work in a system. They underpin all digital systems including AI and the IoT. One of the main drivers towards EU's digital sovereignty will be its capacity to produce high-quality microelectronics[225].

Chip shortages that occurred during COVID-19 revealed Europe's dependence in the area of semiconductors. The EU is supporting the global efforts of the G20 and WTO to monitor and keep critical supply chains open, while trying to increase and enhance its resilience and the sustainability of supply chains. Open source chips, as one of the most advanced areas of the open source hardware, could be beneficial for different European industry sectors, such as the automotive industry, edge computing, data storage solutions, aerospace, energy and health[226].

The newly launched Key Digital Technologies partnership on microelectronics will support the digital transformation of all economic and societal sectors[227]. This partnership contributes to the supply of clean, affordable and secure energy, resource-efficient buildings, sustainable and smart mobility, as well as healthy and environment-friendly food supply chains

- that could support the European Green Deal. Semiconductor chips, in particular processors, are of growing importance in data processing for data infrastructure and communication, high-end and general purpose computing and future applications such as autonomous driving[228].

Expanding digital connectivity

It is estimated that the number of connected devices globally might increase from 30.4 billion in 2020 to 200 billion in 2030[229]. Hyper-connectivity is driving an increased convergence of industries, products, technologies and services. High-performance computing (HPC) and AI will increasingly converge with new computing, storage and communication technologies.

High Performance Computing has been identified as a strategic investment priority to underpin the EU's digital strategy, from big data analytics and AI to cloud and cybersecurity. In order to strengthen HPC innovation capabilities and supercomputing capacity, the European Commission has proposed a budget of over €8 billion through a HPC Joint Undertaking in the period 2021-2033[230]. This will come from Horizon Europe, Digital Europe programmes, Connecting Europe Facility as well as participating Member States and private partners.

Next generation mobile network technologies is a key enabler for the industrial internet of things. Fast connectivity based on 5G and successors is an opportunity for technology leap in numerous industries from remote robotic surgery, autonomous mobility, precision farming and livestock management. Secure real-time connection to central cloud servers enable smart process management onsite and in mobile applications[231]. 5G satellites enable wide area digital high speed connectivity; they allow provision of smart services, beyond densely populated urban areas[232]. Combinations of ubiquitous network and high performance computing technology will create a transformative potential for society, in areas such as virtual education, remote work, access to health care in rural areas[233].

One of the challenges for the EU is industry convergence that represents a growth opportunity for foreign digital giants. Global firms active in digital markets are merging or making acquisitions to bridge into often-unrelated markets, disrupting the industry and society[234]. This gives rise to powerful global operators such as Alibaba, Alphabet, Amazon, Facebook, Tencent. For example, Alphabet acquired more than 200 companies, among others: YouTube (acquired in 2006); Motorola (acquired in 2011); Deep Mind Technologies (acquired in 2014); and FitBit (acquired in 2021).

The alliance of global corporate players is intensifying global competition. In order to prevent potential harmful effects on competition (as some mergers can reduce competition), the EU Merger Regulation[235] provides the regulatory framework for the assessment, review and approval of mergers, acquisitions and joint ventures in the EU. Some of the previous examples that were assessed by the European Commission are the review of Microsoft-Skype (in 2011), Microsoft-Linkedin (in 2016), and more recently Google-Fitbit (in 2020) acquisitions (under its umbrella company Alphabet). A reform of the Merger Regulation started in 2021. This will be especially important for digital sector and start-up acquisitions[236]. In parallel, the US Federal Trade Commission is expected to reform its approach to antitrust, through expansion of antitrust enforcement that will impact digital giants in the US[237].

The use of non-European data services poses a concern for European industries. GAIA-X, a network of cloud computing and data services, will try to challenge and provide an alternative to the dominance of big tech companies. It is developed under the EU legislation, thus implementing privacy by design (as a legal requirement of the GDPR). Through collaboration between business (more than 100 European companies), science and politics on the European level and beyond, the goal of this next generation open source data infrastructure will be to provide "a secure, federated system with highest standards of digital sovereignty while promoting innovation"[238]. This would be a foundation of an EU-wide interconnected open data infrastructure, based on European values and law. Therefore it is important to ensure that two of its seven key principles, *digital sovereignty and self-determination* and *free market access and European value creation* remain priorities for this initiative[239]. The first GAIA-X services are expected by the end of 2021[240].

Deepening impact of AI in society

The digitalisation and automation of a number of tasks will carry far-reaching implications for European societies. It will affect the workforce in terms of jobs lost, requirements for (re)training and potentially widening inequalities within societies[241]. Estimates differ widely, but between 75 and 375 million workers world-

wide may need to change their occupation between 2016 and 2030[242]. The reallocation process for workers to find new jobs might be a longer process calls for respective social policies[243]. Before the COVID-19 pandemic, it was estimated that around 14% of EU workers could face a risk of job loss due to automation[244]. This has been further accentuated since the pandemic. However, re-training and education might counteract automation displacement. The societal aspect of frictions in individual careers also affects the intrinsic value of jobs, like meaning, dignity and fulfilment[245]. This calls for a broader response beyond education and training. While activities using manual, physical or basic cognitive skills will decline, activities that require technological skills as well as socio-emotional skills will increase[246].

The full extent of social and ethical impact of AI is still uncertain. With the increased use of digital technologies, it is crucial to consider social and ethical challenges that could emerge from their use. These include issues regarding fairness and bias in machine learning, human dignity and autonomy, impact on humans via recommendations and nudging, safety and liability[247]. While digital technologies such as AI can be a driver of progress, they can also lead to discriminations, increase illegal hate speech, digital surveillance, or the vulnerabilities of certain societal groups[248]. For example, the emergence of emotion AI, i.e. 'affect recognition technology'[249] based on facial recognition looks at micro-expressions i.e. what people say, how they say it and what expressions they make. This technology is receiving attention in job interviews, criminal suspect examinations, or for setting insurance prices, and it could lead to biases. Racial biases have been noticed[250], but also biases in hiring, and in pain assessment[251]. Similarly, in connection to the use of citizens' data with data analytics used as a basis for behavioural targeting and personalised advertising, some organisations are proposing a right "not to be measured, analysed or coached"[252].

This is why it is important to ensure that human rights and the freedoms of people are respected while they use AI. Despite many known issues regarding fairness, accountability, transparency and ethical biases that are built into them, the competition for global leadership means that these technologies may be implemented faster than expected (and faster than regulation can keep up).

The advancements in a 'smarter' digitally connected society pose further human rights issues that go beyond privacy as well as cybersecurity threats. This is especially important for the second generation of IoT, where borders between the physical and virtual worlds become blurred. These devices can take autonomous decisions beyond just collecting data. It presents both challenges and opportunities for the future. For example, digital technologies drive a transformation of city infrastructures into "smart" cities, modelled in digital twins, to become more user-driven and demand focused[253]. The applications go beyond optimisation of smart buildings, autonomous mobility, energy infrastructure[254], etc., to the internet of the body, where medical implants (such as pacemaker, cochlear implants or in the future digestible pills and brain computer interfaces) communicate to central cloud[255].

Europe could further attract talent and prevent brain drain through support to deep tech start-ups.

The creation of a European data space will contribute to ensure a better availability and management of data for all. The European data strategy and the proposed European data act lays down a path towards the creation of European data spaces to ensure that more data becomes available for use in the economy and society, while keeping companies and individuals in control of their data. This can benefit citizens and businesses through for example: improving healthcare, creating new products and services, or providing public services that are more efficient[256].

A common EU approach and action on AI ethics would be beneficial for all EU economic sectors. It is estimated that a common EU approach to ethical aspects of AI has the potential to generate between

€221.8 and 294.9 billion in additional GDP and 3.3 to 4.6 million additional jobs for the European Union by 2030[257].

Digital technology, including AI, could bring innovation opportunities into the public sector, improve interaction between government and citizens through the simplification of procedures and contribute to open government[258]. The full digitalisation of public services will become common in digitally advanced future societies. At the core of the Commission's e-government Action Plan is the development of cross-border digital public services[259].

Digital Innovation Hubs and smart specialisation

The EU is not as strong as the US or China in the digital sector. Despite ranking in the top three, the EU has a smaller digital proportion of ICT sector[260] (1.7 % of GDP), compared to China (2.1%) and the US (3.3%). A recent European Investment Bank report[261] indicates that established EU firms are weaker than their US counterparts. They lag behind in adopting digital technologies, particularly in the Internet of Things and the construction sector. In the latter, the gap is significant with the share of digital firms standing at 40% compared to 61% in the US. The adoption rates of digital technology differ between EU and US firms also in service (13%) and infrastructure sectors (11%).

As critical sources of innovation, small and medium size enterprises (SMEs) are considered to have a central role in the digital transformation. However, before the COVID-19 pandemic, it was estimated that 90% of European SMEs are not taking full advantage of digitalisation opportunities[262].

COVID-19 stressed the important role of Digital Innovation Hubs (DIHs)[263]. Hubs are 'one-stop shops' that help companies with aspects of the digital transformation. A research and technology organisation, or a university lab is at the core of the hub, in collaboration with other partners. In this way, SMEs can benefit from artificial intelligence, digital skills and cybersecurity.

Digital innovation hubs help companies to become more competitive through experimentation and testing. They can give quick and easy access to technological infrastructures for experimentation and testing with new digital technologies, such as AI, High Performance Computing, Cybersecurity, Blockchain, Photonics, 3D printing. This allows an understanding of the future opportunities and return on investments for companies (in relation to digitalisation options for their business).

They can also provide financial advice and training. In this way, they help to accelerate the digital transformation of the economy and society throughout the EU, helping to overcome the possible negative consequences of the COVID-19 crisis and strengthen innovation ecosystems. For example, boot camps, traineeships, exchange of curricula and training material can be organised. Digital innovation hubs can also support organisations to find investments. New business models and innovative products, as well as ways of work, will be needed for the future. For example, adopting data-driven business models and solutions that protect against cyber threats are among the most important.

Several issues are key for innovative and smart economic transition. These are: enhancing R&I capacities, harvesting digitalisation benefits, supporting growth and competitiveness of SMEs, and developing skills for smart specialisation. The European Commission smart specialisation strategy[264] in the period 2021-2027 includes among others: analysis of bottlenecks for innovation diffusion and digitalisation, improvement of national or regional research and innovation systems, as well as managing industrial transition and its impacts. Digital innovation is one of the smart specialisation priorities[265]. Boosting digitalisation will help implement smart specialisation strategies and boost SMEs' innovation capacities.[266]

European Digital Innovation Hubs will be funded through a newly established Digital Europe Programme[267]. The newly established programme will support projects through funding in five key capacity areas: supercomputing, artificial intelligence, cybersecurity, advanced digital skills, and ensuring a wide use of digital technologies across the economy and society, including through Digital Innovation Hubs. It isestimated that by 2023, EUR 310 million will be injected into Digital Innovation Hubs that will offer local support to SMEs for their digital transformation and access to technology testing[268]. By then, three out of four companies should use cloud computing services, big data and Artificial Intelligence and more than 90% SMEs should reach at least basic level of digital intensity[269].

Key Enabling Technologies

The European Commission identified several technologies as strategic for the EU's industrial future, with the possibility to impact both the econ-

omy and society. Key Enabling Technologies (KETs)[270] will allow European industries to remain competitive and capitalise on new markets. Some of the prioritised KETs[271] are: advanced manufacturing, advanced materials, micro/nano-electronics and photonics, artificial intelligence and cybersecurity.

KETs drive innovation with a trend towards full convergence and integration of industries. They sustain EU's leadership across industrial value chains and have the capacity to contribute to improvement of people's health and safety, and reversing climate change[272].

KETs have been financed through several EU research framework programmes. For example, they are financed through Horizon Europe, the EU's R&I programme for the period 2021-2027. They were also funded in Horizon 2020, the previous programme with nearly €80 billion of public funding dispersed over seven years (2014-2020). Other instruments, such as the 5G-PPP, a new AI and Blockchain Investment Fund, and a large-scale research initiative to foster the development of a competitive quantum industry in the EU, is supporting companies working in the AI and blockchain sectors[273].

Blockchain

The EU wants to strengthen its position in blockchain and distributed ledgers technologies (DLTs). Blockchain has the potential to revolutionise the way we share information and carry out transactions online. However, there are still several unresolved issues including high-energy consumption, protection of personal data, scalability and performance, as well as interoperability[274]. Although environmental concerns around bitcoin[275] have been raised, it is believed that blockchain will lead the way to a sustainable global economy[276].

The goal of the EU's strategy on blockchain is to build a more secure online environment for EU citizens and businesses. The application of blockchain is seen in spaces such as financial inclusion[277], fair supply chains, energy and environment, identities and vulnerable populations, or skills and education. It often leads to blurring the boundaries and enhancing collaborations between public, private and third sectors[278].

The European Commission wants to support blockchain and DLTs that embrace European values and the EU legal and regulatory framework[279]. Particular standards that are required include environmental sustainability, data protection, enhanced e-identity framework, provision of cybersecurity and interoperability. EU research funding, blockchain investment fund and start-up support help European innovation that implements and materialises the EU standards for blockchain.

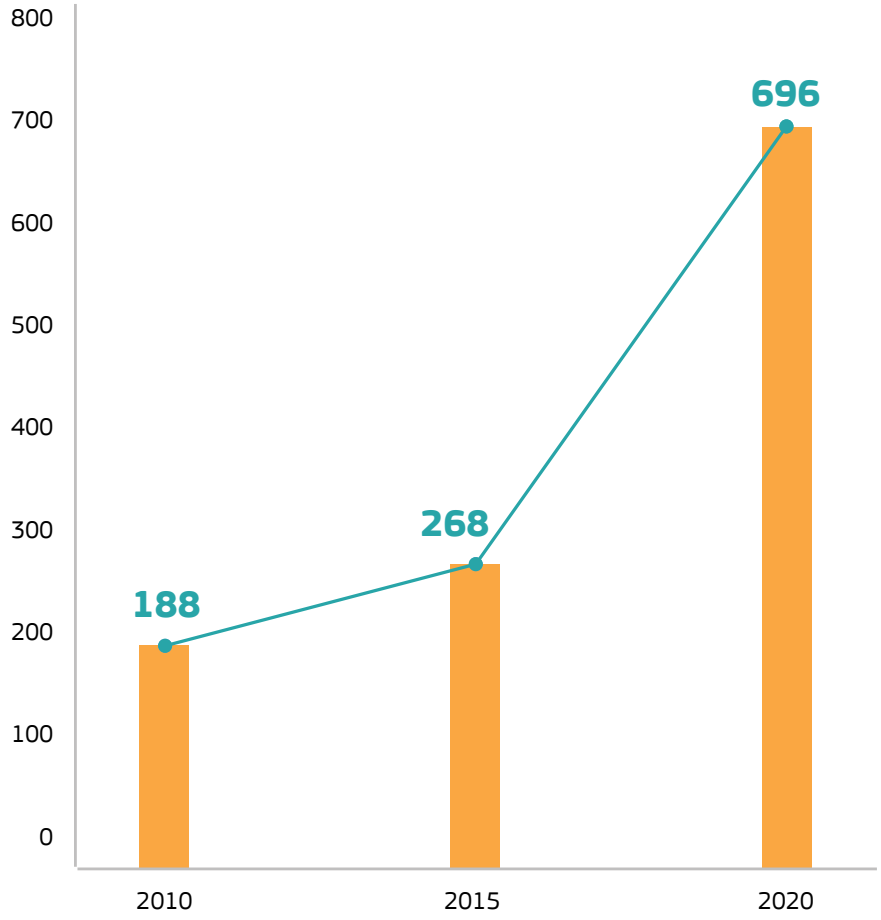
European Blockchain Services Infrastructure is the first EU-wide blockchain infrastructure and was built through the European Blockchain Partnership. **Its goal is to leverage blockchain for the creation of cross-border services for public administrations. Consequently, their ecosystems could be used to verify information and make them trustworthy and transparent**[280]. Similarly, the European Union's Blockchain Observatory has already discussed the benefits of establishing a blockchain-based digital identity system (to both secure and share data and records), as well as the digitisation of national currencies[281]. Blockchain-based central bank digital currencies could help overcome current vulnerabilities (e.g. enhancing security) and enable financial innovations and modernisation[282].

Deep technology

There is a new European vision aiming to support future excellent science and innovation, which consists of scaling up deep-tech start-ups. A deep tech is a company whose business model is based in engineering innovation, or significant scientific discovery, having both R&D risk and product-market risk. It spans across many technologies, e.g. AI, robotics, blockchain, advanced material science, photonics and electronics, biotech and quantum computing that are trying to solve some of the most pressing challenges such as food, health, energy, mobility[283]. Deep tech[284] is essential in innovation ecosystems. Several current tech giants either have emerged from deep tech or are currently doing deep tech. They propose revolutionary solutions to global problems, with the disruptive potential to create entirely new markets. However, these companies usually have a longer R&D cycle and need more time and more capital investment to develop, with many failing (especially if they do not receive funding on time). The value of European deep tech companies is almost €700 billion combined[285] and is raising steadily (Figure 9).

Many promising EU start-ups are being bought by foreign companies, or go public abroad[286]. The so-called "killer acquisitions" that occasionally occur could harm both innovation and competition. This happens when a company acquires "innovative targets solely to

Figure 9. Combined value (EUR billion) of European-founded Deep Tech companies.



Source: https://europeanstartups.co/uploaded/2021/01/EUST-Dealroom-Sifted-Deep-Tech-Jan-2021-1.pdf

discontinue the target's innovation projects and pre-empt future competition"[287]. It is important for the EU to encourage, stimulate and fund innovators, researchers and enterpreneurs. Based on this, innovation opportunities for industry in the EU will emerge[288].

A large number of European governments have included AI, quantum computing and cybersecurity among the prioritised fields for the future. For example, by June 2021, twenty Member States had published national AI strategies, while seven were in the final phase of drafting them[289]. Quantum computing and its use in cybersecurity (i.e. quantum cryptography) could play an important role in safeguarding critical and personal data[290]. With the COVID-19 pandemic, and the role of BioNTech in vaccine development, biotech start-ups found themselves in the spotlight. Europe's role in biotech is growing and European companies can play an important role in the future[291]. The big success of BioNTech highlights the need for long-term R&D and stronger EU capital markets[292]. BioNTech received EUR 9.8 million from EU funding between 2008 and 2018, while it was still in the development phase[293]. Alongside health-related companies, some other the key innovation domains are cybersecurity and climate change. Aligned with the EU policy agenda, these fields represent business and innovation opportunities[294].

Europe could further attract talent and prevent brain drain through support to deep tech start-ups. Scaling up in deep tech is key to translating the talent and innovation into economic growth of the regions of Europe and keep talent in European companies[295]. For the accelerated innovations, talent and skills are needed. Better connections between start-ups and different societal actors are also needed (such as investors, academia, policymakers, SMEs, citizens)[296]. As a part of this strategy, the European Commission recently announced a new initiative called 'Women TechEU' to support women leading deep tech start-ups in Europe, and to help grow their companies into tomorrow's deep tech champions[297].

Some deep tech start-ups are the so-called "unicorns". Unicorns are start-ups with a value over $ 1 billion[298]. Compared to the EU, the US and China are

leading considerably in the number of tech unicorns: the US has approximately 10 times more and China has approximately 5 times more tech unicorns.[299]. Increasing the number of unicorns in this area could better sustain the EU technology ecosystem and would create EU technology giants. One of the targets of Digital compass is for the EU to double the number of EU tech unicorns by 2030[300].

There is still much potential to be unlocked, especially as some start-ups work in a cross-disciplinary manner, which attracts different talent and investment in R&D cycles. Unequal regulations across Member States and a lack of clear focus in the innovation strategy impedes EU companies' development. Early support from governments and EU funds could help the EU ensure tech leadership in the future[301]. The newly established European Innovation Council provides a €10 billion budget for the period 2021-2027 for breakthrough technologies and game changing innovations and their scaling up. The EIC will support start-ups, SMEs and research teams developing high-risk, high-impact breakthrough innovation, especially those that contribute to the European Green Deal and the Recovery Plan for Europe[302].

Further developments in deep tech will be instrumental for the economy, but also society. Many enterpreneurs believe deep tech could help solve some of the challenges Europe faces today and in the future.[303] The unicorn leaders have recently proposed:

- sovereign EU Tech fund;
- provision of substantial funding for the procurement of innovative technologies;
- sovereign EU Green Tech fund;
- commitment to becoming fully carbon neutral by 2030;
- scaling up Important Projects of Common European Interest (IPCEI) framework for deep tech (e.g. quantum computing, 6G, and green hydrogen);
- upgrade of immigration process for talents through EU Blue Card 2.0;
- channelling the investment into EU small valleys of excellence, a pan-EU sandbox[304].

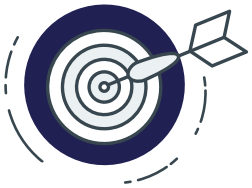
ECONOMY

Economy

This section describes the key elements that are shaping the economic dimension of the EU's open strategic autonomy, both in the present and towards 2040 and beyond. The infographic below depicts the EU's existing strengths that are key to addressing current weaknesses and vulnerabilities, upcoming challenges, as well as to seizing underlying opportunities; each of them are elaborated in more detail in this section. Briefly, Europe is building on its economic power in the single market, its regulatory power to balance interdependencies, but it has to deal with one-sided dependencies in several areas. To leverage the EU's global position, it has to strengthen the competitiveness of its economy, manage the green and digital transition, balance interdependencies, and grow its regulatory power and political influence to achieve a level playing field in global trade. At the same time, it has to strengthen institutional capacities to be able to act in a more fragmented global economy in the future.

AREAS FOR IMPROVEMENTS

- The EU needs to decrease its economic vulnerability due to one-sided supply chain dependencies
- The EU's competition policies need to balance one-sided economic dependencies
- The EU has to keep control on its key trade hubs to avoid one-sided dependencies of the Achilles heel of EU's gateways to global trade



EXISTING STRENGTHS

- EU's economic power and global interlinkages
- Global reach of EU economic policies to balance its open market against one-sided foreign dependencies
- Stable governance system and strong social pillar show resilience in crises, avoid disruptive shifts of economic interdependencies

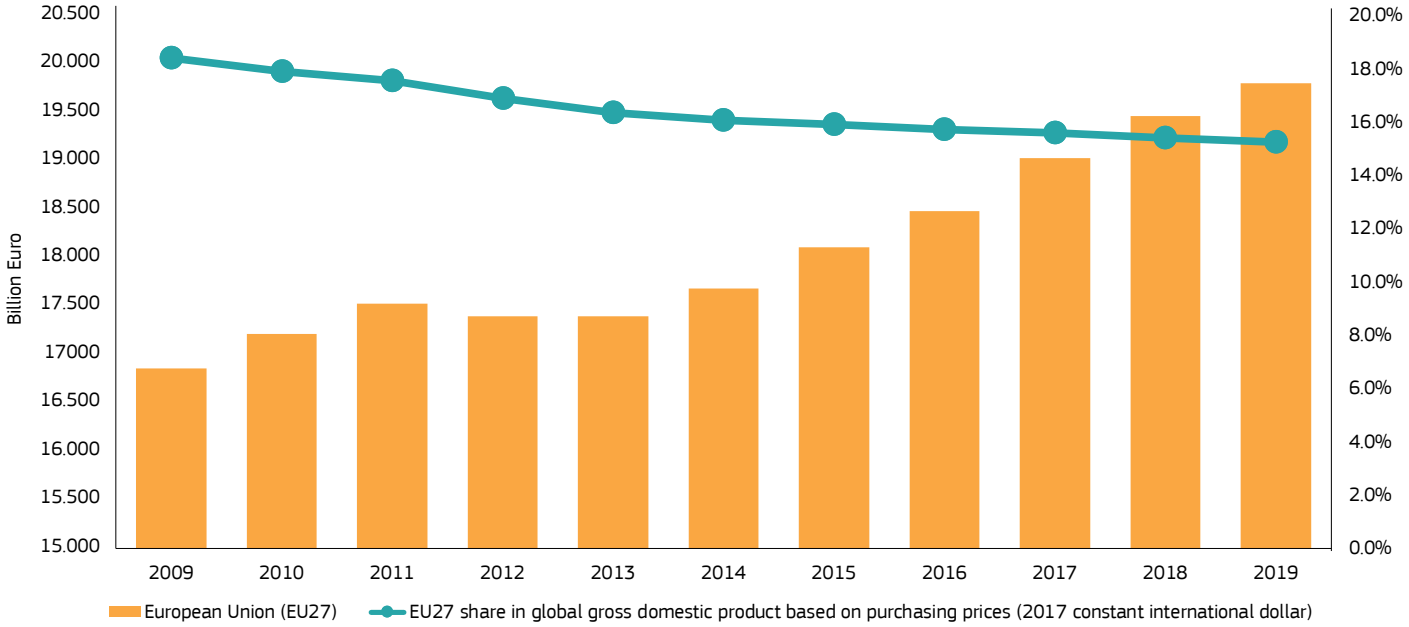
EMERGING CHALLENGES

- The EU's economy is expected to lose relative weight, as mainly Asian emerging economies are growing at higher speed; EU's market power is shrinking
- The competitiveness of Europe's economy is challenged; one-sided dependencies on foreign economies could grow
- Global debt is growing, limiting countries ability to act and growing increasing dependence on creditors

OPPORTUNITIES FOR EU'S OSA

- With growing risk of increasing fragmentation of the financial and monetary system, the euro could play a stronger international role, reducing one-side dependence on the US dollar
- A successful green and digital transition of the EU's economy reduces resource dependencies and prevents economic losses strengthening its market power

Figure 10: EU gross domestic product in purchasing power parity and its share of global gross domestic product (constant 2017 international dollar)



Source: World Bank (2021): World Development Indicators, database

Current strengths and weaknesses

The EU should be able to set objectives and mobilise the necessary resources without depending on the decisions and assets of others[305]. Europe wants to develop its economy in line with its interests and values, and to be able to deal with growing economic competition in a more volatile international system[306]. One-sided structural dependencies from foreign countries, or market actors, need to be avoided. The goal is twofold: to decrease asymmetric dependencies and enhance Europe's regulatory power. Leveraging the full potential of the Single Market, and achieving and enforcing a level playing field with other major economies are the essential steps to uphold Europe's competitiveness and sustain growth. By doing so the EU can preserve the economic power base that underpins its regulatory power and open strategic autonomy[307].

Key strengths of the EU with respect to open strategic autonomy are its market and regulatory power. Also, its good connections in the world and its ability to balance an open economy while upholding economic resilience and strategic autonomy. Key areas for improvements include increasing the resilience of global supply chains, adapting competition policy to global challenges, and keeping control of key hubs for trade to avoid foreign interference in the EU's global economic flows.

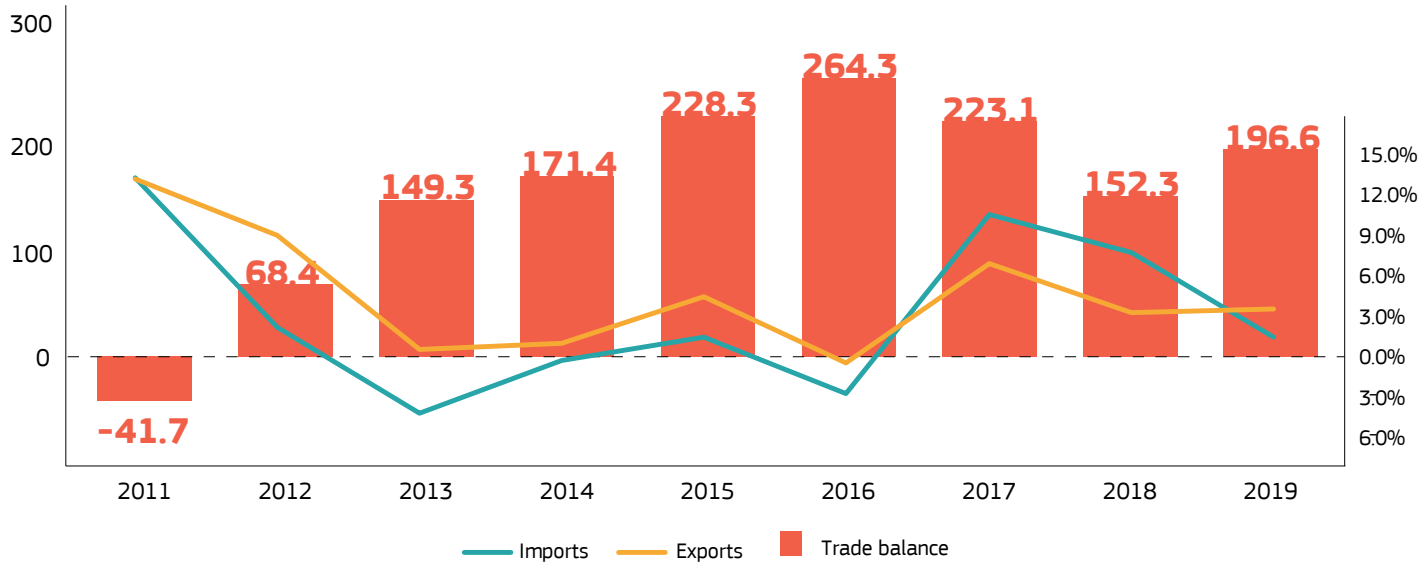
Europe's economic power and global interlinkage

The EU has a powerful economy with global influence. As the second largest world economy and the third largest in terms of purchasing power parity after China and the US, the EU wields significant economic power. The EU's GDP (13,900 billion euro in 2019) accounts for about one-sixth of the global economy at current price (see Figures 6). Figure 10 shows the evolution in purchasing power parity[308]. With over €3.1 trillion exports (i.e. 17.3% of the world share) and €2.8 trillion imports (i.e. 15.6%) of goods and services in 2019, the EU is the main partner in world trade for 74 countries, as compared to China (66) and the US (31)[309], as shown in Figure 11[310].

The Single Market is a strong pillar of Europe's economy. It is one of the key pillars of the European project, driving European integration, the EU's internal cohesion and external economic action. Being the world's largest single market area, it is under the top three largest economies, able to influence global prices and trade volumes. Intra-EU trade of goods is approximately 1.5 times higher than extra-EU trade[311]. The economic power of the European economy and its integration with a diversity of global partners are strongly needed[312] to advance in open strategic autonomy.

There is an added benefit to the diversity of European economies.

Figure 11: Annual growth rate of extra-EU trade in goods (in percentage) and trade balance (in billion euro)



EU's share of global trade considering the EU's share in world import and export markets, intra- EU trade (trade between EU Member States), the EU's main trading partners, and the EU's most widely traded product categories.

Source: JRC calculation based on Eurostat[313]

The diversity of EU Member States' economies with different sectoral foci and various international interdependencies (including the dominant intra-EU trade), makes the EU economy more resilient to international trade volatility. Europe is quite diverse between its North and South, West and East in terms of different economic structures and stages of economic development, with diversity in technological, commercial, financial and institutional environments[314]. Diversity provides a variety of regional specific competitive advantages in terms of labour costs, productivity, and specialised knowledge, which are thereby available in the Single Market along with the four fundamental freedoms of movement of goods, services, capital and people[315]. Europe has strength in economic autonomy in many areas that enables it to balance global interdependencies. However, diverging political and economic interests across Member States limit the political capacity to speak as one EU voice in multilateral settings.

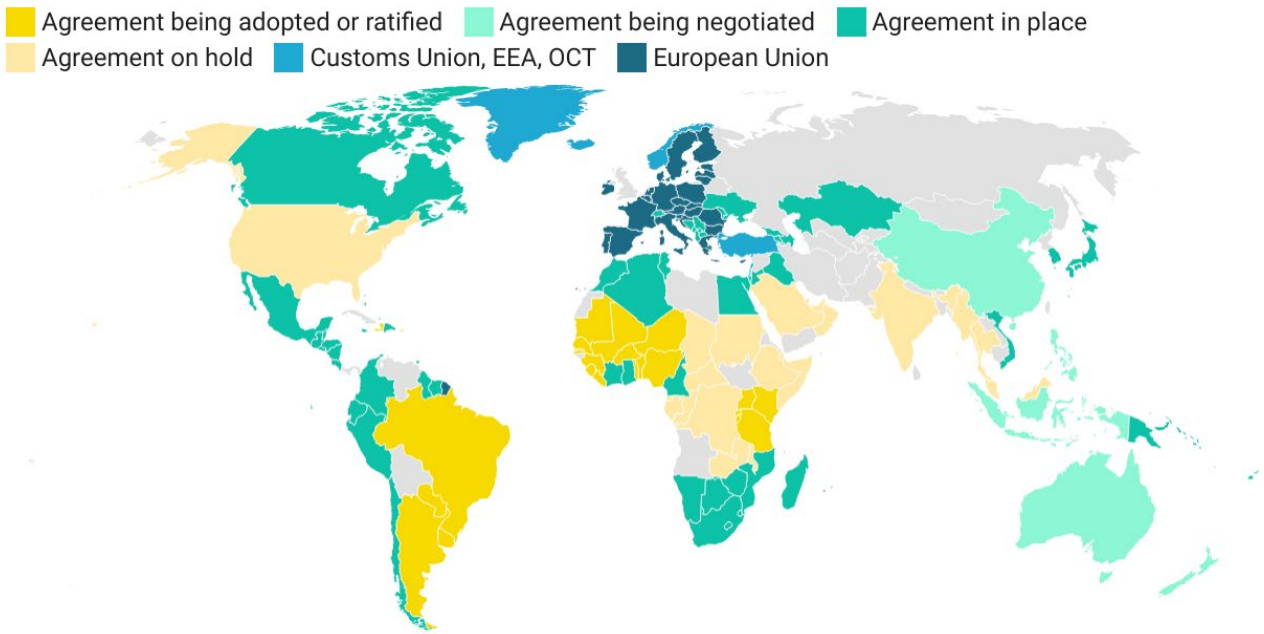
Global reach of European economic policies

Trade policy in Europe has proven effective. Member States have agreed on a shared concept trade policy, with the principles of: i) openness, ii) rules and iii) competition. This open market policy has been promoted as a means to an end, including helping developing countries to open up to trade and using trade agreements to advance EU values. Increasingly, trade agendas include non-commercial objectives such as the promotion of fundamental political and human rights from quality and environmental standards to labour rights. Europe is able to play out a proactive agenda by projecting the EU's own values and approaches to foreign partners and the multilateral partner level. In this way Europe preserves the capacity to act in the world and govern globalisation, thus strengthening its resilience against the risks of interdependence[316].

The EU is expanding alliances with like-minded foreign partners. 36 major trade agreements with 65 countries cover 30% of the EU's global trade[317]. The global coverage of EU trade agreements in place, in ratification or negotiation is presented in Figure 12. The EU draws on an institutional requirement for open strategic autonomy, as it speaks with one voice when negotiating trade agreements, monitoring their implementation, and when responding to unfair trade practices.

The European Single Market is the most advanced and integrated economic union. Based on the European experience and learnings in the process to build the single market, the EU can help foreign partners to advance their emerging bilateral and regional trade agreements, while proposing the application of values and norms that are compatible with the EU's at the same time. This is timely, as the number of trade agreements is currently growing[318]. Beyond widening the network of EU trade agreements, the EU is also proactively working at a multilateral level to improve the functioning of the World Trade Organisation, and towards regulating unfair trade practices across the world[319].

Figure 12: Map of EU free trade agreements – state of play July 2021



Abbreviations: EEA: European Economic Area, OCT: Overseas Countries and Territories

Data source: DG TRADE[320]

The EU can tackle threats that derive from an open economy. Threats to the EU economy due to its openness include asymmetric restrictions on foreign investments, further exposure of EU industries, unfair competition from foreign heavily state-backed companies. However, the EU has put together an effective set of instruments to balance one-sided influence, with balanced competition approaches. This includes effective trade defence instruments, with anti-dumping and anti-subsidy measures[321]. These are safeguarding measures to provide interim relief to a sector, to protect it against imports for a limited period in the form of tariff-rate quotas[322]. And an EU-wide foreign direct investment (FDI) screening to safeguard key assets and protect collective security[323]. The EU uses regulatory and market policies to balance the interdependence of their open economy.

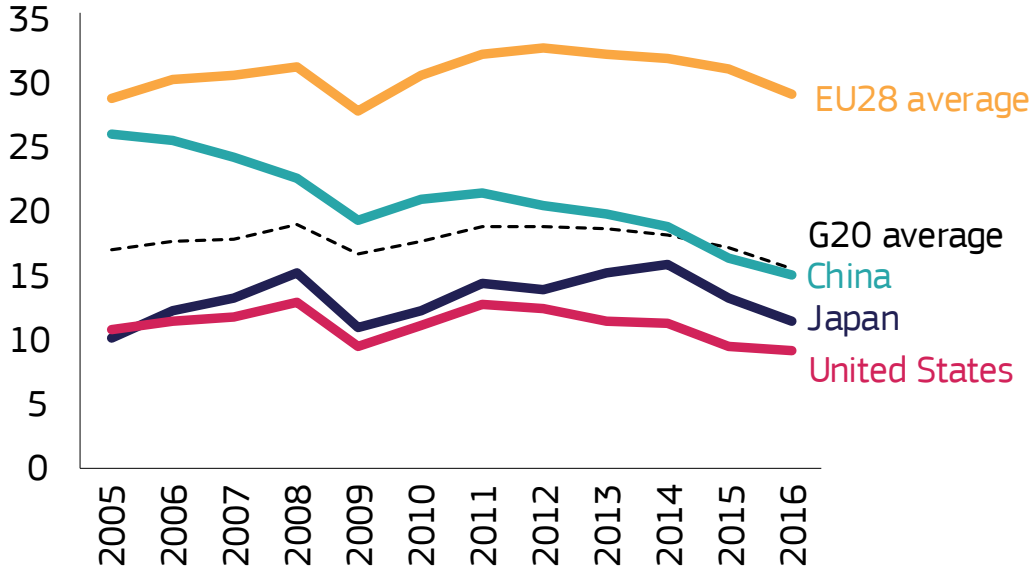
European competition policy applies to foreign business activities in Europe. This policy aims to protect market efficiency and avoid market failure through antitrust law and to limit state aid and enable a level playing field in the single market. EU competition policies are also influential for foreign companies' business activities in the EU, e.g. on Gazprom breaching antitrust rules in some EU Member States in 2015, or Alphabet/Google for abusing market dominance on Android operation systems in 2018[324]. The EU has the capacity to project its rules, values and standards to foreign business and economies that threaten the openness of the EU's economy.

Europe has instruments to support smart specialisation. Smart specialisation is a policy approach to boost growth and jobs, based on regional competitive advantages. The EU is building economic development programmes to build industrial ecosystems and European value chains for emerging sectors supported by research and innovation funding, such as the Battery Alliance[325]. This is an examplary economic response of the EU to increasing competitive distortion in sectors, where foreign competitors receive strategic state support, like globally dominating Chinese battery manufacturering[326]. Smart specialisation aims to strengthen regional innovation systems by bringing together local authorities, academia, business spheres and civil society to implement long-term growth strategies supported by EU funds[327,328]. The EU has a set of soft policy instruments to push competitiveness of sectors and regions. Some of them are used strategically to address the risk of dependency from foreign dominant market actors.

Governance system and European of Pillar Social Rights

Robust public services and governance systems increase economic resilience in times of shocks[329]. While the impact of the pandemic has been uneven in countries, the ones that were positioned to quickly take advantage of changing economic opportunities have fared well.

Figure 13. Foreign value added share of gross-exports (in percent)



Foreign value added content of gross exports captures the value of imported intermediate goods and services that are embodied in a domestic industry's exports. The value added can come from any foreign industry upstream in the production chain.

Source: OECD (2018) TiVA Indicators 2018 update [330]

The countries that until November 2020 have been able to cope better with the COVID-19 pandemic in terms of mobilising actors to meet challenges on the basis of their functioning crisis management plans, are notably Nordic countries - where crisis management plans are required, and Asian countries - that are drawing on their SARS pandemic experience. They have robust political and governance systems in place (for crises management), supported by state-of-the-art technologies and digital, health, research and other critical infrastructures[331]. Investments in these kinds of strategic assets are emerging as a priority for effective governance, in order to ensure economic and societal resilience to shocks[332]. These assets are instrumental requirements for open strategic autonomy when facing natural disasters, or pandemics, or other causes of economic volatility that create one-sided dependencies, such as supply bottlenecks. Building "capacity for the unforeseen, yet probable crisis is important when designing governance."[333]

The European pillar of social rights increases the resilience of a workforce in times of crises. It combines fundamental principles of a free market economy with social policies and welfare state provisions[334], while ensuring fair competition and a level playing field in the internal market. The EU's social protection systems are highly developed[335]. The pan-European support for short-time work arrangements (SURE) is one approach to increase social cohesion within the COVID-19 pandemic-related labour market disruptions[336]. A strong social protection system supports a well-functioning labour market. It could increase attractiveness for talent from foreign countries, and help to overcome the skills gaps that exist in Europe. It also buffers the short-term the volatility of the economic crises, and helps to re-activate the workforce quickly following a rebound of the economy. This strengthens the market power of the European economy, reducing temporary one-sided dependencies.

Supply chain dependencies

The European economy is deeply entrenched in 'global value chains'. Global value networks are a characteristic of the highly interdependent and open global economies participating in production processes. Production processes divided into steps can utilise advantages of specialised suppliers. Cheap transportation costs and reduced transaction costs due to the removal of trade barriers has pushed the expansion of the EU's global value chains.

Global value chains have been expanding steadily since the early 1990s. In the global financial crisis of 2008/2009 their growth stalled. However, EU countries were less affected by this slow down (see Fig. X). They are significantly more involved in cross-border value chains compared to the level of the US or China. Relative to the global average, EU countries consume more foreign content compared with the 'reverse flow'

of goods and services to other countries[337]. This indicates a relatively high dependence of EU countries on global supply chains.

Strengthening the EU's supply chains and fostering the implementation of the EU connectivity strategy are central. They contribute both to reducing asymmetric dependencies, and to helping shape multilateral regimes in line with Europe's values and interests. In particular, in sensitive areas where the EU economy is highly dependent on open trade[338], Europe needs to balance these dependencies through a mix of diversified supply chains, reshoring and near-shoring of critical production steps, that means having more suppliers, or moving production to domestic sites or in European neighbourhood.

The COVID-19 crisis led to a disruption of global supply chains, revealing the vulnerability of the European economy. In the first lockdown of early 2020, manufacturing and medical supply sectors were affected[339]. Later in 2020, large shifts in consumption towards digital devices led to a huge shortage of semiconductor chips, which affected the production of 4 million vehicles globally[340] (and which might last until 2023[341]). In addition, container freight rates have surged since mid-2020, due to a gap in shipping capacity and the many empty containers[342]. The pandemic has highlighted the supply dependency that affect Europe's economic power.

The revival of the economy during the COVID-19 crises came with unexpected market turbulences. Huge economic stimulus programmes in the US and Europe, due to economy recovery plans, led to skyrocketing prices for all kinds of commodities from food (corn), metal (steel, aluminium, copper) to lumber. Some of them, like steel and lumber were at a very low price level before. China is boosting the market volatility by reducing production of steel and massively buying grain[343]. The strong interdependence of the economy has unexpected implications across all steps of global value networks in times of crises, that pose longer-term economic threats.

Control of logistics hubs

Globally interdependent economies are dependent on their logistics hubs and borders. Europe is a highly interdependent economy and relies on seamlessly working supply chains. In March 2021, the seven-day blockage of the Suez canal due to an accident, (the central gateway for shipping between Europe and Asia[344]), resulted in more than 400 ships lined up queuing on both sides[345]. Alongside various product shipment delays, it caused rising oil prices and supply pressure on European chemicals[346]. This indicates the 24/7 need for reliable logistics chains and the vulnerability of European economy.

Europe has lost partial control of some of its critical gateways for global marine transport[347]: China has taken over the port of Piraeus, the European bridgehead to Asia, the Zeebrugge terminal of Belgium with its connections to North-western Europe, and it holds shares of ports in Italy, Spain and Croatia[348]. In total, China and Chinese companies now control about 10% of Europe's port capacities[349]. China's owns the world's second largest merchant marine (moving cargo and passengers)[350]. Foreign powers controlling the transport infrastructure introduces an Achilles heel in the EU's economy, and creates a one-sided dependency. It could turn out to be a huge threat, if these assets are exploited in future conflicts, e.g. through the closing of harbours, airports and/or rail routes, etc.

Competition regulations

Competition laws vary globally. Attempts to harmonise competition law at the international level failed a decade ago[351]. European competition law aims to ensure that single companies do not dominate the market due to oligo- or monopolistic size and State intervention does not distort competition. In contrast, the US has reduced control of the concentration of companies, and abuses of dominant positions are more or less accepted. In addition, the US do not regulate state aid that could distort competition. China is actively pushing their national champions, strategically building dominant corporations under State control, to become competitive in the world[352]. For example in 2019, the European Commission prohibited a merger of the rail industry players Siemens and Alstom, whereas China went ahead and merged their rail industry into one company, CRRC[353]. Different competition laws allow a distortion of competition between globally active companies[354].

Protection of home markets distorts competition globally. China is protecting its home market, in particular in strategic high-tech industries. Utilising the vast size of the domestic market allows Chinese industry to build-up competitive product offerings protected from foreign competition. For example, the establishment of

Chinese solar panel manufacturing based on state support and economies of scale in the domestic market, beat European solar photovoltaics industry on the global market through low price offerings. While low-priced goods are positive for European consumers, the resulting erosion of European firms could weaken some key industries that are critical for critical infrastructures, as the debate on 5G network equipment supply from Chinese ZTE and Huawei revealed in recent years.[355]

Enforcing a level playing field with other major economies is essential. As mentioned above, the EU has elements of trade and competition policies that contribute to balancing one-sided market dominance. Enforcing a level playing field contributes to uphold Europe's competitiveness and sustain growth, thereby preserving the economic power base that underpins Europe's regulatory power and open strategic autonomy.

Future opportunities and challenges

Developments are creating challenges for open strategic autonomy in three areas: 1) The shift of economic gravity (average location of economic activities on the globe) from established Western economies to Asia reduces the EU's economic influence. 2) An increase in fast-growing emerging economies might lead to a fragmentation of global economic interdependencies. The EU risks losing competitiveness, as other economies innovate faster, are less open and more strongly protect their markets. 3) Global debt is rising further, driven by governments' spending to help cope with managing the COVID-19 crises impacts. The growing dependencies on creditors, and limited ability for government spending, present challenges and further drive one-sided dependencies. For instance, in the EU, the government debt-to-GDP ratio increased from 77.5 % at the end of 2019 to 90.7 % at the end of 2020, the highest in the time series.

The economic challenges are linked to opportunities too. With the fragmentation of the economic landscape and stress on the financial systems, the euro could gain a stronger international role, breaking up one-sided dependencies on the US dollar. Challenges to the competitiveness of the European economy and addressing the climate crisis, call for a progressive green and digital transition that could shift economic dependencies and strengthen the EU's market power.

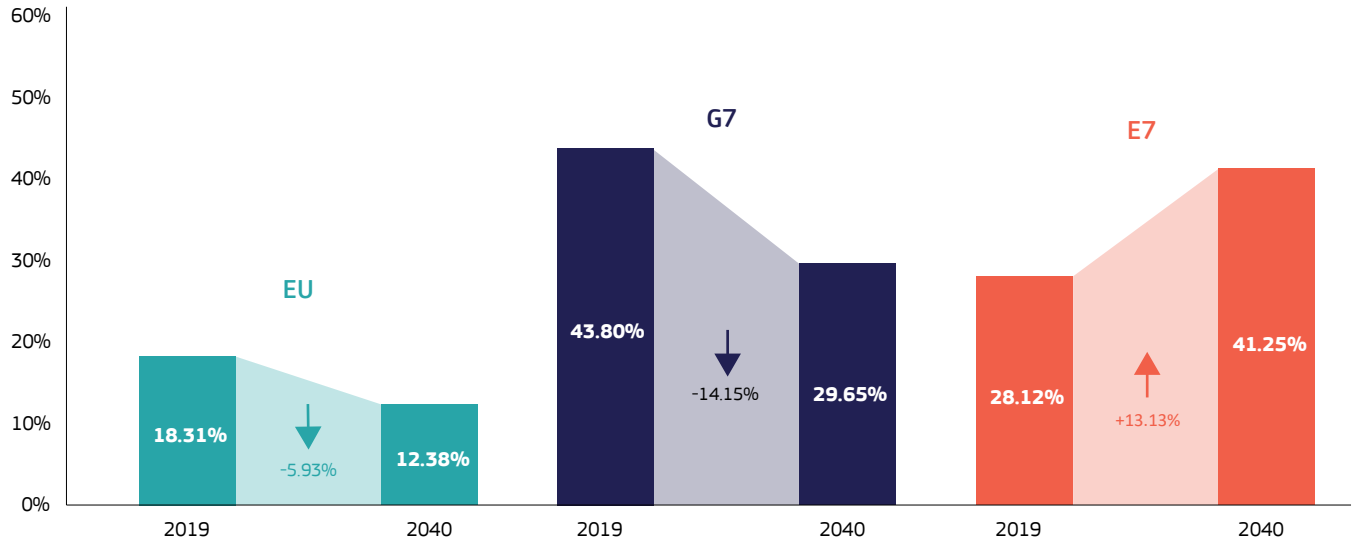
[The EU] has to strengthen the competitiveness of its economy, manage the green and digital transition, balance interdependencies, and grow its regulatory power and political influence

Europe's economy in the world

Europe is expected to shrink in terms of global economic weight, as Asian economies are growing faster. The most recent long-term economic forecasts are pre-COVID-19 forecasts. Disruption due to the pandemic continues to "paralyse most economic activities"[356] across the world, with unprecedented job losses. Huge government stimulus packages prevented economic collapse. The UN estimates that the long-term impacts of the pandemic will lead to a lower growth trajectory (than earlier forecast)[357]. The pre-COVID-19 long-term global economic perspectives were already rather moderate, but might need to be revised downwards. Pre-crisis OECD estimates expected real GDP growth to decline from about 3.2% in 2019, to 2.1% in 2040[358]. The E7 emerging economies (Brazil, China, India, Indonesia, Mexico, Russia and Turkey) are expected to grow more than twice faster in terms of annual GDP growth rates, compared to G7 countries (Canada, France, Germany, Italy, Japan, the UK and the US).

The economic 'centre of gravity' is expected to shift from North America and Europe to Asia. Asian economic growth centres are mainly China and India, but also Indonesia[359]. The EU27 could reduce its economic weight from 18% to about 12% share of gross domestic product at current prices[360]. This large loss of economic power in Europe and shift towards China, India and Indonesia, will to lead to a transformation of economic interdependencies between the global actors.

Figure 14: Economic weight of EU27, G7 and E7 in share of global GDP (at current prices)[361]



Source: OECD

The EU's will have less opportunity to draw on economic power for global influence[362]. The EU needs to build up other powers, such as alliances to increase its soft power and regulatory power, as well as a commercial strategy with the relevant markets.

Foreign countries are increasingly aligning their geopolitical and geo-economic power to be more assertive. Economic powers such as the US and China have long been merging economic and geopolitical interests. In contrast, Europe's governance style has been designed to preserve external economic relationships from the interference of geopolitics[363]. Growing economic pressures, due to the relative growth in power of foreign economies, combined with growing geopolitical tensions, could further challenge the competitiveness of Europe. In addition, it could affect the innovativeness of its industry, influence its monetary and financial autonomy, and expose critical infrastructure and national security assets to foreign interference. To preserve the openness of the EU economy, balanced rules are needed to enable a level playing field for foreign powers and industry.

Europe's competitiveness in the world

Europe's competitiveness level is quite diverse across regions. The World Economic Forum (WEF)[364] performs global competitiveness analyses looking at preconditions for long-term growth, using a holistic view of enabling environment, human capital, markets and innovation ecosystems[365]. In their pre-COVID 2019 assessment, Singapore leads the ranking, followed by the US[366] and Hong Kong. European Member States range between rank 4th (The Netherlands) and 63rd (Croatia) of the 141 countries analysed. The EU is quite diverse in its competitiveness levels, even more when looking at the subnational level with mainly metropolitan regions performing better[367], such as Utrecht (in the Netherlands), or Hovestaden (Copenhagen region) than elsewhere in the country. In the WEF analysis, China places 28th in the ranking[368], the best performer of the BRICS countries. The other strongly growing emerging economies rank in place 50 for Indonesia and 68 for India. Despite the well-ranked position of the EU currently, its long-term high-ranking is in peril[369].

China's economic strategy is challenging European competitiveness. The strong links between the EU and Chinese value chains and trade relationships are undergoing a transformation. China is trying to be more self-reliant in its domestic market, and is reducing its openness to foreign economies, in accordance with the 'internal circulation' element of its 'dual circulation strategy'[370]. The Chinese market should become a future growth driver for its domestic industry, as China is expected to achieve a high-income country status by 2025[371]. Therefore, China is aiming to reduce the export-dependence of its economy[372]. The role of China as the EU's second biggest export market risks diminishing. EU industries that have built their strength on exports to China will be particularly affected, such as machinery and equipment, motor vehicles, aircraft, chemicals industries[373]. The EU economy will get more competition from the 'Made in China 2025' vision and further updates.

China is aiming to become a leading global superpower by 2049[374]. Competition with China is also increasing in other world regions where European industry is active. For example in Africa, Chinese players have

become by far the biggest infrastructure builders in the last decade, while European players lost ground. The Belt and Road Initiative (BRI) is being used as a lever for exporting construction of infrastructures. Chinese development banks and BRI funds are backing Chinese industry's tenders[375]. Chinese actors are increasingly active in EU and Member States tenders for infrastructure too[376], while access to Chinese market is heavily regulated and relatively closed[377]. The EU is losing economic influence through these one-sided dependencies.

The US and China are outpacing Europe in some emerging growth areas. In the last decade, a range of innovations such as 5G, AI, cloud computing and the IoTs, have become major strategic assets for the EU economy. With the global market for new digital technologies expected to reach €2.2 trillion by 2025, a large part of Europe's growth potential resides in this digital market[378]. However, the EU risks lagging behind in some areas, such as genomics, quantum computing, or AI[379] [380].

Demographic change is further challenging European competitiveness. The working age population will have shrunk by about 16% in Europe and 17% in China[381] by 2050, compared to 2020[382], while in North America and in India, it is growing. A shrinking working age population results in a lack of workforce that make it challenging to maintain robust economic growth and this will affect the global importance of the economy and its competitiveness. As well as the reduced workforce, an ageing population will lead to the economic challenges of financing the social system, in particular increasing pensions and health costs[383].

Keeping a high level of competitiveness enables Europe open strategic autonomy. A competitive global market helps to avoid one-sided economic dependencies, as countries can diversify supply chains and rely on quality products and services from elsewhere. It offers the baseline to create welfare and government revenues that reduce dependencies on creditors. Dynamic innovation capabilities provide the competence to develop technologies, processes, products and services and to be less dependent on foreign innovation providers to advance the economy. Being open, means that the economy relies on global value networks, it produces, creates and innovates in collaboration with foreign actors, and provides goods, services and approaches to global markets. Several signals indicate that Europe has to invest more in its own economic, research and innovation capabilities, its labour market and its education system in order to avoid being taken over by emerging economies.

Global debt

The world is in a global debt wave, which has created dependencies on creditors. The COVID-19 pandemic hit the world when it was still in a "global wave of debt", where it has been since 2010. Global debt has grown mainly in emerging markets and developing economies to reach an all-time high of 230% of GDP in 2018. The dimension of debt build-up in term of size, speed and reach of the debt, and in this wave, is significantly larger compared to previous ones, at the same time as economic growth prospects are low[384].

The pandemic required huge government spending. It has added EUR 20 trillion global debt, during a phase of sharp economic contraction[385]. This has raised the vulnerability of the global economy to financial market stress[386]. Some economies are getting close to dangerous levels[387]. Fiscal sustainability risks limit a country's ability to act. Public spending might need cuts. This will reduce capability to invest in health, education and infrastructure. Digitalisation and 'greening of the economy' relies upon the market. But if dependency on creditors is huge, it limits open strategic autonomy. An upcoming financial crisis, resulting from this global debt wave could mean the harsh disruption of global economies, turning the current economic interdependencies upside down.

China is the world's largest creditor, potentially influencing debtor's policies. China is one of the top lenders to the US and the largest lender to emerging economies.[388] China is investing in infrastructure construction in line with their Belt and Road Initiative between Asia and Europe, such as ports e.g. in Pakistan, Djibouti, Piraeus/Greece, and railroads including Budapest-Belgrade railway[389]. The projects are mostly financed via China's own funds, state-owned banks and the Asian Infrastructure Investment Bank. Lending conditions for projects mainly in Africa and Latin America[390] are being criticised due to their potential to lead to a debt trap and political dependencies. There is a lack of transparency due to confidentially clauses. Chinese lenders seek advantages over other creditors, limiting collective restructuring of debt, and with contract clauses potentially allow lenders to influence debtor's domestic and foreign policies[391]. Some projects have led to project standstill, or financial instability, also in close proximity to Europe, such as the Montenegro highway project[392] or the Budapest-Belgrade railway. China's credits are creating financial dependencies in Europe's neighbourhood and even inside the EU.

International role of the euro

The role of the euro in global trade is second globally, but far behind the US dollar. From 1945 to today, the US dollar has been the world's most major currency, with approximately a 60% share of foreign exchange reserves. The euro is the second largest currency with a 19% share. The share of global payments in euro amounted to around 36%, following the US dollar with 39% in April 2021[393]. Overall, the euro's international role has remained stable in 2020, but it is at a low level[394]. Stability in times of a global health and economic crises and exceptional policy support is a sign of its resilience.

The euro has a strong regional reach and in euro-area trade. But it is far from challenging the dominance of the US dollar[395]. "The monetary autonomy that comes with an international currency helps to provide a buffer against political or military pressures from outside, and the greater the monetary dependence of third countries, the wider the choice of policy instruments, including the possibility of exploiting access to financial and payments systems"[396].

The European Central Bank provided monetary policy measures during the COVID-19 crisis. This contributed to ensure credit supply and to stabilise the euro area economy. It included provisioning of liquidity to non-euro area central banks. Stabilising the euro in times of crises supports its international status. The non-euro area intervention offered access to its currency at the international level. It contributes to increasing confidence in euro asset markets. National fiscal policies, EU level instruments, and ECB monetary policy have shown their capability to enhance the resilience of the euro area in times of large shock and as a side effect have strengthened the international role of the euro[397].

A greater international use of the euro will increase the EU's economic open strategic autonomy. To increase its importance[398], the euro needs to become the standard currency for payments and investments in more areas, both as a reserve currency and as the denomination of state and corporate bonds. With trade in commodity markets being strategically carried out in euro, progress is visible[399]. The Commission's Next Generation EU instruments use safe euro area assets[400] through debt issues. This large EU bond issuance of up to euro 800 million by the European Commission provides highest creditor status. It raises the attractiveness of the euro as an investment currency for international investors compared to single Member State's bond markets. A well-designed common European safe asset could enhance financial integration and stability for states borrowing and investors lending money. European safe assets could support the international role of the euro[401]. However, for the euro to become a 'crisis-proof' leading currency, the political will of Member States is needed to further deepen the Capital Markets Union[402].

The rapid development of private and public digital currencies could be a game changer. In this context, Central Bank Digital Currencies are considered to be the natural next step in the digitization of money and payment systems and a global race to define the world's reserve currency of the digital era has started[403]. China is the frontrunner in experimenting with and applying digital currency[404]. The Central bank money offered in digital form for retail payments of citizens and businesses does not alter the fundamental economics of global currencies, but can impact their international role[405]. The European Central Bank launched a project to prepare a possible issuance of digital euros that could facilitate payments efficiency and security across the eurozone[406]. If a similar digital euro would not be provided, other digital currencies, such as China's renminbi or the US dollar would step in and expand their international role. Beside other countries issuing digital money, also global tech companies could step in with their platforms, while central banks loosing influence in the financial market[407]. Therefore, an ECB-issued digital euro could futureproof the euro against these developments.

The EU has the capability to cope with a more fragmented global monetary and financial system. Having the second largest currency globally, the EU could build capabilities to play a stronger role in a less US dollar-dominated world. The EU would need to advance in several areas, such as a:

- stronger integration of the Banking and Capital Markets Union;
- widening of instruments first applied in the COVID-19 crisis with euro-area safe assets;
- intensifying non-euro area central bank exchanges; and
- updating the objectives and tasks of established financial institutions and instruments, such as the European Investment Bank (EIB) and the European Stability Mechanism (ESM).

The introduction of a digital euro would be an additional asset to incentivise currency substitution. All of these could be the basis to develop a European financial system to complement institutions of the current global financial architecture[408].

Beyond the stronger role of the euro, completing the Single Market means strengthening Europe's foundation for wealth and regulatory power. The Single Market offers the scale for European companies to grow and become more competitive in the international market. It could be further used to mobilise investments in research and innovation,[409] as well as to raise venture capital for start-ups to push disruptive technologies, and business models to improve the future competitiveness of industry. The single market for data is critical for the European data economy's scale, and depends on secure digital connectivity infrastructure[410].

Economic impact of the digital transition

Digitalisation is transforming Europe's industry, as well as the areas already covered within this report in the Technology and Geopolitics sections. There are also different dimensions of digitalisation of EU industry: digital processes, such as Industry 4.0 and 5.0, can drive efficiency of production and services. They are an enabler for the circular economy, reducing emissions and improving a sustainable economy. Digital business models enable new forms of value creation, innovative ways of delivering products and services. Both dimensions require enabling technologies like AI and digital infrastructures from 5G, cloud computing to quantum computing. Europe's economy is challenged by competition from big powers in digital technology and security standards, mainly from US and Chinese actors (such as the 5G Huawei procurement debate)[411]. To balance the interdependence of European industry in the digital transition with foreign actors, the EU needs to further intensify its activities in smart regulation and investment, as well as its collaboration with foreign digital actors.

Economic impact of climate crises and green transition

Climate change impacts will incur substantial economic costs. Without profound and system-wide changes in consumption and production patterns, it will not be possible to support the 10 billion people expected to inhabit the earth by 2050[412]. The costs of climate change in a 3.2°C climate world would cause an accumulated economic loss equivalent to 18% of global GDP by 2050, if compared to a world without climate change. While Europe and North America would be less negatively affected (9.5-10.5% of GDP), Asian countries would face a much more devastating effect (ASEAN countries: 37.4%).[413] Regarding Europe, annual welfare losses of € 175 billion or 1.4% of GDP can be expected if global warming reaches 3°C.[414]

The Green Transition requires substantial investments that would lead to a modernisation of the EU's economy. To reach a climate neutral society by 2050, all sectors need significant changes in how they operate. The 'Green Transition' would require annual investments of EUR 1 trillion in the EU, 80% of which shifts from carbon intensive to low carbon investments, and 20% additional spending that would be offset by savings[415]. This investment would lead to a fundamental revamp of many industrial sectors and would increase the innovation rate of the economy. There is an increasing recognition that such an investment strategy would not only reduce environmental impacts, but also make the economy more resilient.[416]

The smooth transfer of labour from declining to growing sectors in a green transition will be essential to realise economic growth opportunities. The green transitions will have an unequal impact on different economic sectors (and regions across the EU). Fossil fuel sectors and/or those depending on them (e.g. technology providers to the refining industry) will contract. New jobs will be created in clean energy, energy efficiency and circular economy sectors.[417] The transfer of people from declining to growing sectors will be a major challenge, as regional mobility and skill availability are limiting factors that could lead to a shortage of workforce and therefore could prevent growth in green sectors.[418]

Successful management of the green transition would help to increase the EU's open strategic autonomy. Establishing a resource efficient and circular economy could reduce the impact of strict climate policies of foreign countries and reduce one-sided resource interdependencies without generating extra tensions on one's own economy. It could even further contribute to higher competitiveness and technology leadership.

ENVIRONMENT

Environment

The EU is strong in leveraging the advantages of the green transition. Europe wields considerable influence and traction in international fora to advance its global change agenda and mitigate threats linked to depleted global commons. It has the most advanced legal framework to achieve the green transition. It has also developed a comprehensive strategy to adapt to climate change. The EU has already increased the share of renewable energy in its energy mix, decreasing its energy import dependence, and has set a framework for sustainable food production. On the other hand, its energy-intensive industries will still have to reduce greenhouse gas emissions substantially to reach climate neutrality. Strict environmental regulation could put these industries at a disadvantage, as they have to compete globally.

AREAS FOR IMPROVEMENTS

New competitors have emerged in the area of green technologies and established themselves as leader in a range of important technology niches, such as low-carbon passenger transport

EXISTING STRENGTHS

The EU has actively contributed to global climate diplomacy and was one of the enablers of the Paris Agreement

The EU has already implemented advanced legislative frameworks to support the green transition and is a front-runner in sustainable development

The EU is a leading innovator in the area of green technologies

EU industry sector is positioned well to lead the way to zero carbon industry

The EU is a front runner in climate change adaptation

EMERGING CHALLENGES

The increase in global population will lead to growing pressure on food and water security but also to an increased scarcity of critical raw materials

The impact of climate change will worsen and might lead to water and food shortages. Europe is not the most affected region and will be able to adapt to climate change to a certain degree

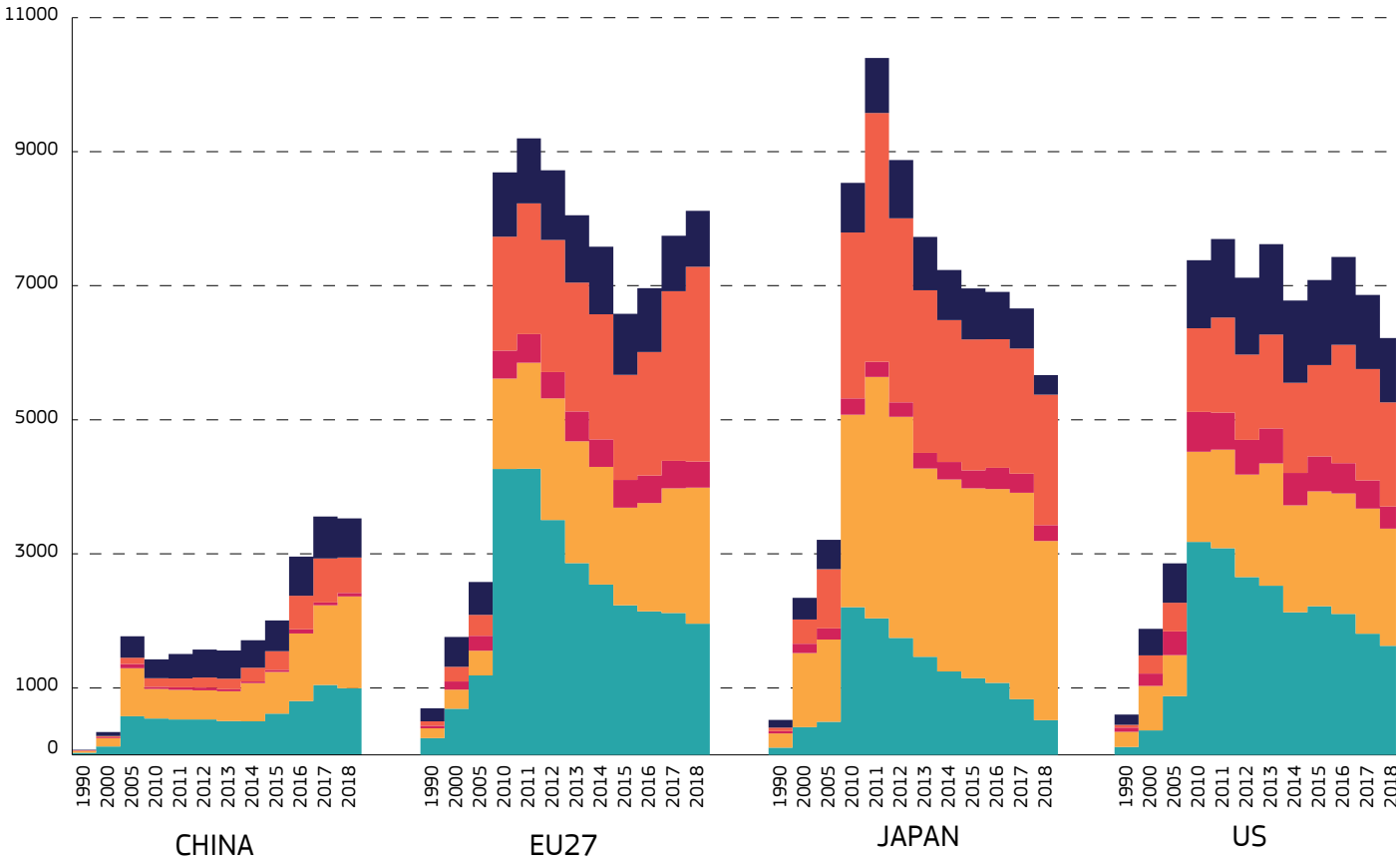
Decarbonising energy-intensive industries can put EU companies at a disadvantage

OPPORTUNITIES FOR EU'S OSA

The EU can benefit from the energy transition by reducing its energy import dependence and by leveraging it technology leadership in energy technologies

The implementation of a circular economy could decrease the EU's import dependency from critical raw materials

Figure 15. Innovation in environment-related technologies, technology development



Source: OECD - Environment Database, https://stats.oecd.org

Current strengths and weaknesses

Climate diplomacy

The EU leads in climate championing and diplomacy globally. The EU and its Member States have established themselves early as climate diplomacy leaders. They were instrumental in setting up the United Nations Framework Convention on Climate Change.[419] More recently, the EU and its Member States have played a crucial role in securing the Paris Agreement. The EU continues to play this role today and is currently setting the standard and pace for other global powers. For example, it was the first region to commit to achieving climate neutrality, which has led to more and more other countries and regions pledging to become climate neutral.

Championing the green transition

The EU provides planning security for the green transition. The success of climate change mitigation and adaptation depends on public and private buy-in of policies and strategies. The European Commission's proposed Climate Target Plan aims at ambitious greenhouse gas emissions cuts – amounting to 55% less of current emissions – by 2030, and the European Green Deal proposes climate neutrality by 2050[420]. The Climate Target Plan was backed up by a far-reaching package of proposals aimed to achieve the new climate target.[421] It is very comprehensive and it will have profound effects on economic and political relationships, industries and lifestyles. With its long-term climate and environmental plans, the EU provides all stakeholders certainty, which makes it easier for everyone to plan for the climate transition.

The EU has substantially increased the share of renewable energy in its energy mix. The EU has legally binding long-term targets for renewable energy and energy efficiency and a comprehensive regulatory framework to monitor compliance with these targets.[422] These have led to a doubling of the share of renewable energy in the EU between 2004 and 2019.[423] The European Green Deal further stresses the importance of renewable energy and energy efficiency to become climate neutral in 2050. Reaching this goal would reduce the EU's energy import dependency from 54% in 2018 to 20% in 2050.[424]

The EU has a comprehensive strategy to secure sustainable food production. While the EU has a food trade surplus,[425] it does rely on other countries

to supplement its food supply. Recent crises have revealed the strong interlinkages between health, ecosystems, food supply chains, consumption patterns and planetary boundaries. The Commission's Farm to Fork Strategy commits to building a robust and resilient food system that functions in all circumstances.[426].

Green technology leadership

The EU leads in a few 'green technology' categories. The EU is technology leader when it comes to offshore wind and is positioning itself strongly in other emerging green technology areas, such as renewable hydrogen and electric vehicles. Of the granted patents in several green technology segments, the EU is ahead of the US, Japan and China.

New key players are challenging the EU's technology leadership. While Europe had an early market lead in solar photovoltaic panels, China has been able to catch up in some areas. Despite relatively few patents, China leads in lithium-ion battery production,[427] and has by far the highest installed capacity of renewable energy power generation.[428] It currently produces over 70% of the world's photovoltaic cells and half of the world electric vehicles, and it controls the supply chains of some critical raw materials[429]. This makes other regions vulnerable to a decrease in exports from China.

Reducing vulnerability to climate change

The EU has made some progress in reducing its vulnerability to the negative effects of climate change. Resilience concerns extend to flooding of coastal economies and infrastructures, the increase of extreme weather events such as droughts on economies,[430] and the spread of infectious diseases[431]. With the proposed EU Strategy on Adaptation to Climate Change[432], the European Commission aims to strengthen its preparedness for the increasing frequency of extreme weather events and other climate change-related challenges, which lie ahead.

Future opportunities and challenges

The EU's open strategic autonomy is set to benefit from the green transition. The growing stress on natural resources globally and the increasing impacts of climate change are threats to the EU. Accelerating the green transition is an important way to mitigate this issue and reduce potential future harm. The energy transition could reduce import dependency on fossil fuels, while the effective implementation of a circular economy could reduce the need to import critical raw materials, or other goods. When it comes to energy-intensive industries, there is the risk of reducing the competitiveness of EU companies, by implementing stricter environmental standards than other regions that serve the same global market.

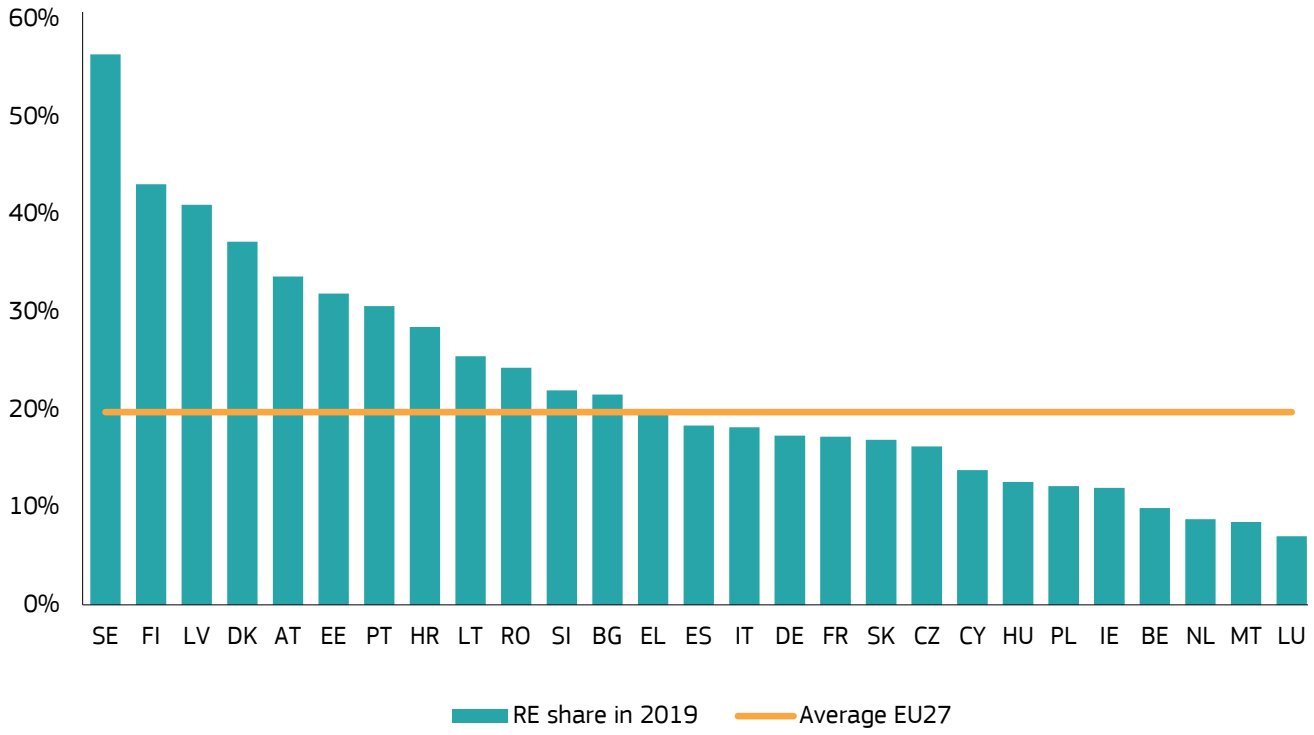
Europe wields considerable influence and traction in international fora to advance its global change agenda and mitigate threats linked to depleted global commons

Growing stress on the Earth's natural resources

The increasing population and growing consumerism is leading to growing resource consumption. The expected global population increase from 7.7bn people in 2019 to 8.6bn in 2030[433] will result in an increase of 50% in food demand and a 40% increase in energy demand as the middle class grows[434]. In addition, by 2030 the global middle class will substantially increase, mostly in Asia (e.g. 70% of the population in China is expected to be middle class by 2030)[435]. Increased purchasing power and income levels often come with increased food, water and energy demands, as well as increased consumerism.

Resource stress is set to increase dramatically. A growing and wealthier population will put further strain on the scarce resources available on Earth and cause further environmental degradation to keep up with growing consumption patterns. Increased consumption translates into the loss of natural habitat and increased waste and pollution levels in water, soil and air, all of which threatens biodiversity, health and increases the environmental footprint.[436] Weak global governance on the 'global commons' such as the shared deep sea, Arctic etc., make it difficult to reduce environmental impacts in these ecosystems.[437]

Figure 16. Share of renewable energy in the EU



Source: EUROSTAT https://ec.europa.eu/eurostat/web/energy/data/shares

Declining biodiversity is a threat to European ecosystems. The reduction in number or the extinction of species caused by humans has accelerated in recent years. Some of the reasons are changes in land use, pollution and human-induced climate change.[438] There is the possibility in ecosystems that the loss of one species triggers a domino effect of extinctions of other species.[439] A further future risk is posed by the reduction in pollinators in the EU,[440] as more than three quarters of our food crops depend on them.[441]

Increasing impacts of climate change

The tangible impacts of climate change are increasing. While Europe is not the most affected region in the world, negative effects such as flooding or wildfires could affect the EU and its economy will increase. On a global scale, the climate crisis is expected to cause substantial economic damage.[442] The increase of climate change effects could be accelerated by reaching and surpassing tipping points, such as the loss of the Antarctic ice sheet, which would catalyse further global warming.[443]

Rising temperatures will severely affect water and food availability. In the next decade, the MENA region[444] will be particularly hard hit, as it faces increasing pressure on water availability and crop production[445]. These developments could cause disruptive long-distance migration flows that will also affect the EU. However, there is also the more systematic risk of global food shortages. As the food supply is global, disruptions in one food producing region can have knock-on effects on others. Even more severe would be crop failures in many of the main food-producing regions, which is referred to as 'multiple breadbasket failure'.[446]

Increasing climate change pressure might lead to risky unilateral attempts to 'solve' the climate crisis. The increasingly negative impacts of climate change could lead to unilateral attempts to accelerate climate action. Particularly the use of geoengineering (e.g. ocean iron fertilization), which is the manipulation of the climate on a large scale, is highly contested.[447] Such an attempt would infer substantial environmental risks because the impact of geoengineering are not yet sufficiently researched.[448] Geoengineering also poses a moral hazard, as climate action might be postponed which would simply shift the problem to subsequent generations.[449]

Accelerating energy transition

The energy transition is expected to accelerate globally and lead to a transformation of the world's energy mix. The accelerating transition is the product of technological innovation, of the rapidly falling price of renewable energy and of legislative and societal choices across the world, motivated by the pressing need to mitigate climate change. Considering that energy production and consumption account for about 75% of greenhouse gas emissions,[450] substituting fossil fuels by sustainable alternatives is a crucial requirement to keep the rise of global temperatures within two degrees above pre-industrial levels. If the EU reaches its goal of climate neutrality by 2050, it would reduce its energy import dependency from 54% in 2018 to 20% in 2050 at the same time.[451]

Electrification, the substitution of fossil fuels, and renewable energy enable the energy transition. These include the progressive electrification of the economy and the provision of green hydrogen to operate those sectors that cannot rely on electricity, such as aviation. The shift "from carbon to electron" will therefore be at the core of the transition[452]. With a view to meeting current commitments under the Paris Agreements, electricity should provide 50% of the energy needs by 2050, up from 20% today[453]. Worldwide, according to the International Energy Agency, renewables will overtake coal as the largest source of power generation by 2025 already.[454] Those countries that have technological knowledge in the relevant areas are set to benefit from the energy transition.

Implementing a Circular Economy

The Circular Economy can reduce import dependencies. Resource efficiency is a key component of the Commission's European Green Deal, which aims to achieve a sustainable and carbon-neutral economic system. To meet this aim, the circular economy[455] action plan has been developed to keep resource consumption within planetary boundaries and reduce import dependence on raw materials, or other resources. The circular economy aims to reuse and recycle products and other resources, reducing the need for new resources, reducing waste and pollution and ensuring a well-functioning internal market for high quality second hand raw materials.[456] This is a key building block of a sustainable product policy framework, in which consumers are also empowered with cost-saving opportunities through repair possibilities, or product maintenance services, and trustworthy information on the real environmental footprint of the products they want to purchase.

Decarbonising energy-intensive industries

The industrial sector is a vital backbone of modern economies but is a major emitter of greenhouse gases and pollutants to air, water, and soil. Particularly energy-intensive industries are those that produce crucial materials such as steel, cement, and chemicals.[457] While they are used in several products, they also play an even bigger role in the context of the green transition, as several decarbonisation enablers, such as wind turbines or PV installations require energy-intensive raw materials too.[458] However, the industrial sector emits large quantities of greenhouse gases and contributed to 20% of EU greenhouse gas emissions in 2017. Globally industry is responsible for approximately 50% of global green house gas emission.[459]

Technology options to decarbonise energy-intensive industries already exist. Europe's energy intensive industry is operating established, older infrastructure and therefore is more carbon intensive than the more modern Asian operators are.[460] However, the EU has an advanced research and innovation roadmap to decarbonise.[461] Decarbonisation options to bring industry emissions close to zero include a mix of: i) energy efficiency improvements; ii) electrification of heat; iii) replacing fossil feedstock by sustainable alternatives; and iv) applying carbon capture and storage.[462]

Decarbonising energy-intensive sectors could lead to a disadvantage. As the EU has already established infrastructure for these sectors, decarbonisation entails the retrofitting of existing plants. Such a 'brownfields conversion' increases the already substantial investment requirements in these sectors.[463] As many of the products produced are global commodities, EU manufactures compete at a global level. Green EU manufacturers might have a disadvantage if they have higher production costs than international competition due to the higher EU environmental standards. This might lead to the relocation of energy-intensive production plants to locations with less strict environmental standards, a phenomenon also referred to as 'carbon leakage'.[464]

SOCIETY

Society

Open strategic autonomy is only possible if the EU preserves its commitment to the respect of the rule of law and other fundamental values. An open society is also required, while achieving greater cohesion in society and having human resources and capital to sustain it. Despite its relevance, social aspects of open strategic autonomy are significantly less explored in EU policy documents to date.

Public policies have the goal of changing society and the economy, while creating public value[465]. The EU is active in shaping a society of equal opportunities. EU policies in general are based on the principle of intergenerational justice, solidarity, human dignity. People are the cornerstone of any successful attempt to achieve open strategic autonomy. An open society helps to not only engage and bring together European citizens but also develop collaborations with others and attract foreign talent.

AREAS FOR IMPROVEMENTS

- Reducing inequalities remains an area for improvement
- Digital skills and education is not equally offered across the EU and this needs to change if the EU is to remain competitive and wishes to ensure inclusiveness and enhanced quality of life for its citizens

EXISTING STRENGTHS

- Human rights and democracy and universal values for all
- Cohesion among regions and Member States
- Solid education system
- Social welfare and protection systems

EMERGING CHALLENGES

- Increasing polarisation risk for the stability of internal affairs and internal cohesion
- Demographic challenges will produce a strain of sustainability of EU social protection systems

OPPORTUNITIES FOR EU'S OSA

- Citizen engagement in policymaking to increase democratic legitimacy and restore trust
- Co-creation of public services

Current strengths and weaknesses

High standards of fundamental rights

The EU is founded on the values of respect for human dignity, freedom, democracy, equality, the rule of law and respect for human rights, including the rights of persons belonging to minority groups[466]. The EU has been committed to underpin these values in all of the EU's internal and external policies[467]. Despite negative trends in this area, recently seen in some Member States, the EU has remained resolute in defending human rights and democracy, and has committed to further advancing universal values for all.

This is particularly important nowadays when a global decline of democracy has been perceived worldwide. According to the Freedom House[468], democratic systems around the world were negatively impacted by COVID-19 crisis. Excessive surveillance, as well as restrictions on some human rights (such as the freedom of movement and assembly and freedom of expression), together with lack of transparency for governmental decisions, were noticed around the world. In autocratic regimes in particular, they were often disproportionate to the threats posed by the virus. Misinformation and disinformation about COVID-19 virus, treatments and vaccines, have spread quickly through online public sphere to advance political aims by undermining trust in the EU while jeopardizing lives[469].

The European Commission's Action Plan on Human Rights and Democracy is the only instrument of its kind aimed at promoting a values-based agenda on the world stage[470]. This and similar policy initiatives can build more resilient, inclusive and democratic societies in the EU. They can also strengthen the EU's global leadership in protecting and empowering individuals. Through the Action Plan, the EU will be able to promote a global system for human rights and democracy, gender equality and strengthened civil society.

A new strategy to strengthen the use of the EU Charter of Fundamental Rights has recently been adopted[471]. The strategy[472] focuses on enhancing the application of the Charter in Member States through enhancing partnerships between the Commission and Member States. It will strengthen citizens' awareness (a Eurobarometer survey from 2019 showed that only 12% really know what the Charter is, while 42% have 'heard about it'[473]) and empower civil society and practitioners through taking actions against measures that breach EU law. The Strategy's intention is to have the Charter serve as a compass for EU institutions whose actions all need to comply with it.

Reduction of inequalities

Reducing inequalities and improving living conditions is high on the policy agenda for the European Union institutions. Inequalities are often seen in connection to gender, age, disability, sexuality, employment status, skin colour, or citizenship. These have very real implications for salaries, access to jobs, welfare, health, education, services, personal safety and other rights that are often taken for granted.[474] Racial, ethnic, and gender inequalities became more pronounced during COVID-19 pandemics in countries around the world[475].

The European Pillar of Social Rights aims to tackle inequalities in key areas and thereby to strengthen the European Social Model. While reflecting the Union's founding principles, social policy aims to reduce inequality, maximise job creation and allow Europe's people, its human capital to thrive.

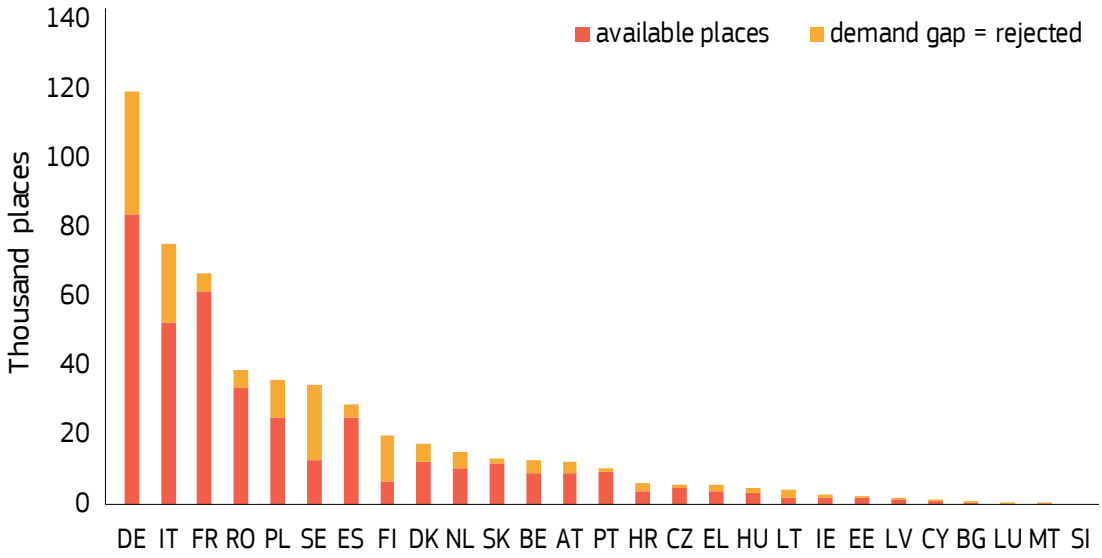
The Pillar sets out 20 key principles and rights that are essential for fair and well-functioning labour markets and welfare systems in the future. The Pillar is structured around three chapters:

- Equal opportunities and access to the labour market;
- Fair working conditions;
- Social protection and inclusion.

The European Pillar of Social Rights Action Plan also proposes targets for employment, skills and social inclusion at EU-level that are to be achieved by 2030.

By providing harmonised measures of various social progress indicators, the European Social Scoreboard[476] facilitates monitoring of the implementation of the Pillar. This is achieved through comparing Member States areas of strengths and weaknesses in the social domain. By closely monitoring key socioeconomic and environmental indicators, the Scoreboard provides an important tool for adopting tailored policy initiatives in a coordinated manner and is key for monitoring. How these aspirations will translate to legislation, and legislation to impact on society, is also crucial.

Figure 17. Demand and availability of AI master studies



Source: López Cobo M., et al. Academic offer and demand for advanced profiles in the EU. Artificial Intelligence, High Performance Computing and Cybersecurity, 2019[477]

Besides the Pillar, several key equality strategies have been adopted since 2020. These are:

- the EU Roma strategic framework for equality, inclusion and participation for 2020- 2030;
- Gender Equality Strategy, 2020-2025;
- the LGBTIQ equality strategy 2020-2025;
- the EU Anti-racism action plan 2020-2025;
- the Strategy on the rights of persons with disabilities 2021-2030.

The Gender Equality Strategy, for example, brings forward a vision of gender equality that is free from violence and stereotypes and has equal opportunities. This is connected to other actions to ensure equal participation of girls and women in ICT studies and developing their digital skills as announced in the 2020 Digital Education Action Plan and the European Skills Agenda. Also, the European Pillar of Social Rights puts gender equality at its core with ambitious targets for women's participation in the labour market and the provision of early childhood education and care (particularly important for working mothers). All of these initiatives contribute to a stronger cohesion in EU society that are important for achieving open strategic autonomy.

Skills availability

The EU has solid education systems. Despite this, continued advancements in education and training are necessary to ensure the personal and professional development of citizens and to guarantee a match between education and the future job market. Ensuring high quality and widespread access to education is one of the drivers of economic growth, social cohesion and research and innovation[478]. Alongside education, a substantial investment in skills is needed to support future jobs, critical sectors and emerging technologies[479], which will be key to supporting the EU's open strategic autonomy. A target of the European Pillar of Social Rights Action Plan is to have 80% of EU population having at least basic digital skills by 2030[480].

The EU's excellence in education helps to attract and retain global talent. The Digital Education Plan (2021-2027)[481] offers a vision of high quality, inclusive and accessible digital education in the EU and proposes to equip young people with cutting-edge skills and expertise. EU education and training exchange programmes (ERASMUS and ERASMUS MUNDI) expose young people from the EU, as well as people worldwide, to multicultural learning.

The EU's technological strength depends on the scale and quality of Member State capacities and competencies in critical technologies and sectors. According to the Digital Economy and Society Index (DESI)[482], the EU has a shortage of digital experts for developing cutting-edge technologies and 70% of firms lack adequate in-house digital skills. This requires substantial investment in human capital development[483]. For the moment, the US is leading with the highest number of programmes offered in the technological domains of AI, High Performance Computing, as well as more general

computer and data science courses. The next two most relevant geographical areas are the EU and the UK (with regards to having many programmes offered)[484].

In the area of AI, there is a small gap between the EU, UK and US in the offer of Masters programmes. Despite its world-leading universities and research institutions, the EU does not educate enough data scientists, programmers or business translators to ensure sufficient scale and depth for AI integration in commercial use[485]. While an increased demand exists in Europe, the offer (i.e. the number of Masters courses on offer) is not adequate (Figure 15). The EU needs to increase the offer of first degrees, Master and PhD progammes and to attract more international talent. Closing the gender gap and ensuring the inclusion of women is also an important aspect to address in the area of digital technologies (as well as STEM in general) in order to avoid gender biases and increase the numbers of skilled workforce.

Investment in skills will remain an important component for the EU's open strategic autonomy. The European Skills Agenda and the initiatives such as Pact for Skills, support the green and digital transition through upskilling and reskilling the workforce in the EU and skills partnerships. Estimations foresee that the EU and Member States would need to invest €42 billion per year to educate, upskill, and reskill the labour force in order to manage the digital transition. This is important, as 90% of new jobs will require digital skills[486].

Future opportunities and challenges

Increasing demographic imbalances

Demographic projections suggest that the world's population could reach nearly 10 billion people by 2050[487]. Despite a general convergence towards demographic profiles characterised by low fertility and longer life expectancy, the inertia of demographic processes will cause profound demographic imbalances between high- and low-income countries in the coming decades. On one side, in high-income countries, low fertility rates[488] are resulting in the rapid ageing of the population and the shrinking of the labour force. On the other, low-income countries with high fertility levels,[489] will experience an expanding total population with high shares of young adults in their populations. These demographic imbalances in terms of redistribution of total population and age structure are unprecedented in human history. They will play a key role in future geopolitical, economic and political positioning of countries worldwide, in the decades to come.

The already existing demographic imbalances mean that the EU's geopolitical and economic weight could fade. This is related not only to the decline in the sheer number of people in the EU compared to increases in the global south, but also to the size of the labour force and level of productivity, due to an ageing population. Besides this, there are other disparities and dynamics that need to be factored in, such as education and skills of the people[490] that further impact innovation capacity. This explains the differences in terms of economic growth between countries across the Global North and the Global South, and will also be key for the future.

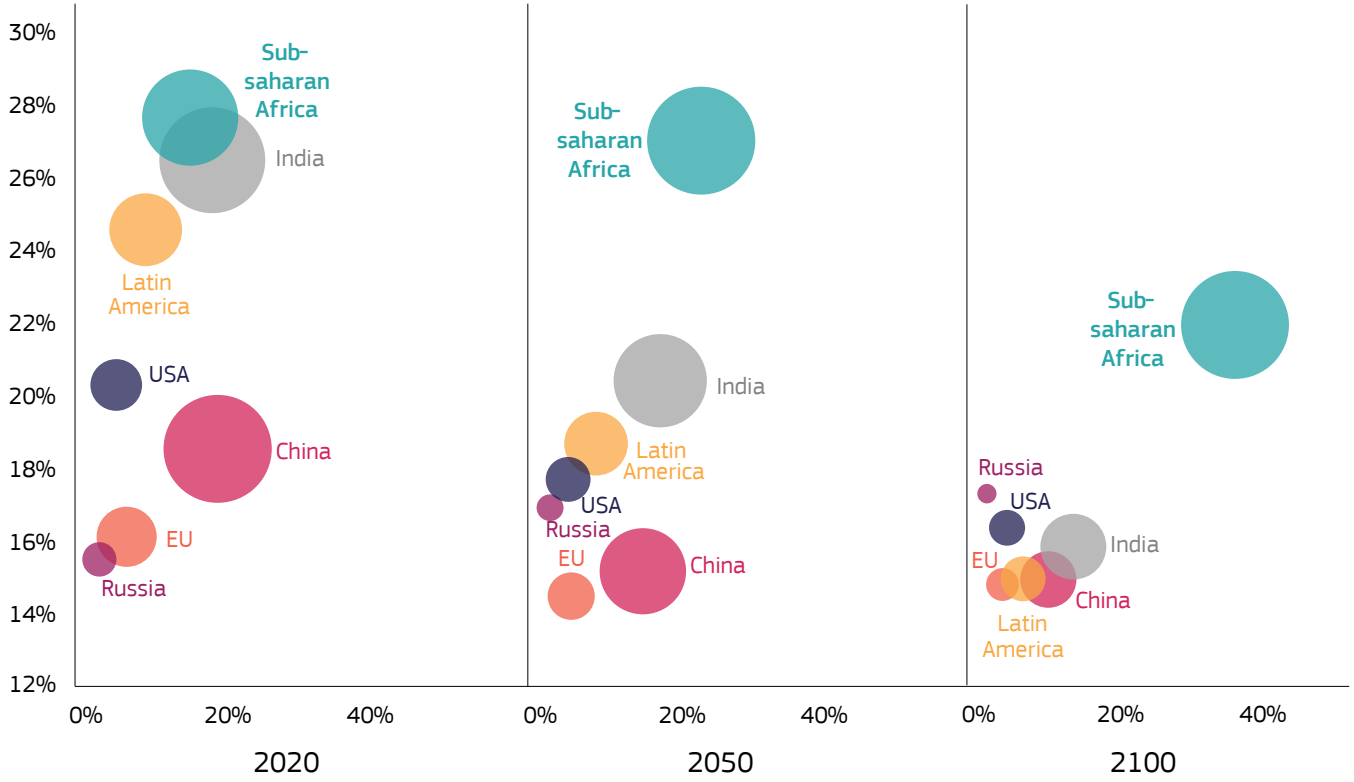
Demographic change will affect the EU's position in the world, its geopolitical strategy[491] and will create a need for the EU to be united, stronger and more strategic[492]. At a lower geographical level within the EU, large internal movements and residential preferences will continue to reshape demographic structures across regions and will and increase differences[493].

Demographic challenges place a strain on the sustainability of EU social protection systems. In the EU, ageing and declining birth rates have direct consequences for economic growth, demand for goods and services, as well as health and elderly care. While there are regional differences within countries, the old-age-dependency ratio in the EU has been increasing in recent decades, reaching about 1:3 in 2019, on average[494].

The EU will need to ensure that living longer at an individual level turns into an asset at the macro-level. Welfare systems need to remain sustainable; despite the shrinking labour force and ensure that internal demographic territorial differences and increased mobility do not lead to polarisation and lack of internal cohesion.

EU health and care systems will have to adapt further. Higher amounts of age-related public spending will be needed.[495] The EU4Health (2021-2027)[496] programme has committed to boosting the EU's preparedness for major cross border health threats, strengthening health systems to face large scale epidemics and other long-term challenges, as well as to making medicines and medical services available and affordable for everyone.

Figure 18: Share of the population in the world population (x-axis) by the share of the youth, in selected countries and regions, 2020, 2050 and 2100, United Nations medium variant.



Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population

The ageing process in the EU is associated with residential patterns that may result in an unbalanced mix of generations in the future. If individuals' social networks become increasingly homogenous along age and territorial lines, it will remove opportunities to experience intergenerational interactions and to get in contact with a variety of political views and issues. These dynamics may negatively affect social cohesion and nurture polarisations in the future population, with serious implications for the stability of the EU[497].

Greater importance needs to be given to securing talent. In an ageing society, attracting and maintaining talent becomes increasingly important. Well integrated migrant workers are key for keeping the economy going. Higher shares of female labour market participations could also increase the availability of talent. Lastly, securing the continued engagement of more mature citizens in the labour markets will be important considering they will constitute a growing share of the population.

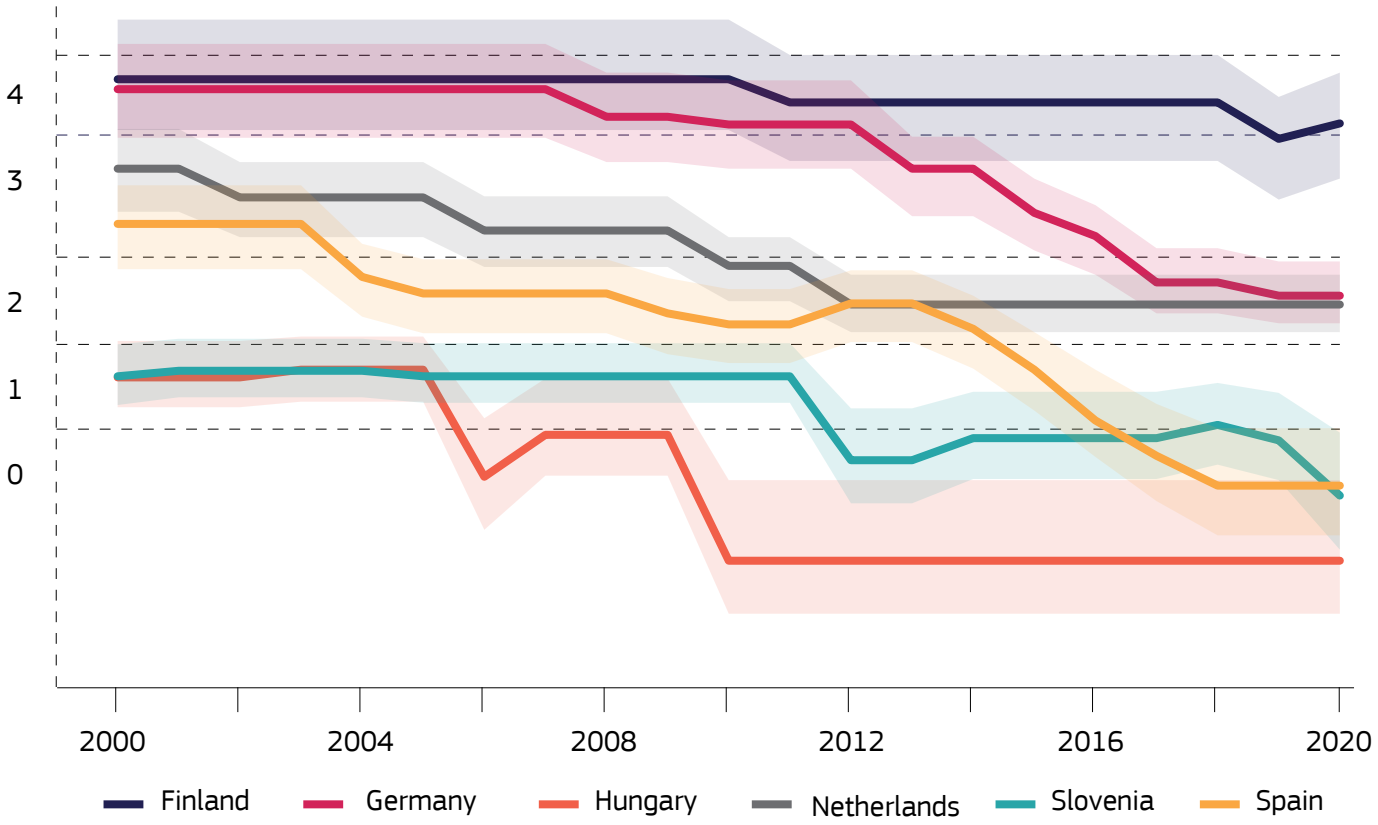
Increasing polarisation

Increasing polarisation in society poses a risk for our democratic systems and institutions, as well as the stability of internal affairs and international relations. Polarisation in society means the state or process of increasing divergence of people's attitudes towards ideological extremes[498] and leads to dissatisfaction and deep divisions in society. It is partly driven by social media rise and the disruption of traditional media industry. It influences personal interactions and everyday life, as well as for example, judiciary systems, media or civil society (with attacks on courts, journalists and activists, considering them as biased)[499].

Almost all EU societies have become more polarised since 2000, on almost all key political issues[500]. Figure 17 shows the increase of polarisation in several EU Member States, confirming the general tendency. Polarisation impacts negatively social cohesion and could cause political instabilities that might create obstacles for the implementation of open strategic autonomy policies.

Together with polarisation, disinformation, misinformation and conspiracy theories seem to have increased in recent years. Although for some scholars it is questionable how much disinformation influences political beliefs and increases political polarisation,

Figure 19: Polarisation of society in Europe



Source: V-Dem. Polarisation in Europe.

Note: (0 indicates serious polarization on almost all key political issues and 4 indicates no polarization)

the two phenomena seem to reinforce each other. [501]

Populism is another phenomenon directly fuelling polarisation. The traditional division between right and left wing parties has been increasingly replaced by a new division between establishment and anti-establishment parties. Populism tries to establish close relationship with the population and distance itself from the establishment, thus creating new divisions in society ("pure people" vs "corrupt elites")[502].

Given the present trends, growing polarisation, expansion of populism and disinformation are likely to continue to exist in the future, but their scale will remain uncertain. The national recovery plans supported by the EU need to tackle pre-existing inequality challenges, along with the detrimental effects brought on by the COVID-19 pandemic, to promote and ensure long-term social and economic resilience.

Citizen engagement with policymaking

Better inclusion of citizens in policymaking could increase the EU's democratic legitimacy and make social cohesion stronger[503]. Engaging citizens in policymaking processes ensures that public policies are in the public interest. By co-designing them with citizens, reliability and validity of policies can greatly improve.

Giving more direct power to citizens could contribute to the better functioning of European democracies, increased social capital and trust in political processes[504]. This can be done through diverse forms of citizen engagement such as citizen assemblies, deliberative polls or juries**.** Citizen engagement is one of the key pillars of open and transparent government. Successful examples in the EU have been seen recently at local and regional, as well as national levels of governance. EU Member States such as Ireland, Estonia, Luxembourg and Romania have employed deliberative methods to review their constitutions[505]. For example, citizens' assembly were organised in Ireland (2016-2018) that discussed and made recommendations for several constitutional questions, including climate change, the abortion referendum, gender equality and ageing population questions[506].

Citizen-led debates and discussions on policy issues could enable people from across the EU to share their ideas and help shape the common future. The European Commission's initiative 'Conference on the Future of Europe'[507] is a major pan-European citizen engagement exercise. While its impact on policymaking will be understood better in the future, it will provide lessons on more effective citizen engagement that could be done more often at the EU-level.

Technical tools and platforms are increasingly being used to engage with citizens too. The goal of these tools is to enhance and simplify the ways for citizen engagement and participation in policymaking. One such platform, Decidim, was developed in Barcelona. The success of the Decidim platform helped to spread its use to other cities and regions in the world. (For example, the Conference on the Future of Europe also runs through this platform).

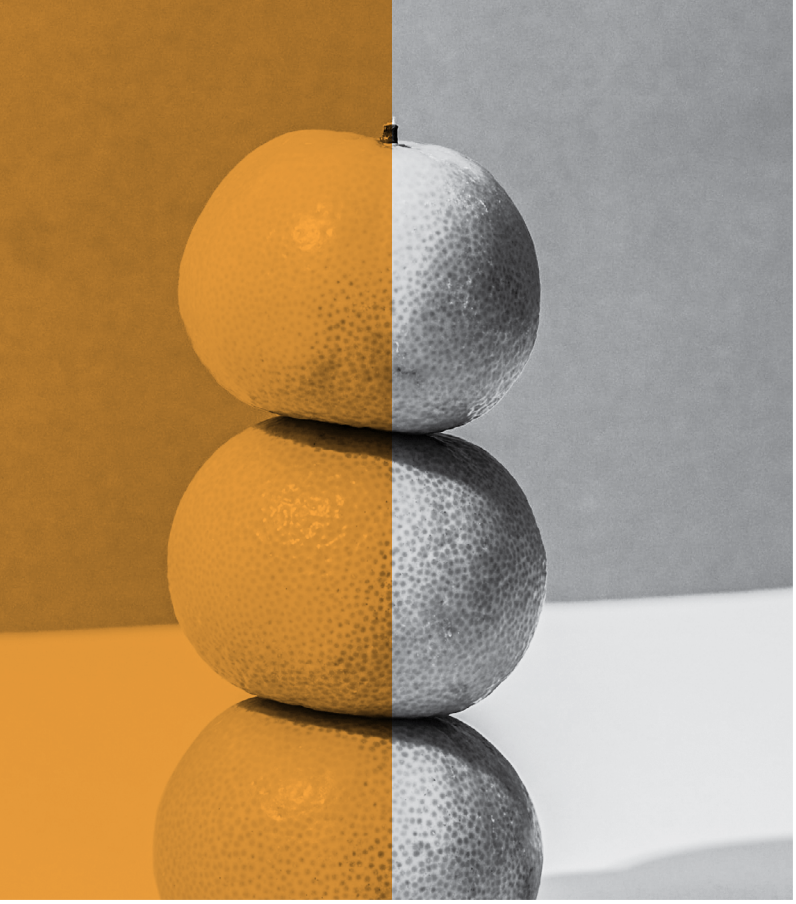
There is a space to increase the adoption of digital government services in Europe. For the moment, online public services are used by less than 50% of citizens. Around 48% of adult European citizens has used the internet for interaction with public authorities, ranging from 10% (Romania) to 89% (Denmark) in different EU Member States. Only 38% "submitted completed form" to public authorities via internet[508]. Besides digital divide and access, one of the main reasons is that the existing services were only transposed to the digital environment without being redesigned[509]. According to the Digital compass[510], it is estimated that all key public services should be available online to EU citizens by 2030.

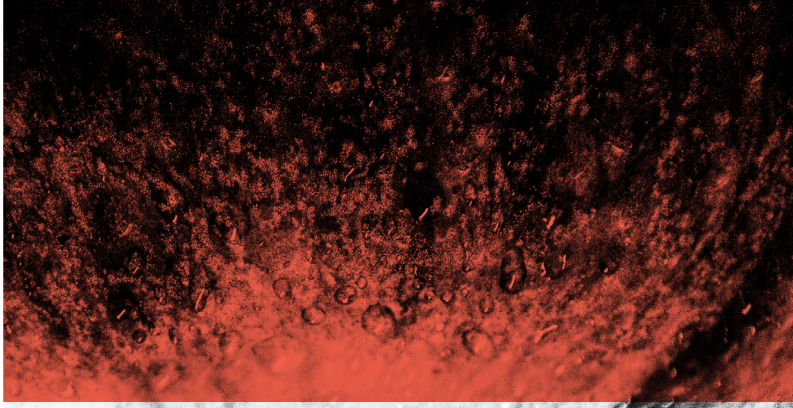
Citizens could be involved in the co-creation of (digital) public services. The digital transformation brings an opportunity for public administrations in the EU to redesign the services they offer to citizens and address society's needs better. Such human-centric digital public services would be accessible, inclusive and transparent, while respecting personal data protection rules[511]. If the data on the adoption of digital services were open, it would be visible in real time whether services are meeting user needs. This accountability mechanism could contribute to orienting decisions on public services in the direction of citizens' needs[512].

The involvement of citizens in policy making is crucial for open strategic autonomy. They can shape a common narrative to it. This is key for acceptance of trade-offs in any policy strategy and for citizen's commitment to the EU's pursuit of open strategic autonomy

In the next 20 years, a new generation Alpha (born between 2010 and 2025) will emerge in the public space. It is estimated that among others, this generation will live longer, stay in education more and be the most technologically skilled compared to the previous ones. The EU will need to monitor and ensure that its policies are fit for this and other future generations. Measures to improve social resilience in the future could include incentives for bottom-up innovation and active citizenship.

Giving more direct power to citizens could contribute to the better functioning of European democracies, increased social capital and trust in political processes.





SCENARIOS

Scenarios on the global standing of the EU in 2040

The following section presents constructed foresight scenarios that look at the EU's standing and the role of the open strategic autonomy in four different possible futures. However, the world in 2040 is not something that can be grasped with absolute certainty. These scenarios therefore represent an attempt to construct a number of hypotheses about the future, which can help frame assumptions about the present as much as about the future. By design, each of the four scenarios is at the edge of plausibility.

Scenarios enable us to explore possible futures and their potential implications by reframing individual and collective assumptions[513]. By showing gradations in the EU's possible internal and external contexts in 2040, the scenarios challenge assumptions about the future of the EU.

It is important to clarify that foresight scenarios are not predictions of the future, forecasts or desirable visions. Rather, they are coherent simulations of plausible future states of the world that highlight the ways in which trends, weak signals and uncertainties from the present could develop in the future. In so doing, foresight scenarios reveal the choices available today and their potential consequences for the future.

In essence, the future cannot be predicted, although some of the elements of the future can already be discerned. There will inevitably be a mixture of 'known unknowns' and 'unknown unknowns' – so called 'black swan' or wild cards events. To give an example, foresight processes over the last 10-15 years have consistently pointed to the plausibility of a global pandemic. In the same way, foresight scenarios do not claim to be complete, but rather to give a sense of what possibilities the future could hold.

The scenario building exercise helps to increase preparedness in policymaking. Foresight scenarios challenge the policymaking world to consider afresh what actions it could and should consider taking, in order to be prepared for some future event, or to mitigate the effects of others. In other words, by making the future explicit and contestable, the scenarios can provide a springboard to consider the adequacy and effectiveness of current and planned policy interventions.

Eight workshops in which scenarios were co-created took place from November 2020 to March 2021. Members of the European Commission's dedicated working group on open strategic autonomy from different services participated in these workshops. In a second step, selected experts from EU institutions, academia, industry, policymaking and civil society organisations were involved in the process, in order to test the plausibility and coherence of the set of foresight scenarios.

A set of scenarios presented below shows what the open strategic autonomy would mean in each of these futures. The four scenarios have been named: 'Green Leadership, 'Complex Prosperity', 'Economic Growth Above All' and 'Retreat Inwards'. They each present different, plausible futures of the EU in 2040.

GREEN LEADERSHIP

A glimpse of the world in 2040

The EU leads by example and promotes a green vision for a carbon-neutral way of living. The EU and a close group of like-minded countries prioritise natural ecosystems. Together they represent around 30% of the world's economy. These countries are 'clean tech' leaders, on track to becoming carbon-neutral by 2050. Renewable energy provide 100% of the electricity in the EU. The EU uses its soft power to convince neighbouring countries and others around the world to join this group, focused on the green economy and delivering on the SDGs and where GDP is no longer at the centre of the economic model. The EU and like-minded countries require high environmental standards as part of trade agreements. However, the majority of the world's nations continue to prioritise economic wealth, with more relaxed trade regulations and lower environmental standards. Conflicts emerge at the global level over access to resources, economic power and in regards to trade and technology standards.

The perspectives of open strategic autonomy in “Green Leadership”

Geopolitics

In this scenario, geopolitical tensions are present in the majority of the world’s countries around access to resources, trade and standards. This competition leads to significant rifts in a few regions. For example, the US and China are in constant conflict regarding technology standards, trade, or access to raw materials due to their resource-intensive economies. The EU has increased its presence in NATO and uses the organisation not only for defence purposes, but also to promote EU priorities among the partners of the alliance.

Cyber surveillance and physical control of goods, people, and capital inside EU, along with external border control are utilised widely to guarantee stability of what is considered a balanced system, without too much external interference. High priority has recently been given to combating fraud from within and outside the EU. These mechanisms are also used to control external influence on social movements, to avoid political turbulence.

Technology

Based on substantial research efforts and innovation support, the EU is becoming fully independent of clean and digital technologies from countries outside of the green alliance. The culture of tech start-ups is flourishing. Through technology leaps, it manages a quick transition to a carbon neutral energy system, and it is even able to export surplus energy. Circular economy, material development, synthetic food production and agri-tech are key enabling fields driven by smart connectivity, also in Europe’s autonomy strategies of sustainability. Following a dual use paradigm, Europe is strong in second generation quantum computing, scalable satellite mesh networking, and new decentralized data protocols for public services. However, globally the technology market is fragmented. Multiple different digital standards at the international level and conflicting extraterritorial events are a serious weakness.

Economy

The EU reduced its dependency on global resources drastically, through energy independence based on nearly 100% renewable power, circular economy and the substitution of critical raw materials where possible. These measures also reduced Europe’s dependence on imports.

Limited market reach for its high standard products is a problem for the EU, as their group of sustainability countries covers only a small share of global GDP. The EU tries to overcome this limitation by swapping green technology for scarce resources to build lasting partnerships and at the same time transfer the values of a sustainable economy for the long-term perspective of economic well-being.

Environment

The EU has committed to actively project a green agenda and carbon neutrality, cutting edge technology companies and strong funding from central banks. Nature conservation is part of the EU’s philosophy. The capacity of ecosystem services is strengthened; their use is managed sustainably through carbon taxes and payments for ecosystem services.

The EU tries to project its values through soft power negotiations, partnerships globally and by offering sustainable technology as an incentive for critical resources.

The vulnerability of the European-led bloc is the global interconnectedness of the nature ecosystem and climate change impacts. As long as the majority of societies do not join the sustainability path, the climate crisis will accelerate, natural resources will be exhausted and nature irreversibly destroyed.

Society

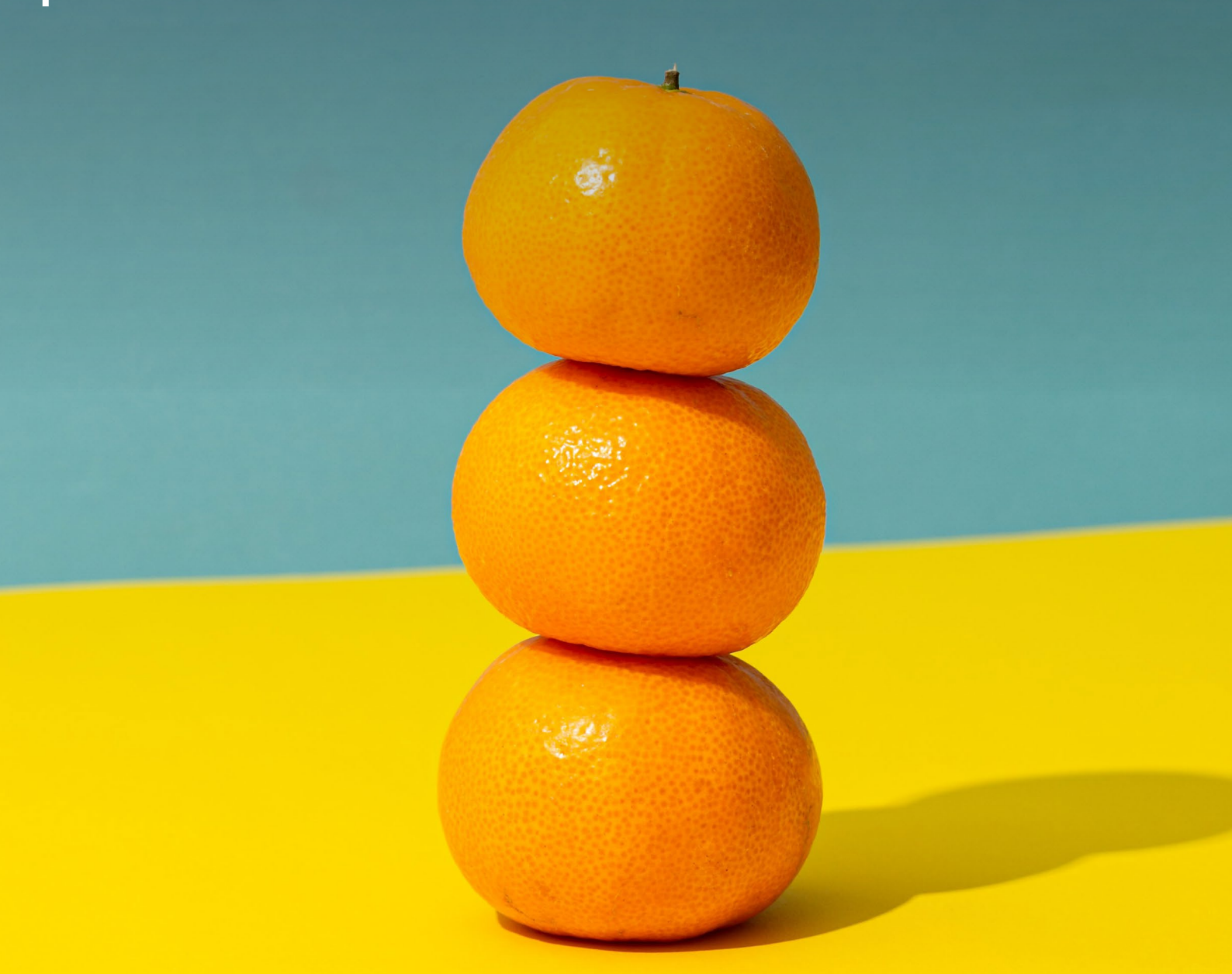
The green transition has created winners and losers. Income disparities, access to education, healthcare and technology, and their compounded effects represent the most important social challenges in the EU. The EU urgently needs deep social reforms, but they are not prioritised. Public spending centres on green investments and public budgets are strained due to low economic growth rates, as international trade is limited to only the group of sustainability countries. A malfunctioning health system counteracts the image of excellence that the EU is trying to sell to the rest of the world.

The EU is open to migrants, but only the ones that help to overcome its lack of specialists. Shelter is not something that Europe offers. Alongside all of the green efficiency and digital transparency, this is a weak point for the continent in international debates on human rights and inequalities.

COMPLEX PROSPERITY

A glimpse of the world in 2040

Society has inched forward to create a more sustainable planet, but how sustainable it is, is not clear. We live in a world of relative economic prosperity and multilateralism. There are efforts towards the joint governance of the commons. In this multilateral world, a focus on strategic autonomy has equipped the EU with the ability to participate in setting the global agenda. The EU is still able to attract Eastern European countries away from Russian influence. The US and China are economic leaders in global trade that offers growth and prosperity for the most part. The EU remains a part of this globally trading world, but continues to lag behind in the latest research and innovation trends. Citizens are supportive of the EU's ecological ambitions, but they now reject traditional governance systems. They feel excluded by experts and are more prone to embracing conspiracy theories and believing in 'alternative facts'.



The perspectives of open strategic autonomy in "Complex prosperity"

Geopolitics

The EU is still a global actor. However, it struggles to remain influential in a multilateral world where the US and China lead. The EU is not the preferred partner for the dominant regional players in Africa, Latin American or Asia, but keeps strategic ties with several of them. In this multilateral world, the UN and its agencies are the ultimate platform for steering global developments.

There is stability in the EU's Southern and Eastern neighbouring countries even with a recent wave of migratory flow coming from Sub-Saharan Africa. NATO is the institution that secures the EU's position in the global order and military investments by EU Member States are low. EU defence structures are now tackling cybersecurity attacks on corporate and industrial actors and developing intelligence monitoring on external economic interests.

Technology

The EU and its Member States focus on public programmes in frontier science at EU-level. Similarly, R&I budgets have been transferred from the national to the EU-level and are larger than ever; a fourth round of 'moonshot programmes' is targeted at relaunching the EU's global leadership in R&I.

The EU's main goals focus to manufacture and secure synthetic substitutes for critical raw materials, and to stimulate the internal market on emerging green technologies. The latter should reduce a growing dependence on China and the US, while increasing the competitiveness of EU industrial and business ecosystems. European digital healthcare and renewable energy players are among the global leaders.

There is full alignment amongst EU members on the need to strengthen EU standards within technological sectors even more. There is a renewed push to maintain the EU as a central player in sectors where ethical and responsible research and innovation can be an asset.

Economy

In the EU economy, stakeholder-centric models have emerged, with mitigating climate change and environmental destruction as the leading driver. However, apart from core public investments in R&I, and strong private conglomerates in climate mitigation and health industries, EU innovation ecosystems are not flourishing enough.

EU investments mainly aim to support domestic interests. US players invest heavily in EU industry and the governments of EU countries are trying to help the EU players in their domestic markets with dedicated support programmes. Similarly, the EU and its Member States try to maintain influence in Latin America and Africa, where China is increasing its presence.

Alongside giving financial support to EU companies, the EU is trying to invest in attracting the best talent, as there is an increasing brain drain towards the US and Indian markets. This is leading to the challenge of high levels of public debt, which the EU institutions and Member States have to deal with.

Environment

The EU's environmental priorities are in alignment with the SDGs and compliant with multilateralism. The bloc relies on the engagement of its institutions and Member States in international fora such the new Association of Southeast Asian Nations comprising 15 nations, now also an alliance of climate mitigation frontrunners. The EU leads the new ecological order and supports the growing global governance of the commons (i.e. the natural environment).

EU investments pivoted largely towards climate mitigation technologies and renewables that have helped to secure Europe's fast energy transition and independence. Strong political support around these options makes it easier for European political actors to focus on them.

There is a lack of similar policy priorities towards other environmental issues. Public funding and regulatory impulses targeting environmental issues other than climate change are more limited. An imperfect consensus between international and regional levels makes it more difficult to act on those issues.

Society

The EU as a whole lags behind North America and ASEAN on policies that are successfully stimulating high employment and education levels.

Despite continuous investments steered by European institutions, some European regions still lack robust welfare and labour policies. These regions are characterised by low levels of life satisfaction, a spike in non-communicable diseases and mental health issues.

The younger generation is experimenting with new modes of civic participation, albeit with limited interest from decision-makers. There are increasing frictions around social rights, which in the past were considered to be amongst the core values of the EU. Intergenerational solidarity in Europe is fragile and pressure is mounting. Extreme pension reforms have been put in place due to the high public debt reinforced by ageing population.

ECONOMIC GROWTH ABOVE ALL

A glimpse of the world in 2040

This is a world where instant wealth has priority over long-term well-being. Global trade is booming. The EU has new alliances with Africa on raw materials. Industry 7.0 (characterised by human-machine interaction, computer-aided manufacturing and automated individual one-off production) is underway. Private interests dominate public policy. Open strategic autonomy also depends on private sector interests. Polluters avoid consequences, the natural ecosystem is collapsing and social capital is low. However, global financial institutions are intact and functioning well. The EU is enhancing the power of euro. Big Tech is pervasive and winning the race for talent. Self-governing communities of like-minded people have arisen that share high levels of solidarity as well as resources. Powerful state and terrorist rogue actors exploit disinformation to underpin cyberwarfare. The US and India dominate the space race, with the EU in third place. China's centralised political system is under pressure from demographics, debt and enhanced global competition.

The perspectives of open strategic autonomy in "Economic growth above all"

Geopolitics

The EU is collaborating strategically with India, Africa and South America. These new and redefined relationships focus on economic connections (e.g. investment agreements). Deeper longer-term agreements and partnership were established between the EU and African partners 15 years ago to support African trade integration, as well as digitalisation, and the EU is still benefitting from these. India has become strong in the fields of biomedicine, pharmaceuticals and APIs (Active pharmaceutical ingredients), important for new diseases and epidemics caused by climate change. An ageing China is under social, economic and military pressure. Internal social tensions have forced it to devolve power to the surrounding regions. However, the EU is still dependent on it for rare earths and lithium, with needs for lithium having increased 60 times in the past 20 years.

Technology

Technology breakthroughs, followed by soft regulatory approaches, have increased and tech use has expanded relentlessly, empowering tech companies. Following Industry 5.0 (collaborative robots) and Industry 6.0 (boost of computer-aided manufacturing), investment is now channelled towards an Industry 7.0, aiming to help maintain corporate power and to fuel GDP.

The EU, as well as the US space companies are investing in projects that prepare to mine the Moon, rich in three critical resources: water, helium-3 and rare earth metals, which is planned to start by 2045. With massive investments through public-private partnerships, the EU is among three leading players in the global technology and space race, although it still lags behind the US and India. Innovation is stimulated through venture capital investments. Richer Member States invest heavily in the development of 'dual technologies' that are used in both military and civic applications. AI and 'upgrades' of humans using augmentation technology has created advantages for those having the means and the skills. Cyber-security has become a prominent issue and the private cyber-security corporations play a leading role now, attracting the IT talent.

Economy

The main challenges that have emerged are to enhance the power of the (digital) euro and engage in the technology race. Economic growth is fuelled by unregulated markets. Small and medium-sized enterprises are left behind in this world, where strategic autonomy ambitions foster only larger businesses.

The EU is a big producer of synthetic food and to some extent algae (which used for food, but also pharmaceuticals, bioplastics, fertilisers and biofuel). The EU imports more than 50% of its vegetables, fruit and meat (mainly from South America). Two out of the first five synthetic food technology companies were developed in the EU. They quickly expanded their food production globally and gained material power with the mass production of synthetic food - which the world now needs to survive. In the EU, energy sources are 50/50, own energy versus imports.

Environment

The EU and other continents failed to achieve the Sustainable Development Goals by 2030. Those who rely on fragile natural ecosystems are under pressure to change their source of income and place of living. Fishing communities struggle because the rise in sea temperature has impacted seafood habitats and fish stock. Coastal communities face a crisis, with internal displacement and forced migrations towards neighbouring countries and other continents.

The EU invests in the green technologies that are aligned with its economic interests. Agriculture relies more on chemicals, synthetic meat and high-tech food production, as well as imports. GMOs are widespread because they are the only crops that can resist extreme weather conditions and are required to satisfy human food needs. Synthetic milk, cheese, yogurt and meat have partly reduced the demand for land, water and energy and the threats of potential diseases.

Society

Reskilling programmes are part of the packages offered by private companies in the EU to help meet new work requirements. However, there is still a substantial part of society without job security. They are turning into a flexible, but vulnerable lower-class workforce. Rich Europeans can largely benefit from the use of AI and new technologies in healthcare prevention and treatments. They live longer, healthier lives.

Investment in promoting shared values and societal cohesion is not a priority. Polarisation skyrockets, fuelled by the misuse of new technologies by extremist political parties and non-state actors. The majority of states have retreated from the social sphere and from an active construction of a better-shaped society.

RETREAT INWARDS

A glimpse of the world in 2040

Independence to act in one's self-interest is the modern credo for nations in this mid-21st century society. This is a de-globalised world. Weakened food supply chains, growing water scarcity and the spreading of diseases prevail. The EU has been less negatively affected by the impact of climate change than other regions. The choice of food has dwindled, but the EU has still reliable food supply chains and unlike other regions has no existential threat of water scarcity. The EU invested heavily in its open strategic autonomy. The elected leaders and voting patterns have resulted in the prioritisation of the interests of an ageing society – pensions, healthcare – over those of younger generations. Even if that means overtaxing youth, excluding them from political power and failing to address environmental concerns adequately. Traditional military alliances and the institutions underpinning the Western world since 1945 have become ineffective, as each nation prioritises its own interests rather than aiming to reach shared goals.

The perspectives of open strategic autonomy in “Retreat inwards”

Geopolitics

Regional blocs of nations concentrate on reducing their dependence on critical imports, which has led to a diversification of regulatory standards. The circular economy has become a political priority, and regions implement high import duties on commodities, to protect local production.

After the US disengaged from multilateralism and following the abolition of NATO in 2030, the EU founded the European Defence Alliance that also includes some non-EU countries such as Norway, Switzerland, the UK and Turkey. The alliance protects its southern border from the growing political instabilities in the Middle East.

The EU switched from fossil fuels to renewable energy and has reduced its energy dependence from 54% in 2018 to 35% in 2040. The mobility transition is less advanced and only short-distance road transport has shifted to battery-powered electric vehicles. Long-distance cargo and passenger transport still rely on fossil fuels.

Technology

The global technology landscape has changed into local platforms and standards. The World Wide Web does not exist anymore. Instead, there is the ‘splinternet’, driven by protectionist policies and censorship. The EU continues to invest in research and innovation. The desire to become less dependent on critical materials and goods has created strong domestic markets for relevant technologies. Priorities for innovation in the EU include fields necessary for its independence.

Climate-change adaptation technologies are being developed (e.g. quantum computing for meteorology). Technologies that support human adaptation to the hostile environment (such as biological engineering) and defence technologies are also prioritised. In addition, there is investment in e-health i.e. remote medical solutions and home-based care that uses robots, as well as technologies that support circularity and resource independence.

Economy

Remote working gained acceptance and digital platforms became a critical infrastructure for the EU. Supported by a regulatory framework that effectively dis-incentivised foreign operators from running these platforms, EU-based platforms emerged.

In the late 2020s, China, limited their exports of critical raw materials to protect their own technology leadership in electric vehicles and renewable energy. These developments triggered efforts in the EU to become less dependent on critical goods and their materials imports.

The resulting reduction in global trade and reduced GDP growth rates has reinforced several pressures on EU public finances. These include adaptation to climate change, independence from critical materials and goods imports, welfare system costs, and military expenses.

Environment

The ageing population prioritised the preservation of their welfare states over climate action. The climate targets set in the Paris Agreement were not reached, leading to a drastic increase in the frequency of extreme climate events.

The EU continues to invest in climate change adaptation measures, to decrease its vulnerability to extreme weather events. As the impact of climate change varies across the EU regions, there is a growing north-south divide within the EU.

While water scarcity in the EU has increased, the adaptation measures have helped to manage this challenge and the EU can still grow excess food.

Societv

Europe’s high standard of living keeps the region attractive for immigrants. However, the EU’s ageing society has put the EU’s economic development at risk. The EU has launched programmes to promote active and healthy ageing and lifelong learning. In addition, AI makes the EU’s shrinking workforce more productive.

Social and economic divergences have led to increased tensions between different social groups in the EU. Young people have been excluded from political power, as policymakers do not pay attention to their needs, and migrants are finding it difficult to access welfare systems.

Key conclusions and uncertainties emerging from scenarios

Policy issues are characterised by a mixture of complexity and uncertainty. Open strategic autonomy related policies are long-term strategies, as they build on bundles of initiatives in several policy areas and fora. To give a better sense of what the EU could do now to better prepare itself for an uncertain future, we present some key uncertainties that have emerged from the scenarios. Following this, the implications for the EU's future open strategic autonomy related policies have been considered based on the analysis of the foresight scenario set. These can be used to help to visualise and understand the most important steps ahead.

Geopolitics: building alliances and political cohesion

● As the scenarios imply, building strategic alliances with like-minded countries while fostering multilateral and rules-based international cooperation will be important elements of open strategic autonomy. These will be critical to ensure access to the assets and resources that Europe needs to implement its green and digital transitions. Some scenarios suggest that the EU could build strategic alliances with Africa, or form an EU-India alliance. The scenarios point to the possibility of monopolistic exporters limiting the global supply of raw materials, while the EU's dependence on food from South America might increase. China may also advance in its dominance of critical EU supply chains, such as ICT, medical equipment, infrastructure, with the EU struggling to remain influential in a multilateral world where the US and China lead.

● It is important to develop the EU's security and defence capacity to address potential conflicts and attacks. The possibility that conflicts between regions may arise in the areas of standards, trade, access to raw materials and cyberspace is significant. In addition, the scenarios offer different pathways for the evolution of the EU's security and relations with the NATO alliance.

● It is important to exert influence on and establish a clear position with regards to important global players, such as the US and China, who will likely be the world's key economic and military powers in 2040. This will entail withstanding competition and promoting cooperation with these powers concurrently. This could involve, for example, maintaining a sustainable presence in the space race as this has consequences for the future of the EU's communications, earth observation, and manufacturing capabilities. India and the US could for example dominate the space race, coupled with an EU 'brain drain' towards these countries. This is important to consider, because the ways in which India, Africa, Russia and Latin America will position themselves in the growing redistribution of power is unclear, with alternatives ranging from moving alone, in bilateral partnerships, or favouring developments and influence coming from either the West or East.

Technology: EU leadership on R&I, regulatory frameworks and standards

● R&I and start-up investment will be important to support European technological leadership. A fragmented global innovation ecosystem would slow down innovation rates, which in life sciences could delay the fight against any new diseases. Prioritisation of R&I and start-up investment could drive GDP, for example in synthetic substitutes for rare earth elements, bioengineering technologies, or frontier research and breakthrough projects. In the digital domain, respecting rules of privacy, data ownership and protection of digital services is a prerequisite for open strategic autonomy.

● If Europe is not strong enough in digital technologies and the regulation of cyberspace, European critical infrastructures (e.g. hospitals) as well as citizens will be vulnerable to potential disruptions by malicious actors.

● Promoting Responsible Research and Innovation (RRI), together with regulatory frameworks and standards, will be a European asset in a number of sectors. A lack of standards and ethical and regulatory frameworks in R&I could make Europe vulnerable (examples range from autonomous vehicles, to genomics). RRI is therefore of considerable importance for European societies to thrive. In addition, the EU will need to have an impact on global technological standards in the future in order to stay competitive.

● Private-public partnerships will be important in sustaining the further development of technologies such as AI, data, blockchain, photonics, robotics and quantum computing. The EU could explore how to better co-design and cooperate with private investors to de-

velop public-private funding mechanisms to further finance young innovative start-ups. This could include the promotion and facilitation of tech start-ups led by women that still account for only a small proportion of tech start-ups.

Economy: level playing field and norms in global trade

● Establishing a level playing field in global trade will contribute to ensuring the competitiveness of the EU economy. Open trading conditions combined with competitive advantages and favourable production conditions could enable EU businesses to remain active and competitive across the world. European companies face the risk of unfair competition due to monopolistic or state-backed actors. Increasing protectionism (policies that restrict international trade to help domestic industries) can lead to a fragmentation of the global economy. Such a development could also limit the market for domestic products and harm export opportunities. Trade is also a means to project European values globally.

● The EU could shape the norms that regulate global markets through proactive collaboration with technology developers, start-ups and scale-ups companies, research organisations, and international standardisation organisations.

● An adequate regulatory framework with fair taxation can ensure a more diversified landscape of digital players, thanks to the digital transition. This could reduce the possibility of global IT giants running the operating systems of the digital industry and having the power to create service supply dependencies.

Environment: climate change mitigation and adaptation, climate diplomacy, green technologies

● Climate change mitigation and adaptation as well as developing the circular economy will remain key issues in the future. The implementation of a circular economy is not only a pillar of environmental priority, but can also help to decrease the EU's import dependence on critical raw materials by extending the lifecycle of products. All scenarios reflect the importance of a green transition and the negative effects of non-action, such as the increasing frequency of extreme weather events, or food and water scarcity.

● Climate diplomacy will be important for the future. Insufficient global climate action create lose-lose situations. Global efforts to combat climate change would create a level playing field that avoids the risk of the relocation of carbon-intensive industries from regions with high climate ambitious, to other regions (carbon leakage). Affected sectors include chemical, steel and cement production. It is important for EU economies to protect their industries from unfair competition (e.g. by implementing carbon price adjustment mechanisms).

● Green technologies are an enabler of the green transition and constitute a growing market. Building on its pioneering role in funding green technology development could help the EU remain a technology leader. The economic importance of green technologies (e.g. wind power generation, direct solar to hydrogen conversion technologies, atmospheric carbon capture and conversion) is growing in a world that strives to become climate neutral. Such technologies affect all sectors of the economy and are crucial for emissions reduction and increased circularity.

Society: social cohesion, participatory governance, talent attraction

● Strengthening the participation of citizens in policy-making, as well as social and resilience, while diminishing social fragmentation, will remain priorities for the future. Potential vulnerabilities could emerge from increased polarisation and tribalism in society that could tear the social fabric apart, and diminish trust in government.

● The alienation of citizens, especially young people, and their exclusion from political life is a potential threat.

● Attracting talent and upskilling the workforce will be important for the EU's Open Strategic Autonomy. The EU has to retain existing talent in Europe and to attract talented individuals from other regions. The EU might be capable of attracting highly motivated and engaged talent in circumstances where it continues to have high social and environmental standards.

IMPLICATIONS

FOR THE FUTURE

Implications for the future

The following section presents the implications for leveraging the EU's capacity to achieve and maintain Open Strategic Autonomy by 2040 and beyond. These implications highlight the ways in which the EU can use its existing strengths and develop further capacities, both by itself and through alliances. It also addresses current weaknesses and upcoming challenges, seize underlying opportunities, and implement identified priorities required to shape and guarantee its open strategic autonomy. The implications outlined should be considered as a set, as in this way they can ensure establishing a coherent policy framework.

The implications for the future are presented below across the five areas of analysis of open strategic autonomy. Implications square the identified priorities and with the strategic learnings from capacities areas of improvements and forward-looking trends and scenario insights.

Geopolitics

Build inter-regional relations in the EU's neighbourhood as a priority

The EU needs to strengthen inter-regional relations, especially in its local neighbourhood. Current expectations concerning the future of the international order have shifted drastically in the last ten years. The world has grown more diverse and contested, with major powers, such as China, asserting not only their interests, but also their respective worldviews and norms. Current developments clearly point to the intensification of competition both at the global level and across key regions. In this context, the EU could focus its efforts on inter-regional relations, including EU-Asia relations that are expected to grow. As the world moves from global multilateralism, inter-regional multilateral relations become increasingly important, especially regarding Eurasia, East Asia, the MENA and sub-Saharan Africa regions[514].

The deterioration of the conditions for stability, development and security in the MENA region and Africa represents a key test for Europe's open strategic autonomy. In the current highly contested environment, the EU needs to position itself to be more in the driving seat, by focusing less on its own agenda and focusing more on the needs of these regions and their people. The EU needs to prioritise their stability and resilience, policy development and resources, to lead a co-designed agenda with the key stakeholders. Developments in neighbouring regions carry direct implications for the EU and its Member States, while Europe's engagement in these regions has been particularly intense, involving a wide range of policy initiatives and considerable resources.

Framing Europe's strategic autonomy should go hand in hand with shaping stronger partnerships with neighbouring countries and Africa. This is key as opposed to mainly externalising decisions taken at EU level[515]. Achieving more strategic autonomy when partnering with neighbouring countries and Africa requires the targeted and joined-up use of these resources, including innovative forms of development finance. Fostering the Team Europe approach[516], beyond dealing with the immediate impact of the pandemic and with the close involvement of the European Investment Bank and the European Bank for Reconstruction and Development, can be part of this approach. Europe should also use its convening power to engage other international actors through broader alliances on specific priorities, such as providing basic health facilities, ensuring food security and building digital infrastructure.

Strengthen the transatlantic partnership

A robust transatlantic partnership is in EU's strategic interest. Fostering open strategic autonomy can be seen as contributing simultaneously to strengthening the transatlantic partnership, bargaining more effectively with the US where positions differ, and preparing for possible future discontinuities in US politics and foreign policy. The strength of the partnership depends on the strength of the partners. This concerns not only the central role of NATO in Europe's collective defence, but also cooperation between the EU and the US to reform and strengthen the rules-based international order[517, 518]. Advancing open strategic autonomy would make the EU a stronger partner both by equipping Europeans to take more responsibility for their security, alongside the US or on their own, and by reinforcing the EU's regulatory power to engage with the US and others in rule making.

Advancing open strategic autonomy would enable the EU to define and defend its position on its own, in bilateral and in multilateral fora. It can also create incentives for transatlantic compromise as opposed to simply aligning with the positions of others. This is important even in the context of the renewed partnership, for instance if the EU and the US may not see eye to eye on some issues, such as trade or digital

matters. Moreover, were the US to reduce some of its external engagements, by choice or necessity, or revert to a more nationalist and unilateral posture at some point in the future, the EU should be prepared to uphold its agenda on its own, while still seeking cooperation with the US where possible.

Enable the EU as a laboratory of multilateralism and multi-level governance

The EU has a vital role to play in bringing multilateralism into the 21st century. This can be done by ensuring it is relevant and effective in the emerging context and future-fit, particularly in coping with and meeting the expectations of the multiplicity of players, in particular the rising economic powers. From an open strategic autonomy perspective, the EU needs to invest in this higher-level reframing of the global governance, thus building momentum for anticipatory governance[519]. In fact, it should be at the forefront of this transition process. This is key to setting the rules and defining the process for a better-functioning, more open, and equitable global economy and multilateral relationships[520].

The EU can drive the forces of change in reforming international institutions to make them fit for the challenges of this century. It is important to ensure that these institutions are more representative, less bureaucratic and more effective in advancing multilateralism. This will increase respect for these institutions and the rule of law. The EU is well-positioned to identify the basis for such reforms, drawing on its experience in multi-level governance, to ensure fairer working structures and procedures. To do so, the EU needs to promote its own interests and values using its leverage in organisations such as the WHO and WTO, as well as to enhance the legitimacy of the multilateral order in cooperation with regional organisations such as the African Union, the Organisation for Security and Cooperation in Europe, ASEAN, G7, G20 and more[521].

Position the EU on US-China rivalry

The EU has to position itself considering the increasing US-China rivalry. This growing rivalry raises the question of how to coordinate better the pursuit of open strategic autonomy. An approach could include a definition of the EU's approach to China, with a sustained dialogue with the US and other like-minded partners on the implications of China's rise[522]. The EU could also act a moderator to enhance its contribution to agenda-setting, open avenues for building new strategic alliances.

Strengthen the EU's soft power and ability to compete in setting global standards

The EU needs to develop and maintain the same level of agility and purpose as its competitors. This will entail building worldwide alliances and using international institutions, and focusing on the critical areas where it can exert the most influence. In order to strengthen its standardisation power, the EU could connect its vast experience in setting internal rules and de facto international standards with its research and technological excellence.

The EU could focus on identifying critical areas and technologies for standardisation. This would entail monitoring international developments of competitors, as well as the connection between research and standardisation, particularly in critical areas (such as digitalization). A proper and fast approach to standardization is needed to advance economic gains, growth, sustainability and competitiveness, and societal benefits from digitalization. The speed of digital developments and global shifts requires bold action[523].

Embed space and strengthen the EU's defence and security policy

Critical requirements to advance the EU's strategic autonomy include enhancing coherence between the recently established frameworks for defence cooperation within the EU. Another important aspect is the strengthening of Europe's defence technology and its industrial base. Fostering open strategic autonomy will contribute to better collaboration between the EU and its allies whenever possible, and to be more self-reliant when needed. A strong defence base will enable the EU to play a more incisive role in NATO.

A strong defence and security capacity will bring the EU closer to its neighbours. Europe's will and capacity to take more responsibility for its own security and that of others, in particular in the EU neighbourhood, is required for the EU to be able to advance its interests, values and agenda in a world of growing geopolitical struggles.

The Strategic Compass arrives at a time when there is a need to more fully integrate space into EU security and defence. The Strategic Compass[524] is the EU's first real opportunity to craft an EU Space and Defence Strategy that can simultaneously link various policy domains, while also enhancing the visibility

and importance of space for security and defence. Other strategies such as the existing Connectivity Strategy with Asia and/or the EU Maritime Security Strategy can also benefit from the work conducted under the Compass. New strategies on the Indo-Pacific may also benefit from a more coherent EU approach to space and defence.

The Strategic Compass could elevate space and defence to a political level through the development of an 'EU Space and Defence Strategy'[525], [526]. While recognising the technological and political autonomy of the EU in space matters, there is also scope to enhance EU-NATO cooperation on space[527]. The EU could increase its cooperation with new NATO space bodies and initiatives, beyond exchange of information. The scope of the Strategic Partnership Agreements (SPA) with Japan and Canada could be enhanced, especially as the SPAs already recognise the importance of space[528].

Build political cohesion

A strategic approach to positioning the EU in the world entails building political cohesion. The convergence of Member States around a shared vision for security and defence and an agreed set of priorities is essential. This depends on a common assessment of challenges and opportunities, including a strengthened and shared strategic culture. It further requires adaptation of the distribution of competences between the EU and Members States that enable strategic planning and joined-up decision-making as institutional requirement. Political cohesion and institutional requirements are both key to enable the EU to prioritise current and future material and immaterial requirements to secure its open strategic autonomy. These requirements refer to the assets and resources that the EU needs to implement its priorities. They comprehend a well-functioning single market, a strong technology and industrial basis, a highly skilled workforce, secure critical infrastructures, reliable supplies of energy and critical raw materials, and adequate military capabilities. In summary, the challenge ahead is to build internal political cohesion and policy integration (i.e. remove policy silos), combining institutional memory or past lessons learned with existing evidence and alternative futures, based on a strong EU anticipatory capability[529].

Political cohesion is key to enable the EU to act on maritime security[530]. The EU has a major stake in protecting the global maritime rules-based order. It is vital for its economic, food, energy, resource and digital security. Threats range from terrorism, power competition and hybrid tactics beyond traditional confrontation. The use of oceans and seas for global trade are also being tested with lines of communication and critical infrastructure at risk. The EU needs to strengthen its capacity to guarantee its infrastructures and freedom of navigation by averting risks from having access to logistic hubs, supply routes and choke points or being inhibited by hybrid threats. Ensuring coherence among existing and future EU policies is therefore key, as it is coordination between Member States. These include strategies on connectivity, the Indo-Pacific, ocean governance and maritime security. It also includes coordination of Member States naval forces and assets, as well as enhancing surveillance in critical zones.

The same is true to ensure continued freedom of access to air space and outer space[531]. Aggressive aerial postures that rely on defensive and offensive capabilities, as well as the technological race in these domains constitute an increasing threat for EU security and prosperity. Information sharing between Member States, as well as joint training and coordinated action, are key. Being at the forefront of aerospace technological developments is critical to secure access to the international air space and outer space, and it contributes towards building technological sovereignty. Partnerships are important to facilitate logistics. Most importantly, political cohesion across Member States is paramount to ensure interoperability and coordination between military and civil operations, as well as to enable the EU to engage globally in regulation and standard setting.

The cyber-diplomacy toolbox instruments is a good example of advancing political cohesion in the EU[532]. It provides a framework to better face and respond to threats to cyberspace. The toolbox should be strengthened, both in its coercive instruments via sanctions[533], and in its collaborative instruments via strategic dialogues and capacity building. The EU should ensure interoperability and coordination between Member States when developing political responses, technologies and innovation. Defence networks and secure communications links need to be reinforced, as they are a direct target for adversaries. The ongoing revision of the Directive on security of network and information systems (NIS directive)[534] and the adoption of common binding rules, and the establishment of clear gover-

nance for all EU institutions, bodies and agencies will be paramount. Finally, a combination of an inward looking and a globally oriented Cyber Diplomacy Toolbox may be necessary.

Technology

Enable the EU to achieve digital sovereignty

There are three essential requirements for the EU's digital technology leadership and sovereignty. These are: i) unleashing the potential of and scaling up the EU's start-ups through an innovation-friendly ecosystem and better functioning capital markets; ii) international standardisation that play a role in defining a "level playing field" in the digital realm; iii) designing regulatory frameworks that foster innovation in line with EU values.

Preparing the EU to become a leader in digital technologies, such as AI, requires significant investment in research, innovation and deployment, skills, computing infrastructure, data quality and data sovereignty. The leading role of the US and China in developing and applying digital technologies underscore the momentous implications of technological competition for the ability of Europeans to shape their future[535]. The EU needs to increase its efforts in research excellence and leadership in some industrial sectors, to be able to scale them up and translate innovation into economic growth. Achieving digital sovereignty in Europe entails strengthening research and innovation and keeping talent in EU companies[536].

The EU needs to maintain its international profile in regulation of digital technologies (including AI and data) and standardisation. To ensure a trustworthy AI, beneficial for society, international cooperation with like-minded democracies on the governance of AI is crucial[537]. There are already significant overlaps among ethical AI principles in countries and supranational organisations around the world (e.g. US, Japan, Australia, OECD)[538]. At the same time, digital standardisation of technologies (such as 5G, IoT, Cloud, Cybersecurity and Data Technologies) is key to leveraging the EU's ability for leadership in digital technologies, or in the digital domain.

Enhance digital resilience

We need to prepare society and institutions for the digital and green transitions. This can be achieved through the piloting and creation of experimentation spaces[539]. Public-private partnerships and joint digital capacities need to be deployed in the areas of AI, cyber, super- and quantum computing, quantum communication and blockchain.

Developing cutting-edge strategic capacities is key for the design and use of digital solutions at scale, with interoperability, in digital infrastructures. Some examples could include extensive 5G and future 6G networks and deep technology. For example, blockchain and distributed legers technologies offer significant potential for enhanced resilience in trade and supply chains, manufacturing, energy, health and public and third sectors[540].

The use of AI and big data analytics more broadly could discover patterns that are important for impeding crises. AI can be used to predict humanitarian crises[541]. Extending the use of AI-enabled disaster risk management, or infrastructure maintenance, could help the EU to become more resilient[542].

Strengthen Science, Technology and Innovation systems

Science, Technology and Innovation systems (STI) are expected to undergo considerable disruption in the years ahead, due to the deep and wide impact of digital technologies on research and innovation, R&I processes and innovation systems. This is expected to revolutionize STI systems and potentially make parts of them redundant. The result may not prove conducive for the EU, given that scientific and research excellence is the EU's main strength on the technology front, and that open strategic autonomy needs to maintain a careful watch on these developments.

Open Strategic Autonomy is expected to have both negative and positive effects on STI systems. Policy design that is used to advance open strategic autonomy should be based on reducing critical one-sided technological dependencies[543]. Controls on inward investments need to be designed carefully, so as not to act as barriers to mobility, collaboration and genuine investments in research and innovation.

International partnerships are key for Science, Technology and Innovation systems and need to be safeguarded. These include synergies through international partnership and multistakeholder engagement and initiatives[544]. STI systems need to be appropriately

resourced to ensure that the dynamic capabilities, skills and agile platforms are in place to meet sudden crises, as well as the pursuit of longer-term research agendas.

As a critical strategic asset, the EU needs to monitor the state of its Science, Technology and Innovation systems. This should be done not purely in terms of providing sufficient financial and other facilities, infrastructures and resources, but also to ensure resilience, in particular of researchers and the research community, and to address disruptive influences, both internal and external.

STI systems are strategic assets that the EU should protect and strengthen. They contribute to achieving SDGs, eradicating poverty, as well as GDP growth and attracting global talent, firms and investment. The EU will be highly reliant on them in the future to support the development of cutting-edge research and innovation, technological capacities, and analytical and technical skills.

Economy

Enable the EU to act strategically

Open Strategic Autonomy requires EU ability to set economic objectives and act independently in an interdependent system. This requires first, political cohesion about the direction of economic policies in the EU and the world. Second, institutional structures that allow strategic planning and joined-up decision making to play out regulatory and political power. Third, material assets such as a well-functioning single market, a strong technology and industrial basis, a highly skilled workforce, secure critical infrastructures, and reliable supplies of energy and critical raw materials to play out market power. Ultimately, the EU and Member States need to build an economic agenda on such shared priorities in order to be able to play out their strategy globally.

Growing economic coherence could strengthen the EU's capacity to act as a unified front. The EU's policy efforts to advance cohesion and integration are an important building block for open strategic autonomy. These include streamlining the EU's regional policy and structural funds, and completing the Single Market. By co-designing and implementing a more equitable economic model, open strategic autonomy approaches and their embedding in key EU policies including the European Green Deal, Next Generation EU and Cohesion, will prove more robust. As EU economies are highly interlinked in global value chains, the 'open' aspect of the economy will be the key to the success of it.

Open Strategic Autonomy in economy is a mix of proactive and defensive elements. Proactive elements contain advances in forward-looking initiatives in economic, industrial and trade agenda that enable the EU's own choices and scope. They cover, for example, rule-making and standard-setting at the EU and multilateral level, from climate to digital issues, and contributions to rules-based cooperation at large. Defensive elements aim at enhancing the resilience of the EU's economy, reducing its dependencies, mitigating its vulnerabilities. Strengthening the EU's economic market power is required for both proactive and defensive strategies.

The EU needs to level openness and protectionism. Open strategic autonomy requires both openness of the EU's economy and building up resilience against threats and challenges from foreign economic powers. Key elements are the establishment of a level playing field that enables trade and investment based on shared rules and reciprocity, and tackling practices that distort trade and undermine the EU's competitiveness.

The EU could help other free-trade areas to progress in integration of the economies, while pushing for global trade liberalisation. The EU with its experience in building up the most advanced single market could support, for example, the African Union in further shaping their African Continental Free Trade Area. This could support the development of economies, ensure balanced economic relationships with the EU, and be a lever to project EU values to other world regions.

Increase sustainable competitiveness of the EU's economy

The EU needs to decrease asymmetric economic dependencies to enhance the EU's regulatory power. Leveraging the full potential of the Single Market, and achieving and enforcing a level playing field with other major economies, are considered essential steps to uphold the EU's competitiveness and to sustain growth. These are key to preserving the economic power base that underpins the EU's regulatory power and open strategic autonomy.

The EU has to move ahead to strengthen the competitiveness of its economy. Big emerging economies

are growing faster, advancing in achieving competitive advantages in particular sectors, not only in terms of cost leadership, but also in the technological leadership. The EU needs to identify critical strategic areas of its economy that are relevant to achieve its goal of the green and digital transition and where the EU is able to retain or become a global leader. Smart specialisation strategies and industry strategies need to combine actionable research and innovation, industry and policy to accelerate the prioritised sectors. Up- and reskilling initiatives will be a key task to avoid job-skill mismatches in a transforming economy. Increasing attractiveness for foreign talent will be necessary in times of shrinking workforce.

Global connectivity will be needed to achieve competitiveness. Achieving global leadership requires openness to combine the best resources and production and market conditions globally. Economic and innovation policies need to consider their global dimension and global impact. Global value chains will increasingly be the driver of economic competitiveness. Trade agreements will become more important to raise the competitiveness of industries.

The EU needs to care for the resilience of critical supply chains. Strengthening the EU's supply chains and fostering the implementation of the EU connectivity strategy, are central to both reducing asymmetric dependencies and help shape multilateral regimes in line with the EU's values and interests. Energy, critical raw materials, and medicines are among the priority areas. Both the EU and global demand for critical raw materials is expected to rise sharply, driven by the growth of emerging economies and the digital and green transition. While the competition for these resources will intensify, the EU faces the twofold challenge of the concentration of supplies and obstacles to trade diversification, such as state fragility and the risk of economic coercion[545].

Securing strategic and critical assets is an important aspect of open strategic autonomy. Global cooperation and openness go hand in hand with securing critical assets, whether they be strategically relevant intelligent property rights, companies, or infrastructures. The EU needs to balance openness and protectionism to avoid a takeover of the EU's critical assets, whilst harvesting the benefits of collaboration and competition of economies.

Navigating a more fragmented global economy

The EU needs to prepare for a more diversified global economy. With more emerging economies becoming dominant players, global competition will diversify further. The EU needs to monitor possible economic prospects and broaden and/or intensify its economic relationships. While some foreign economies are pursuing strong industrial policies, the EU needs to adapt competition and industry policy accordingly.

Diversification of value chains is key to increasing their resilience. Being too dependent on a limited number of dominant suppliers, intermediaries or markets is increasingly risky. The growing emerging economies will offer options for diversification. Nearshoring and reshoring might be options for supply of security-related issues, such as medical equipment.

A stronger international role of the euro contributes to the EU's open strategic autonomy. A more diversified global currency landscape provides enhanced stability and improved resilience of the international financial system. Reinforcing the international role of the euro will be key component of economic sovereignty. It reduces the EU's dependence on the US dollar-dominated global financial system. It can contribute to reducing transaction and borrowing costs, diminish risks and lower the EU's exposure to the manipulation of financial interdependence by others[546].

Design and export a new EU economic model

The EU needs to restate its commitment to rules-based, multilateral cooperation. Interdependence and connectivity are both platforms for cooperation and mutual gains and arenas of geopolitical and geo-economic competition. They can be harnessed to promote the EU's interests and values in partnership with others, but they can be manipulated or weaponised by others in ways that undermine the EU's goals, security and prosperity. As well as cooperating with like-minded countries and international institutions, these could include club-like arrangements, inclusive multilateral frameworks and trans-national networks with non-state actors, such as (EU) businesses and civil society, or subnational ones like cities. The overarching objective would be to continue to support international cooperation, but to do so with a good dose of pragmatism, directionality and innovation, to address open strategic autonomy concerns within a responsible global change agenda.

The EU is best placed to deploy a major initiative, to craft and pilot a new more equitable and sustainable economic model that is distributive by design. The EU could lead the shift from outdated fossil fuel-based economic approaches, to a new economic model to underpin and enable the green and digital transitions. Innovative economic policy approaches and legislative reforms need to incentivise and regulate the transformation of industry, services and lifestyles. Green and digital transition could be advantageous for open strategic autonomy by increasing the resilience of the economy against climate change impacts and reducing (energy) resource dependency.

The twin green and digital transition could also serve as a model for other world regions. It would enhance the EU's role in supporting inter-regional relations, the neighbourhood and less developed countries. Global problems such as climate change must have global action, they need to be more open in the sense of getting more countries, industries and people involved to contribute, because this will improve the achievements and benefits for all.

The EU should integrate adequate sustainability criteria when establishing new and updating existing trade agreements. This will enable a level playing field for the economy, lay out climate action, fairness, and workers and human rights as standards to global partners.

Environment

Continue to pursue a leading role in climate diplomacy

Coordinated diplomatic efforts are required to ensure that that the green transition becomes a global effort. International coordination is key for the Paris Agreement to succeed[547]. The energy transition will require targeted diplomatic efforts to ensure that energy exporters to the EU, including Algeria and Russia, are not destabilised. Others, such as China, the main exporter of rare earths required for the green transition, stand to benefit and may seek to use their assets to influence EU policy. This highlights the complex web of diplomatic relations, which the EU will have to navigate to ensure that the Green Deal can work globally, if it is to work at Member State level.

The EU should continue to lead by example to maintain its role as pace maker of the green transition. The EU's commitment to green and digital transitions will secure its position among the world's green leaders. This leadership will serve as an important driver for the signatories of the Paris Agreement to ramp up efforts to meet their targets. Advancing the climate change agenda internationally, and implementing environmental standards as a front runner commands respect and could secure support for the EU's own position for responsible global change.

Adapt to climate change by managing risks

The EU needs to protect critical assets from the impacts of climate change and to strengthen its disaster prevention and coping mechanisms, capabilities and competencies. The effects of the climate crisis, such as flooding, could affect EU ports and coastal areas and related industries as well as its suppliers worldwide, slowing down productivity and causing disruptive migration flows. By preserving critical EU assets, such as infrastructures, the EU takes action on different fronts, namely: (i) countering the risk of climate/environmental crises through effective contingency plans; (ii) monitoring the resilience of critical assets to climate and environmental impacts, (iii) monitoring and strengthening societal resilience; and (iv) reducing resource dependencies.

Lead and harness the green transition

The green transition can be a catalyst to modernise EU industry and gain green technology leadership. Decarbonising the entire economy by 2050 will require fundamental changes in the way all economic sectors work. The green transition requires substantial investments that can increase innovation. As a frontrunner in implementing the green transition, the EU can gain a first mover advantage and develop the green technologies that are required to complete the green transition in the EU. Gaining technology leadership in areas with future relevance will put the EU industry in a position to provide other regions with the technologies they need to implement their green transitions.

A more circular economy could provide a double dividend for the EU. Closing material loops would reduce the environmental footprint of the EU and support the green transition. At the same time, material independence will play an increasing role as a growing population might lead to an increase in scarcity of resources and significantly higher prices. A circular economy would make the EU less dependent on imports of

raw materials and in this way substantially contribute to open strategic autonomy.

The EU needs to further develop, and build on the experience of targeted industrial action plans and related multi-stakeholder alliances. This should be done in parallel to boosting innovation efforts. Examples of such alliances include the European Battery Alliance launched in 2017, the recent European Clean Hydrogen Alliance, and the European Raw Materials Alliance. By joining forces, Europeans can benefit from scale as opposed to dispersing their efforts, which would undermine innovation, competitiveness and security. By strengthening its innovation and industrial power base in clean technologies, the EU will also be in a stronger position to set the standards of the green transition, such as in the hydrogen market and in the green bond market[548].

Reduce the risk of carbon leakage

Carbon leakage has not affected the energy-intensive industries at large to date. Energy-intensive sectors in the EU are subject to the EU Emission Trading System (EU ETS). This trading system puts a price on greenhouse gas emissions, incentivising energy-intensive economic sectors to reduce their emissions. Some groups have claimed that this has already put energy-intensive sectors at a disadvantage compared to their global competition, as other regions do not require these sectors to pay for their emissions. However, several analyses indicate that no carbon leakage has been caused so far, as the EU ETS also implement protective measures, such as free allocation and innovation support.[549]

Policy measures can reduce the risk of carbon leakage and pave the way to industrial technology leadership. Deep decarbonisation of the energy-intensive industries might further increase the operating costs of this sector and could make additional protective measures necessary, such as a carbon boarder tax to safeguard the competitiveness of a zero-carbon EU industry sector. An industry sector that is protected from unfair competition can gain a head start when it comes to low-carbon innovation and therefore gain a first mover advantage.

Society

A robust approach to social cohesion

Ensuring that EU social values and fundamental rights are at the forefront of policy initiatives is key. In this regard, strengthening the application of the EU Charter of Fundamental Rights in Member States is key. While drafting national law and policies to which the Charter applies, it is crucial to ensure that such law and policies are interpreted and reviewed against the Charter[550]. The prevalence of fairness, justice, solidarity, inclusion, tolerance and non-discrimination will strengthen the cohesion of EU societies as well as reinforce the EU's position in the world. Investing in human rights, democracy and the rule of law is essential to achieving fairer, greener, more resilient and inclusive societies[551].

The EU is best-placed to take the initiative in setting standards for the protection of citizens. This will entail actions to deliver on the principles of the European Pillar of Social Rights. The EU could explore ways of co-designing such standards with like-minded global players, including relevant international institutions. By investing in these global change efforts, the EU can expect to attract like-minded talent and industries to the EU.

More ambitious and proactive approaches should reflect the new realities of a post-pandemic world. The focus on green and digital transitions has important implications for EU society, from impacts on skills to new definitions of civil liberties, with a broader conception of social protection and a potential opening for the reinvigoration of the EU's ambitions in the social sphere[552]. The new social realities and emerging challenges (demographic, democratic, ideological, value-based) faced in the years leading up to 2040 highlight the need for policy design to focus more on social needs.

Digital and green transitions might require social interventions (such as safety nets), to optimise positive transformations and minimise negative disruptions in society. In this context, the EU needs to look at all social indicators and adopt a transformative 'social model thinking'. If we make sure that no one is left behind, social tensions can be reduced. This can facilitate the process of transitions. Ensuring that people and industries are supported fairly and adequately, and reducing unequal distributional effects is key.

Transforming work and skills and attracting talent

A strategic definition of key areas and fields in which the future workforce needs to be trained and skilled is crucial. This should be done in co-creation with citizens and other societal actors. The renewed European Skills Agenda aims to support labour market actors by strengthening sustainable competitiveness (European Green Deal), having social fairness (European Pillar of Social Rights), and improving social and economic resilience to be better prepared for future crisis[553].

It will be important for the EU to ensure that education programmes can deliver critical skills needed up to 2040 and beyond. Training and re-skilling programmes have to guarantee that the EU's workforce remains competitive in the key areas for open strategic autonomy. The implementation of adequate education and training programmes is also a way to secure social cohesion within the EU and avoid EU brain drain. Given the impact of demographic change, ageing population and declining workforce, a critical issue for Europe is that young people in particular, need to see opportunities for their future in Europe, through new jobs, skills, studies or trainings.

Alongside digital skills, the skills that remain important for the future include critical thinking, creative problem solving, and teamwork[554]. With the higher penetration of digital technologies in our everyday lives, the need for skills such as empathy, care for each other, adaptation to change and its management in complex environments, will remain. These skills are not only developed in schools, but also at home and at work and throughout life. While automation will substitute some jobs, a human workforce will be needed to engage in roles that require interaction, such as teaching, caregiving, or managing others[555].

Europeans will need to improve their literacy in a number of areas. For example, political, policy knowledge, media literacy, civic competence and health literacy will be key for future societies. 'Futures literacy', i.e. the ability to better understand the role that the future plays in our lives and move beyond "a dependency on the illusion of certainty and the fragilities this creates", will be equally important[556].

Engage citizens in policymaking and promote active citizenship

There is a need for citizen engagement in policymaking that can support stronger societal cohesion and active citizenship. Policy co-design means a strong collaboration in society beyond party politics and experts' opinions. Participatory governance through which policy solutions are co-developed, means bringing citizens' knowledge, expectations, visions and imaginaries into policy processes[557]. Through the inclusion of larger number of people in policymaking (based on random selection[558]), deliberative processes can make the governance more inclusive[559].

Citizen engagement can enhance legitimacy and trust in political institutions by giving citizens a role in policymaking[560]. By increasing participants' knowledge of political processes and institutions through deliberations, as well as raising awareness of the complexity and implications of certain policies, polarisation, populism and disinformation in societies can be decreased[561].

BOX: Online Delphi on Open Strategic Autonomy

An expert and stakeholders enquiry based on Online Delphi survey was designed to prioritise the relevant forward-looking issues most likely to influence shaping and securing the EU's open strategic autonomy by 2040. Statements covering trends, emerging issues and uncertainties related to open strategic autonomy, were drawn from literature and scenario analysis. 241 experts assessed these statements in terms of their impact on achieving the EU's open strategic autonomy, the urgency for the EU to act on them, the EU's capacity to act on them and their likelihood of occurrence.

Annex 2 briefly introduces the Delphi process employed, the characteristic of participating experts, the statements and key results achieved. The results give an indication of priorities for achieving and securing open strategic autonomy by 2040. They highlight relevant forward-looking issues most likely to influence shaping and securing the EU's open strategic autonomy by 2040.

The identified priorities are key for Europe to build on existing capacities and reduce known vulnerabilities, as well as to better prepare for the future. They will be crucial for exploiting upcoming opportunities and transforming challenges into potential for positive transformation.

Table 1: Open strategic autonomy priorities

Open Strategic Autonomy priorities per area of analysis as a result of the Delphi survey				
Geopolitics	Technology	Economy	Environment	Society
Develop strategic alliances and alignment with like-minded countries while fostering a multilateral governance and rules-based international cooperation to ensure access to current and future critical resources **Position the EU vis-à-vis important global players and increase its influence** in the neighbourhood to South and East, as well as in the Balkans and MENA. And play a leading role in international and multilateral fora, to leverage its soft power, and to lead the competition in standardisation **Strengthen EU** integration and **cohesion**, and establish a defence force to advance the EU's **security and defence capacity**, and enable the EU to address threats	**Position Europe as leader in digital technologies** through investments in research and innovation, regulation and standardisation **Enhanced digital resilience** through piloting digital solutions and investment in skills and technologies **Robust science, technology and innovation (STI) systems** require an upgrade to grasp the benefits of digital technologies for R&I	**Design and export of a new economic model that is more resilient and sustainable,** based on innovation enabling the twin green and digital transitions and a reconfiguration of supply chains **Enable the labour market transition to the green and digital economy through education and social policy means**, to ensure future that talent and job-skills match. And support this through a strong social pillar. **Empower strategic industries and assets** through control of foreign direct investments, securing intellectual property rights and regulating access to assets, to enable a level playing field of the EU's open economy with other economic systems	The growing risks posed by climate change make the **adaptation to climate** change an absolute necessity The **energy transition** and **changing consumption patterns** are enablers for reduced import dependence The EU has to develop the **green technologies** necessary for the green transition	**Enhance social coherence** in the EU in order not to leave anyone behind **Involve citizens in policymaking** and promote active citizenship, solidarity and respect for the environment **Retain and attract talent** by preventing brain drain and ensuring sufficient talent for the EU

Annexes

1 Annex 1 – Assumptions

The Commission Services' set of assumptions[562] are organised below. First, general assumptions stemming from the initial online survey are outlined in terms of overall expectations and desires in 2040. Second, assumptions from the online survey are depicted according to open strategic autonomy dimensions in 2040, also differentiating expectations and desires. Third, additional assumptions identified via a workshop are described. Finally, assumptions are clustered into a final set that were challenged in the scenarios.

Overall assumptions for expected and desired EU's open strategic autonomy

The overall assumptions regarding EU's open strategic autonomy expectations in 2040 identified through the online survey can be summarised as: 'a Federal Europe, which is paramount for securing its open strategic autonomy, has not yet being achieved in spite the fact that Europe remains a key global market'. Its building blocks are:

- A federal Europe will remain a political goal
- The EU remains a key global market

A Federal Europe is key for securing EU's open strategic autonomy. Moving towards a Federal Europe is key to implement an effective open strategic autonomy strategy and lead by example in areas such as peacekeeping, disaster and risk management, and humanitarian crisis from climate change.

EU's open strategic autonomy has a threefold objective of reducing dependencies, ensuring global leadership and securing data control. It means removal of energy and raw material dependencies, EU global leadership in geopolitics, trade, environmental policy and social rights, and control of the IT infrastructures operating in the Union, with EU citizens controlling the use of their data.

The EU is considered as a key global market, which enables the Union to secure top trade indicators and lead the race towards zero emission. By 2040, the top-5 leading economies in the world are seeking access to the Single Market with the EU, China and the US battling for global markets of high value / hi-tech products. The EU will be able to surpass most equal rivals in key trade indicators and its innovative industry secures a front-runner position in the race towards zero emission.

A stagnant economy, demographic developments and internal divisions after the COVID-19 crisis together with global economic and military rivalries weakens the EU soft power and both its global role and economic position. Economic and military rivalries and a stagnant economy together with demography and internal divisions weakens the EU as a soft power, with its foreign policy able to focus mainly on crisis management and agenda setting. In reality, the economic share of GDP of the EU is below 20% despite a partly reshoring of industry.

In 2040, the world is still struggling to address global problems and the EU is unable to maintain its open strategic autonomy. The EU, the US and China agree on implementing a unified position for global governance. At the same time, the EU is setting its standards higher than ever for non-EU companies that are willing to invest in or trade with the Union. However, the EU is able to secure autonomy only in the field of medical equipment, with dependences on raw materials remaining a real treat for the future of its economy. Hence, is the European push for autonomy heading towards a dystopia?

The overall assumptions regarding EU's open strategic autonomy desires in 2040 can be summarised as: 'a Federal Europe has enabled the EU to secure its open strategic autonomy and to deliver to its citizens, which increased its global credibility as a decisive actor and partner and enabled it to challenge others to follow'. Its building blocks are:

- The EU is perceived as a reliable, stable and fair partner
- The EU will be able to manage increased risks/disasters/impacts connected to climate change
- Multilateralism remains a global force

The EU Federation, as a model for social cohesion and economic development, enabled the Union's open strategic autonomy and its global role for peacekeeping and world stabilisation, successfully managing disasters and humanitarian crisis caused by climate change. The European Federation achieves full strategic autonomy in energy and raw materials, allowing it to implement fully-fledged external and trade policies, develops a sustainable leading economy, free of dependencies on any other country or entity. The EU's position as a strategically autonomous actor gives its increased credibility as a peace actor and functions as a deterrent to

destabilisation in the world. The EU is truly autonomous and able to manage disasters and humanitarian crises caused by climate change.

The EU makes it 10 years early in the race towards zero emission thanks to its innovative industry. By 2040, the EU becomes the first climate-neutral continent in the world, with value-driven firms and a clean and digitalised industry delivering 30% of GDP. The EU as the leading world region to export green and digital goods and services. EU digital technology is at the cutting-edge, autonomous, and interoperable at the global level.

In 2040, the EU hard and soft power protects and delivers for EU citizens, and strengthens multilateralism and EU's role model in the world. EU citizens take their rightful destiny into their hands. Third county young educated people goes to EU to taste freedom more than make profit. The EU sets global agendas such as the UN Conference on the Future of the Planet beyond 2050. The EU renews multilateralism and constructively challenges other key players to deliver, which strengthens global partnerships and collaboration. Ultimately, the EU secures its open strategic autonomy, renews multilateralism and constructively challenges other key players to deliver.

Geopolitical assumptions for expected and desired EU's open strategic autonomy

The assumptions regarding EU's open strategic autonomy geopolitical expectations in 2040 identified via the online survey can be summarised as: 'the EU becomes a hard power with an independent defence/security capacity and able to shape trade and alliances according to its principles, but in 2040 remains its status quo position globally'. Its building blocks are:

- The EU is able to build required alliances and partnerships whilst maintaining its underlying values
- China's geopolitical power still growing
- The EU will have to develop its own defence force

The EU has a flexible defence mechanism and an overall stronger hard power with an independent EU joint defence/security capability. The EU becomes Federal and speaks with one voice, allowing it to firmly protect its interest and develop solid and beneficial partnerships around the globe. The vision of an integrated European continent, with increased EU competences and independent MS, with a collective strategy and agreement on required individual actions, with a clear EU governance scheme, and with EU's open strategic autonomy enhancing MS capacities for action against foreign competitors, has therefore been achieved. The EU has an effective and independent defence capability, and its hard power supports its interests, while keeping its alliances.

There is a shift from multilateralism to bilateralism and regionalism. The EU is able to negotiate and establish trade with world leaders like US and China according to its values and interests. Asian markets surge accumulating capital and driving innovation leading to an economic hegemony of the Asian countries. America is fighting internally to set their global role, shifting between self-isolation and striving for global leadership. Africa has more leverage in international institutions after a few political revolutions. Europe strives for global competitiveness and to break away from saturated internal markets, but is still hindered by coherence. Therefore, the EU has a greater geopolitical focus on regional issues rather than focusing on its international role.

Climate change and humanitarian aid together with grey conflicts, including disinformation, cyber and proxy wars, becomes the source of conflicts between states and regions, thus reducing democracy and forcing the rise of new power blocks. These rewrite the global governance rulebook and redefine the balance of global power thus increasing general instability. However, global challenges and crisis, migration due to climate change, wars and economic inequalities, and other source of conflicts force countries to collaborate and look towards common solutions, with military spending continuing but more focused on local conflicts. To achieve a new balance, regional power blocks are formed, with the EU and the US forming an alliance to counterbalance the economic power and geopolitical influence of Asian countries, especially China, as well as a global reduction in the number and level of democracy.

Open Strategic Autonomy enables the EU to shape alliances and trade according to its interests, but global competition and economic powers lead to Europe maintaining its current global position in 2040. For the EU, strategic autonomy is crucial for the energy sector (less dependency from Russia), and for balancing the achievement of climate targets with the synergistic role of energy storage technologies. Open strategic autonomy will lead to the adoption of QMV in external relations. Internet regionalization with IT governance

(e.g. interoperability standardization and Internet governance) becomes crucial for USA and China competition. Some regions and countries are completely left behind. The EU has maintained at least its current status quo.

The assumptions regarding EU's open strategic autonomy geopolitical desires in 2040 can be summarised as: 'the EU is seen as the leader of the free world and acts as a global broker for peace and cooperation due to a reliable soft and hard power'. Its building blocks are:

- Democracy and human rights remain relevant
- The EU will have to develop its own defence force (same as A8)
- The EU will remain a space power

Europe builds a strong and competitive space capability. This happens with the EU is facing harsh competition in the space sector (US, China, Russia, India), and with its investment capacities still lagging behind those of the US. But this trend is reversed in 2040 and Europe has managed to develop strong threat detection capacities and a European base of secure communications satellites.

In 2040 the EU is taken more seriously by other world powers because it is a reliable soft and hard power. The EU has the rapid decision-making assets to robustly guard its interests. The EU has finally developed a hard power edge that supports its interests, while keeping its alliances in 2040.

The EU has finally developed an effective, strong and independent joint defence and security capability. The EU is moving closer to a stronger European Defence Union that will ensure EU citizens' security. This, of course, requires additional investments at EU level. But the EU has been able to gain further influence on the international scene thanks to economic growth and the attractiveness of its social, environmental and economic model.

The EU is on par with the major centres of geopolitical power and recognized as the leader of the free world. At the same time, the EU is strong in trade and peace making missions as well as a development partner. It has a sufficient number of strong equally-partners and regional leaders around the world. This enables multilateralism to be the preferred forum for discussion, and the military dimension to be less prominent in diplomatic relations.

Europe is seen as a reference at global level for democracy, values and human rights, filling the gap left by the US and China. The world has more stability through renewed engagement in multilateral processes, and the EU speaks with one voice. The collaboration among nations to tackle global challenges will decrease military spending and the number of conflicts.

The EU has achieved at a kind of "smart continent specialisation" and acts as a global broker for peace and cooperation. The EU leads the global scene to find compromises between regional powers (effort on norms and standards) and defend democracy and values. The EU co-lead the IT standardization process, along with the US and China. There is a peaceful cooperation between major power centres, with a more a democratic China, and the EU taking the lead in human rights and environmental issues. Ultimately, in 2040 there is a total balance of global powers. There are synergies and globalisation, instead of conflict and antagonism.

Economic assumptions for expected and desired EU's open strategic autonomy

The assumptions regarding EU's open strategic autonomy economic expectations in 2040 identified via the online survey can be summarised as: 'the EU maintains its economic strength in absolute terms but not in relative terms to others, resulting in increased protectionism and a struggle to recover and prosper, thus being unable to materialise its vision of economic sovereignty'. Its building blocks are:

- The EU remains a stable Union
- Food security is challenged for Europeans
- The EU is not able to respond timely to challenges

A strong geopolitical EU facilitates the development of all domains of the EU economy, which feeds back into strengthening its geopolitical position, in a positive feedback loop. This is also key for the EU to remain among the highest income per capita regions of the world, and therefore uphold itself in global multilateral economic system that delivers for Europeans. Likewise, a strong geopolitical Europe reinforces and depends of the euro as a global currency, as well as to remove barriers to the common market.

In 2040, global capital is accumulated in a limited number of countries, such as China, which drives off competition. Developed countries maintained their current state of growth of 1% to 2% per year (OECD countries).

However, inflation in Europe puts the euro to a test. China leads even while having dramatically slowed down its growth, which in turn is accelerating in sub-Saharan Africa. At the same time, the Digital Economy becomes more and more the engine of developed countries.

In this context, digital market dependencies hampers the EU economic progress and net export position. EU's industry dependence on raw materials makes EU products and goods more and more expensive. Moreover, in spite of the 5 leading economies in 2020 have increased their economic and financial power and concentration, in 2040 the EU has reduced its overall net export position, including in the food and agricultural sector. In fact, the EU has maintained its economic strength in absolute terms but lost in relative terms to other regions.

The EU had its competition law acquis reformed with a protectionist twist. In trying to change its economic positioning, the EU has strengthened its tools and monitoring of foreign investments, and has focused its efforts on securing a European supply chain. This resulted in increased protectionism, while facing continuously growing competition from Asia.

The EU and the world are still struggling to recover and prosper, with Europe being unable to fulfil its vision of economic sovereignty. In light of the EU recovery necessary after COVID-19, the enforcement of trade agreements has not always been feasible and those with access to the internal market of the EU have not always complied with the EU standards and rules. Ultimately, Europe has not been able to materialise its own vision around economic sovereignty, while maintaining close ties with the US and China, both of which have decoupled from one another.

The assumptions regarding EU's open strategic autonomy economic desires in 2040 can be summarised as: 'investments in innovation, people and the planet coupled with internal coordination leads to EU economic prosperity and resilience, as well as the eradication of global poverty, with the euro becoming the global currency'. Its building blocks are:

- The EU will generate power to pay for its objectives
- The euro is around in 20 years

Major investments in innovation, people and the environment led to stronger trade and investment links and capacity. The EU created new and quality jobs, fuelled by diversified and open supply chains and a strong manufacturing base. The creation of innovative legal tools such as the carbon border adjustment mechanism and the digital levy are fully operational and effective in protecting the Single Market from foreign unfair practices and in bolstering European industries. Furthermore, the EU Recovery and Resilience Facility (RRF) have become the blueprint for future European initiatives in investing in multi-country projects that promote European value added in line with the European open strategic autonomy.

Industry alliances leverage EU's global economic hedge. Collaboration between the EU, Member States and industries is as intense as ever, across all strategic value chains. The existing industry alliances, bringing together industrial actors, SMEs, public authorities at national and regional levels and NGOs in key areas, such as batteries, raw materials and hydrogen, have been further reinforced. New industry alliances in other strategic areas have been developed.

The EU has a cohesive economic development based on internal solidarity and external strength. The EU has managed to deal with some of its critical dependencies (energy, digital, industrial). It has also improved its capacity to defend itself from Russia and other regional powers. There is overall more solidarity in the bloc. The EU's economy has seized the opportunities from greening and digitization, and is competitive in relation to all major benchmark. In fact, the Digital Economy outdoes the traditional one in the whole EU.

The EU's economy works for people and planet. The EU is still among the highest income per capita regions of the world In 2040. The global multilateral economic system that the EU upholds still delivers for Europeans. In fact, the EU asserts itself as an economic superpower and uses that power for a more sustainable development and an increased quality life both in the Union and the global world. Products and services quality wins over quantity. As a result, the euro becomes the global currency.

EU territorial balance, coordination and coherence is finally reached. Member states national economies manage to find a fair balance between each other at the global and EU level. Coordination actions among MS enables Europe to reach a balance between the market and social and environment values. The EU economy is resilient to shocks (such as COVID-19), which in contrast enables the EU to play a decisive role in supporting sustainable development in Africa. Ultimately, this enables an economic growth that benefits all, and leads to the eradication of global poverty.

Social assumptions for expected and desired EU's open strategic autonomy

The assumptions regarding EU's open strategic autonomy social expectations in 2040 identified via the online survey can be summarised as: 'in spite of increasing inequalities and digital divide, which lead to social and territorial fragmentation and has put democracy to a test, in 2040 the EU remains the world champion for quality of life and inclusion'. Its building blocks are:

- Income inequality leads to instability
- Europeans deserve prosperity

n 2040, there has been an increase of the digital divide, including in terms of infrastructures, skills and competencies, between rich and poor countries. The divide between technically skilled end educated and those lacking these competences have exacerbated, with the middle class in Europe and in the US continuing to increase their distance with respect to the richest. Teleworking has fuelled social tension and delocalization of work, thus curbing the development of new ideas. There has been a reduction of working time by 1/10 on a global scale leading to more independent workers with limited social protection.

Europe's inadequate focus and investment in the development of digital capacities lead to increased social and territorial fragmentation. Continued polarisation and growing digital divide have further ignited 'alternative facts' and conspiracy theories. These continue to pose serious risks. There is an overall scepticism towards science and democratic systems. Moreover, unemployment remains the key challenge against high social and labour rights' expectations putting pressure on Europe's competitiveness. At the same time, 'the establishment' and 'world order' continues, while increasing inequalities persist.

The inequality gap within societies and between countries expands. Inequalities in Europe are still less compared to the Americas, but worse than in 2021. There is a growing dissatisfaction of citizens, which leads to growing social unrest, which in turn shapes governance models. Democratic values are tested in various parts of the world. Immature 'democracies' experience some form of 'democracy-anarchy-tyranny' cycle.

The EU remains the world "quality of life" champion in 2040. In striving for geopolitical and economic global leadership, in 2040 Europe is able to implement the most progressive and far-reaching social-economic policies in the world, as well as to impose strong social standards to any company willing to operate in the EU market. Social disparities begins to be bridged through a functioning social safety net. However, there is still a high level of unemployment amongst non-qualified people. At the same time, EU legal migrants (which are the large majority of migrants) are integrated as part of the European way of life. Overall, the EU society becomes increasingly mixed and social matters (employment, equity, fairness, etc.) is prominent in the social debate.

The assumptions regarding EU's open strategic autonomy social desires in 2040 can be summarised as: 'investments in (re)skilling and innovation led to a dynamic, mobile and competitive workforce, with Europe achieving work-life balance, social equality, health security and increased quality of life for all'. Its building blocks are:

- Quality of life depends on good health, innovation and skills
- It will be possible to reinforce the resilience of critical supply chains (such as pharma) even in a globalized world
- The EU will not have any mass migration

EU's open strategic autonomy leads to increased security and safety. It enabled the efficient and effective coordination of health policies among Member States towards unexpected sanitary crises. Europe is now able to react quickly to health threats with the help of a diversified and secure pharmaceutical supply chain. Given the inextricable link between the pharmaceutical industry and manufacturing dependencies, Europe has embarked on renewed investment efforts in order to bolster manufacturing capacities for certain APIs and medicines.

The EU has invested sufficiently in training, innovation and entrepreneurship serving a dynamic, mobile and competitive workforce. EU agreements on social protection (e.g. working time, minimum wages, social security) has led to better protection of independent workers and a decrease of working time thanks to AI and continuous technological and economic progress. Work-life balance based on individual needs and desires is achieved. Moreover, the EU is taking a leading position in the eradication of poverty globally, while internally it has become a memory.

The EU has overcome its inner divide and has found internal consensus on thorny issues, such as immigration (not least due to its geopolitical autonomy to take action). There is common understanding and acceptance of certain fundamental 'truths' and values. As a consequence, middle class repositions itself and social inequality is reduced. Migration is reduced. Cities keep on thriving as centres for innovation and exchange of ideas. At the same time, growth in cities slows down while suburban areas increase their services and work opportunities. Overall, social and generational digital divide has been dramatically reduced, in the whole EU and worldwide.

The EU remains the world "quality of life" champion in 2040. There is a renewed commitment to solidarity both internally and externally. EU legal migrants (which are again the large majority of migrants) are integrated as part of the European societies. Furthermore, developing societies have closed the income gap with the wealthiest ones, while in Europe there has been an eradication of social inequalities. The EU is also the champion of tax equity and social equalities in the world. Young Europeans do not need or wish to emigrate outside the block.

Environmental assumptions for expected and desired EU's open strategic autonomy

The assumptions regarding EU's open strategic autonomy environmental expectations in 2040 identified via the online survey can be summarised as: 'environmental degradation and biodiversity loss increase while R&I investments are not enough to deploy required solutions to climate change and ecological tipping points – on the one hand, this leads to Europe's inability to achieve its 2030 climate targets; on the other hand, it also leads to environmental matters playing an increasing role in shaping EU's open strategic autonomy, with Europe emerging stronger in 2040 for setting new targets and monitoring mechanisms, and to lead by example'. Its building block is:

- Climate change will remain a global challenge
- Environmental and pandemic crises will likely change the geopolitical situation we have today

Current environmental degradation continued and accelerated towards 2040. The major positive effect of COVID-19 was a momentarily cut down CO2 emissions, mainly due to reduction of transport. Reduction of emissions happened in India, the US and Latin America. At the same time, climate change intensified leading to extreme climatic events and the reduction of biodiversity, in particular in Africa due to increased competition for spaces. Climate refugees augmented towards 2040. Moreover, a slower economy and a focus in fighting the global crisis with a short-term outlook has led to slowing down the pace of R&I contributing to fight climate change.

EU climate-related R&I investments still lag behind those of the US and China. According to current estimations, the EU invests €7.5 billion per year in climate-related R&D, less than the USA with €12 billion, or China with €8.6 billion. This investment gap has not been bridged by 2040. This phenomenon was aggravated in the aftermath of the pandemic, due to the volatility of the market and increased uncertainties, which the EU was not able to anticipate and act upon accordingly. Therefore, industries were reluctant to invest in ground-breaking, environmentally-friendly solutions for the reduction of CO2 emissions, especially since these were perceived to come at a high cost.

In 2040, focusing on the sustainability of the planet become the new global paradigm. The magnitude of disasters and humanitarian crises due to climate change have almost doubled in the last 20 years. The emptying the cities due to spread teleworking in the aftermath of fighting the COVID-19 crisis increased the impact on soil sealing and loss of biodiversity. Several regions of the world became depopulated due to desertification and flooding, while other regions remained nature sanctuaries.

In this context, in 2040 environmental matters play an increasing role in all the other open strategic autonomy dimensions. The world is getting greener, but we will not reach the 1.5oC target for climate change. Adaptation to climate change is the new norm. Rich countries benefit from clean air, water and soil, often at the detriment of underdeveloped countries (and continents). The planet is divided into the clean and the dirty world. The battle for resources has increased, including water and minerals.

Europe does not achieve its 2030 targets and is unlikely to achieve those set for 2050, but is overall stronger to fight climate change and to lead by example. In striving for geopolitical and economic global leadership the EU has been able to implement the most ambitious and effective environmental policy, finding several solutions to climate challenges, thereby compelling other countries to follow. The EU was able to impose strong environ-

mental standards to any company willing to operate in the EU market with an extra-territorial effect. However, despite the progress made along the way, the EU still did not achieve its 2030 objectives. But in 2040 the EU continues to lead by example on the green agenda. Technological development allowed environmental threats in the EU to decrease. Nevertheless and in spite of having made big strides towards greening the economy, the EU will not be able to reach its 2050 climate targets either. Overall, 20 years later the Green Deal passes the "cost-benefit" test and enables the EU to set new achievable targets for the next 20 to 50 years. Copernicus play an important role in the monitoring of the new targets and in enabling the EU to become a stronger player; and Europe remains the top place in the world for both pensioners and youth.

The assumptions regarding EU's open strategic autonomy environmental desires in 2040 can be summarised as: 'the EU is at the forefront of disaster prevention and humanitarian aid when it comes to environmental risks, pushing a working global agreement to preserve and respect nature and regenerate ecosystems services, as well as to achieve climate neutrality with clean air, water and soil for all'. Its building blocks are:

- The EU will be able to manage increased risks/disasters/impacts connected to climate change (= A4)
- Natural resources (land and sea based, water) remain sufficient to ensure Europe's security

Through innovation and adaptability of its labour force the EU has managed to reduce energy dependency towards foreign players while projecting its values. The "smart" revolution of our industry, space (i.e. Copernicus) and society, enabled by the digital transformation, has significantly improved EU's environmental sustainability. The EU is progressing on its roadmap towards climate neutrality while enjoying the cleanest environment in the developed world.

The European Green Deal strategy has produced its expected effects, in Europe and worldwide, thus passing the "cost-benefit" test. The EU's green deal has made Europe independent from oil and gas supply from problematic regions. Hence, Europe has addressed over-dependencies on foreign actors for scarce raw materials and energy. Also, the EU has set binding targets and indicators towards resource use efficiency and the existence of recyclable and reparable products on the EU market. In a nutshell, EU's efforts towards decarbonisation and modernisation of its industry is on the right track towards achieving the 2050 climate targets.

Europe is seen as reference at global level in protecting the environment and fighting climate change. The EU is at the forefront of disaster prevention and humanitarian aid when it comes to environmental risks. It pushes a working global agreement to preserve and respect nature and the environment, as well as achieve climate neutrality.

Developed economies have reduced the pressure on natural resources of over-consumption. This has led to a drastic reduction of emissions at global scale. New technological solutions to produce energy have been developed leading to increased efficiency of renewables and the first tangible results in nuclear fusion. Urban densification is fostered leaving preserved areas for biodiversity, and regenerating previously destroyed ecosystem services. Overall, the fight against climate change has been won and full circular economies around the world thrive with clean air, water and soil for all.

Technological assumptions for expected and desired EU's open strategic autonomy

The assumptions regarding EU's open strategic autonomy technological expectations in 2040 identified via the online survey can be summarised as: 'the EU is leading on green technologies and regulations, and is on the way to building technological supremacy via creativity and a cutting-edge R&I policy; however, the EU still lags behind in innovation on digital and other competitive technologies due to missed opportunities, brain drain and timing required for achieving consensus, as well as due to the lack of natural resources and IPR'. Its building blocks are:

- The EU remains a regulatory superpower
- China remains one country

Geopolitical and economic global leadership allow the EU to implement an ambitious, cutting-edge R&I policy, which steadily lead the way towards technological supremacy. China will reach the levels of R&I of Europe and the U.S. However, in the absence of democracy, Chinese innovations will reach a limit, well below the capacities of Europe and the US. Africa and Latin America will keep on lagging behind. Globally, AI and digital innovation may prevail and limit innovation in other sectors, such as those related to environment.

The EU will be a leader in green technology and in regulations. The EU has set the benchmark for regulation of information technology, but not made enough progress in building up its own IT infrastructure and industry. Artificial intelligence made 1/10 of existing jobs irrelevant. The EU has established its own ICANN and DNS resolver. The cyber-physical interaction has replaced most of the present physical interactions. 6G and global satellite Internet have disrupted the Internet as we knew it in 2021.

The EU is the most technologically creative region of the world in relation to new technologies: from research to markets, a success story. Technological breakthroughs continue changing the overall picture in unforeseen ways. Data localisation might have become a (dystopian) reality in 2040. The single market for data enables European data to be processed and stored in Europe, thus leading to a severe blow to cross-border data flows and digital trade. Likewise, communications are more integrated and there are new, green forms of energy. Technology advances happened in all fronts, transport, medicine, basic sciences, communications, etc.

However, the EU is still lagging behind in the development of competitive technologies. This happens in spite of its creativity and of having developed ambitious regulations on digital technologies and on consumers' protection. Ethical issues related to technology and a difficult relationship between man and machine (the spectrum of a Brave New World) is commonplace. Digitalisation is a normal part of daily life. Europe leads technological innovation on several fronts, but finds it increasingly difficult to compete, especially with Asia. This is because Europe followed a conservative approach and focused on established markets and products. This led to missed opportunities. Global competitors took the risk and developed new products/solutions and created new markets that are gradually displacing the traditional ones. In addition, the number of researchers in Europe is smaller than that of China and the US, and the EU is a net exporter of PhDs, thus further reducing technological capabilities in Europe. Furthermore, harnessing new technologies requires fast responses and the EU is driven by consensus and suffers from internal divisions. Strong states in the EU have become even stronger in 2040.

Europe, although sophisticated, is unable to leverage technology effectively due to its dependency on key resources and capabilities. Intellectual property rights are controlled by a handful number of firms and countries. The space industry is controlled by private enterprises and is not driven by nation states or regions anymore. Likewise, very few countries have the monopoly of key materials and resources required to build current (2040) and next generation technological products (digital and green technologies).

The assumptions regarding EU's open strategic autonomy technological desires in 2040 can be summarised as: 'human-centric and ethical, disruptive and evolving technologies developed through a boost of R&I investment in Europe enables negative impact on ecosystems, biodiversity and natural resources to subside as well as EU competitiveness and citizens quality of life to increase for all'. Its building blocks are:

In technology regulation Europe strikes the right balance between industrial competitiveness and protection of EU citizens

Digital society has a rights based and fair fundament

The EU has more control over its data, private public and industrial. Its space infrastructures are secure and kept up with progress. The EU is autonomous and interoperable with the global satellite internet technology. The Cyber-Physical revolution also has already happened. Overall, the EU has increased technological non-dependence for critical areas to ensure its security/defence, including in space and digital technologies.

Investment in research and innovation goes up to 4-5% in all EU Member States, which have more effective take up into the market. The EU has invested sufficiently in research and innovation to develop competitive digital solutions (i.e. platforms and services) and secure data sharing / usage serving its citizens and consumers' interests. There is an increased investment in technologies coupled with social awareness of their implications.

The approach to technology development is human-centric. In other words, technology is developed aiming at increasing citizens' quality of life, such as in health. The EU is the most technologically creative region of the world, with new technological developments going from research to markets successfully. Such a success is possible because the EU rules the regulatory and industrial technology complex.

Moreover, a robust, harmonised ethical framework for AI and disruptive technologies across Europe enables it to boost innovation and industrial competitiveness without imposing additional regulatory burdens on SMEs. However, due to the unpredictable and incessant evolution of AI, Europe must remain vigilant in anticipating future technological developments via flexible, malleable legal mechanisms.

Technological progress aims at people and planet's improvement and is accessible to the majority of the citizens in the world. Overall, new technological developments and artificial intelligence facilitates daily life, reduces working time and minimises our ecological footprint on the planet. It also enables the development of new sources of energy. Sustainable energy and transport solutions become affordable in all cities, which offer improved quality of life and an excellent work-living balance. New technologies allow increased quality of life for all and ultimately to regenerate the planet itself.

Final assumptions used for developing and exploring scenarios for the EU standing in 2040

The above 29 assumptions were brought for discussion in a workshop with the open strategic autonomy working group (Figure A-1). The aim was to check how far participants identified themselves with these initial assumptions and to unlock further assumptions within the group. Other 20 assumptions were jointly identified, as outlined below.

Geopolitical assumptions:

Institutional bias towards believing in win-win solutions when trade-offs may be unavoidable

Europe has tools to respond effectively to crisis in EU neighbourhood

The EU is still there in 20 years

The EU remains dependent on the US for its security

An enlarged EU has adopted yet more fragile decision-making procedures in a number of policies, leading to blockage

Global institutions remain weakened

No more Brexit-type operations

African countries foreign policy will balance between China and the EU

Foreign political systems remain stable

The rule of law is credible in the EU

There are no major war involving Europe

Military budgets used for greater goods than (artificial) sense of security

Economic assumptions:

Growth can be sustainable in a finite economic system

Supply chains remain organised globally

There are institutions of global economic governance

Technological assumptions:

Science based policy-making prevails

Social assumptions:

There will (still) be a common narrative citizens believe that will provide the needed support for the costs of action

Nationalism remains strong

Environmental assumptions:

2050 climate goals need to be met

Society remains highly dependent on raw materials and energy

Figure A-1 below depicts a snapshot of the assumptions as discussed in the workshop with the open strategic autonomy working group.

What assumptions are we making about the future standing of the EU in 2040 that perhaps should be challenged by the scenarios? What biases might we have?

The EU is perceived as a reliable, stable and fair partner.	Europe's border remains respected	The EU remains a key global market	Institutional bias towards believing in win-win solutions when trade-offs may be unavoidable	The EU is still there in 20 years	Euro is around in 20 years	Growth can be sustainable in a finite economic system
EU is able to build required alliances and partnerships whilst maintaining its underlying values.	Innovation remains main fundament of EU economy and society	No major climate disaster in Europe	Society remains highly dependent on raw materials and energy	2050 climate goals need to be met	Growth can be sustainable in a finite economic system	EU can continue externalising the consequences of its economic and political decisions
EU remains dependent on the US for its security	EU will generate power (wealth, diplomatic, military) to pay for its objectives (environmental, autonomy, values...)	Democracy and human rights remain relevant	Europe has tools to respond effectively to crisis in EU neighbourhood	Food security is challenged for Europeans	EU will have to develop its own defence force.	EU remains
There are institutions of global economic governance in 20 years	Nationalism remains strong.	Global institutions remain weakened.	The EU is not able to respond timely to challenges.	Environmental and pandemic crises will likely change the geopolitical situation we have today.	EU remains a regulatory superpower.	An enlarged EU has not adopted yet more agile decision-making procedures in a number of policy areas, leading to blockage
Quality of life depends on good health	Supply chains remain organised globally	Foreign political systems remain stable	EU neighborhood stabilizes	African countries foreign policy will balance between China and the EU	It will be possible to reinforce the resilience of critical supply chains (such as pharma) even in a globalized world	No more Brexit-type operations
China remains one country	There will (still) be a common narrative citizens believe in that will provide the needed support for paying for the costs of action	China's geopolitical power still growing	Natural resources (land and sea based, water) remain sufficient to ensure Europe's food security.	Europeans deserve prosperity	Income inequality leads to instability	The EU will remain a space power
Military budgets used for greater goods than (artificial) sense of security	Multilateralism remains a global force.	EU will be able to manage increased risks/disasters/impacts connected to climate change	There is no major war involving Europe	In tech regulation, Europe strikes the right balance between industrial competitiveness and protection of EU citizens	The rule of law is credible in the EU	Digital society has a rights based and fair fundament

All 49 assumptions were consolidated and brought together into a set of 23 that would be then challenged across all scenarios, according to Table A-1 below.

Table A-1: final assumptions challenged in the scenarios

Initial assumptions	Final assumptions
A1; A6; A12; A17; A26; A32; A36	The EU remains a Union
A14; A20; A22; A23; A48; A49	Climate change will remain a major challenge
A16; A26	The euro will remain
A19; A46	Public spending will be dominated by growth in social security
A13; A14; A20; A25; A43	European food and water supply will remain reliable and sufficient
A8; A10; A14; A25; A31	The EU will develop its own defence force, but will not engage in a war
A4; A14; A20; A24; A48	Overall, the EU will cope with natural disasters and climate change
A6; A9; A26; A28; A29; A39; A46	Europe is a group of democratic nations based on shared values and a credible rule of law
A2; A3; A6; A18; A26	The EU will remain a prosperous, key global market
A7; A27	China remains a one party State within its current borders, exercising more geopolitical power
A21; A26; A31; A37; A38; A40	The countries of Africa will not change the current global geopolitical dynamic
A3; A6; A26; A30; A34; A45	Pragmatic, rational, evidence-based policy making will dominate international relations
A42; A43	Global GDP grows
A23	Most environmental costs are borne by society and not companies
A3; A5; A12; A28; A35; A38; A44	Global institutions and their rules will remain are predictable
A11; A29	Data and connectivity will be key driver of geopolitical and economic influence
A21	The EU will not have any mass migration across its borders
A47	Nationalism, including populism, will remain an important and disruptive feature of EU politics
A13; A20; A25; A43	Agriculture gets the highest priority in the EU budget
A15; A48	SDG criteria are broadly followed by the EU
A21	The US will remain fully engaged with NATO
A25; A42; A49	Energy autonomy is a desirable objective
A11; A14; A20; A29 A33; A40; A41; A43	Cyberwarfare will not seriously disrupt society

2 Annex 2 – Online Delphi

Introduction

The Online Delphi represents a public online platform, developed under the umbrella of the EU Survey, by the Competence Centre on Foresight of the Joint Research Centre, at the European Commission, in cooperation with IT corporate teams.

The Delphi method is a structured expert survey used to gather opinions on different possible developments in the long-term future on a given topic[563]. It represents one of the methodologies used by the foresight community to gather collective intelligence about the future. It also serves to create consensus on a specific topic and quantify assumptions regarding the future. Within a specific project, the Online Delphi can complement the qualitative approach offered by other foresight tools and methods.

Initially administrated by post, the advantage of today's Online Delphi is that the results are displayed immediately after each entry, so that the participants can see how the assessments evolve and change their previous evaluation if they chose to do so. Additionally, the respondents can return as many times as they want (within a specific period) to see how the responses evolve, as well as to change their own entries, if they wish so, and comment other answers. This removed the need to run different rounds of the survey for experts to reassess and justify their answers based on the results from previous rounds. Moreover, respondents can choose what to answer and what not to. The Online Delphi is completely anonymous.

The Online Delphi on open strategic autonomy was structured in three parts:

1. The main part (Part I) included 50 statements about the future and EU's open strategic autonomy, structured into five open strategic autonomy dimensions derived from the literature review and the scenarios: Geopolitics, Economy, Society, Environment, Technology. For each of these statements, the respondents were asked to assess the following 4 criteria:

Impact of the statement on achieving Open Strategic Autonomy in the EU
Urgency of the EU to act on the statement
Capacity of the EU to act on the statement
Likelihood of the occurrence of the statement by 2040

   The second part (Part II) included a quantitative matrix mapping EU's dependencies and capacities in relation to open strategic autonomy.

2. The third part (Part III) included six open questions to complement dependencies and capacities.

Part I – Fifty open strategic autonomy statements

For each open strategic autonomy dimension, 10 statements were developed[564]. These are outlined below.

Geopolitical:

- Gp1. The EU is able to secure the supply of critical raw materials through strategic alliances
- Gp2. EU membership expands to countries to the East and to the Balkans
- Gp3. Russia becomes a systemic rival to the EU
- Gp4. China's foothold in Africa and the Middle East reduces Western influence
- Gp5. US retreats from multilateralism
- Gp6. Global competition in standardisation reduces EU leadership
- Gp7. The EU plays a leading role in international and multilateral fora
- Gp8. The EU Member States are more integrated
- Gp9. A EU defence force is established
- Gp10. EU develops strategic alignment with like-minded countries

Economic:

- Ec1. Global supply chains to the EU are reconfigured towards resilience and sustainability
- Ec2. Common and flexible work arrangements across Europe stimulate innovation
- Ec3. Ageing and depopulation reduce the workforce in the EU
- Ec4. Economic growth is deemed more important than environmental action globally
- Ec5. EU implements a protection mechanism to block foreign take-overs in strategic industry sectors
- Ec6. The EU loses control of its strategic industries and assets

Ec7. EU FDI stimulates economic growth

Ec8. The EU has the talent and skills it needs

Ec9. EU Member States implement fiscal reforms to adapt welfare systems to an ageing society

Ec10. EU venture capital accelerates EU innovation

Environmental:

En1. Europeans change their consumption and lifestyle to support the green transition

En2. EU climate diplomacy leads to increased climate ambition in other regions

En3. China and India are the global leaders in green technologies

En4. EU environmental standards make it more difficult to close trade deals

En5. New health threats emerge in the EU due to continued environmental degradation

En6. Resource dependencies in Europe shift from fossil-based to low-carbon technologies

En7. EU's industry becomes more circular

En8. High carbon prices in the EU lead to relocation of carbon-intensive industries to other regions

En9. Long-distance migration to Europe becomes commonplace due to climate change

En10. Continued environmental degradation affects water and food security globally

Social:

Sc1. Active citizenship, solidarity and respect for the environment are dominant values worldwide

Sc2. Social inequalities and poverty threaten EU's stability

Sc3. EU's social market economy expands leaving no one behind

Sc4. The EU implements a minimum income

Sc5. Migration to the EU fuels right-wing populism

Sc6. High burden of communicable and non-communicable diseases lead to the inclusion of health in EU competences

Sc7. Open governance in the EU enables it to set standards on social fairness

Sc8. Social fabric and sense of community break down due to automation and personalised services

Sc9. Misinformation and disinformation weaken EU democracy

Sc10. Brain drain within the EU weakens cohesion

Technological:

Tc1. The EU has sovereignty over its own data

Tc2. AI and automation disrupt the EU labour market

Tc3. Research and innovation is AI generated

Tc4. The EU is independent from foreign platforms

Tc5. Convergence of biology, engineering, computation and other sciences lead to new technological developments

Tc6. Cyberwarfare threatens critical EU infrastructures

Tc7. A new competition for enhanced humans emerges (e.g. AI advancements and bio-engineering/gene editing)

Tc8. A fully digital society disable our ability to shape our future

Tc9. AI and new technologies are strictly regulated in the EU

Tc10. Privatisation of space threatens established forms of governance

Part II – Mapping of EU's dependencies and capacities

EU's current weaknesses and strengths, as well as requirements towards 2040 were assessed through five structured questions with different options and criteria for answering, as outlined below.

Question 1. Please outline the EU position in the supply chain for the following technologies in 2040. Criteria for assessment were: very weak, weak, neutral, strong, or very strong.

- Batteries
- Low-carbon mobility (i.e. land, water and air)
- Smart grids
- Hydrogen
- Renewable energy
- Robotics
- Drones (Unmanned Aerial Vehicles or UAV)
- 3D printing (additive manufacturing)
- Semiconductors and chip manufacturing
- AI
- Big data analytics
- Cloud and quantum computing
- Automation and machine learning
- IoT
- 5G/6G
- Virtual reality
- Gene editing and bio-engineering
- Space exploration
- Military
- Health diagnosis and treatment
- Convergence of bio-, nano- and information technology
- Cryptocurrency
- Blockchain
- Other (specify):

Question 2. Please outline which region will dominate the following technologies in 2040. Options for answering were: Europe, US, China, Japan, Russia, rest of Asia, Africa, India, Latin America, and other.

- Batteries
- Low-carbon mobility (i.e. land, water and air)
- Smart grids
- Hydrogen
- Renewable energy
- Robotics
- Drones (Unmanned Aerial Vehicles or UAV)
- 3D printing (additive manufacturing)
- Semiconductors and chip manufacturing
- AI
- Big data analytics
- Cloud and quantum computing
- Automation and machine learning
- IoT
- 5G/6G
- Virtual reality
- Gene editing and bio-engineering
- Space exploration
- Military
- Health diagnosis and treatment
- Convergence of bio-, nano- and information technology
- Cryptocurrency
- Blockchain
- Other (specify):

Question 3. Please select up to five technologies the EU should invest today in terms of R&D and production to build its open strategic autonomy: Options for answering were: participants could select between 1 and 5 technologies.

- Batteries
- Low-carbon mobility (i.e. land, water and air)
- Smart grids
- Hydrogen
- Renewable energy
- Robotics
- Drones (Unmanned Aerial Vehicles or UAV)
- 3D printing (additive manufacturing)
- Semiconductors and chip manufacturing
- AI
- Big data analytics
- Cloud and quantum computing
- Automation and machine learning
- IoT
- 5G/6G
- Virtual reality
- Gene editing and bio-engineering
- Space exploration
- Military
- Health diagnosis and treatment
- Convergence of bio-, nano- and information technology
- Cryptocurrency
- Blockchain
- Other (specify):

Question 4. Please select the five most relevant sectors for EU's Open Strategic Autonomy in 2040. Options for answering were: participants could select between 1 and 5 sectors.

- Tourism
- Mobility - Transport - Automotive
- Textile
- Creative & cultural
- Renewable energy
- Energy intensive industries
- Aerospace & defence
- Electronics
- Construction
- Digital
- Agrifood
- Retail
- Health
- Proximity & social economy
- Forestry
- Mining
- Machinery
- Other (specify):

Question 5. Please select up to five issues that the EU should invest today to build its open strategic autonomy. Options for answering were: participants could select between 1 and 5 issues.

- Countering hybrid warfare and espionage
- Access to Critical Raw Materials required for the green and digital transitions
- Rollout of digital technologies
- Rollout of low-carbon technologies
- Research and Innovation (R&I)
- Adapting tax and transfer systems
- Fostering new business models
- Expanding the EU's space presence
- Security and defence
- Soft power and international diplomacy
- Education and a skilled workforce
- Industrial standardisation
- Regulatory capacity
- Foreign Direct Investment (EU investing abroad in know-how and supply chains)
- Patents
- Data ownership
- Attracting talent
- Trade agreements, partnerships and global exports
- Other (specify):

Part III – Open questions to complement EU's dependencies and capacities

Question 1. What are the existing critical dependencies/risks/vulnerabilities that will be strategic for the EU in the next 20 years? How their importance will evolve?

Question 2. What new critical dependencies/risks/vulnerabilities will emerge in the next 20 years that will be strategic for the EU?

Question 3. What are the existing critical capacities and areas for preparedness that will be strategic for the EU in the next 20 years? How their importance will evolve?

Question 4. What new critical capacities and areas for preparedness will emerge in the next 20 years that will be strategic for the EU?

Question 5. What are the strategic areas where the EU will or will need to show greater responsible leadership in the next 20 years?

Question 6. What new strategic areas where the EU will or will need to show responsible leadership will appear in the next 20 years?

Participants statistics

The survey was launched on March 18th, 2021 and remained open until April 5th, 2021. By that date, 241 people had answered, of which 92.16% were from an EU country and the rest from outside EU. The most represented professional categories were European institutions (33.73%), Government (23.53%), Academia (11.37%), Civil society (8.63%), and Business (7.45), as indicated in the table.

Respondents were also asked to assess their level of familiarity with the five open strategic autonomy dimensions. As we can observe from the graph below the majority of the respondents considered themselves to be "Familiar" and "Knowledgeable" with open strategic autonomy in each of the five dimensions.

The highest level of expertise can be found in the case of the respondents to statements from Technologies, Geopolitics and Environment. Expertise for the Social dimension is assessed the lowest of all five dimensions.

Figure A-2: Online Delphi participants – sector representation

Please tick the box that describes the sector you are representing.

		Answers	Ratio
· International organisations		8	3.14 %
· European institutions		86	33.73 %
· Government		60	23.53 %
· Business		19	7.45 %
· Academia		29	11.37 %
· Civil society		22	8.63 %
· Other, please specify		17	6.67 %
No Answer		14	5.49 %

Figure A-3: Online Delphi participants – level of familiarity to open strategic autonomy Dimensions

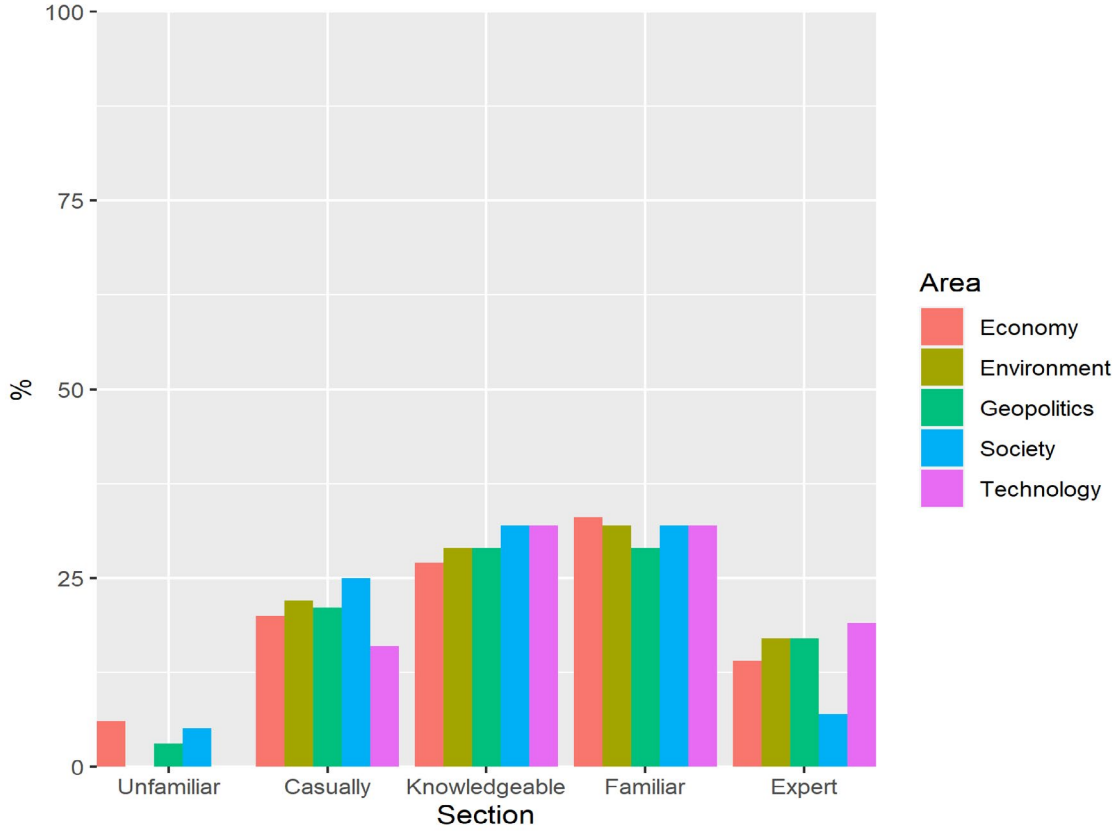
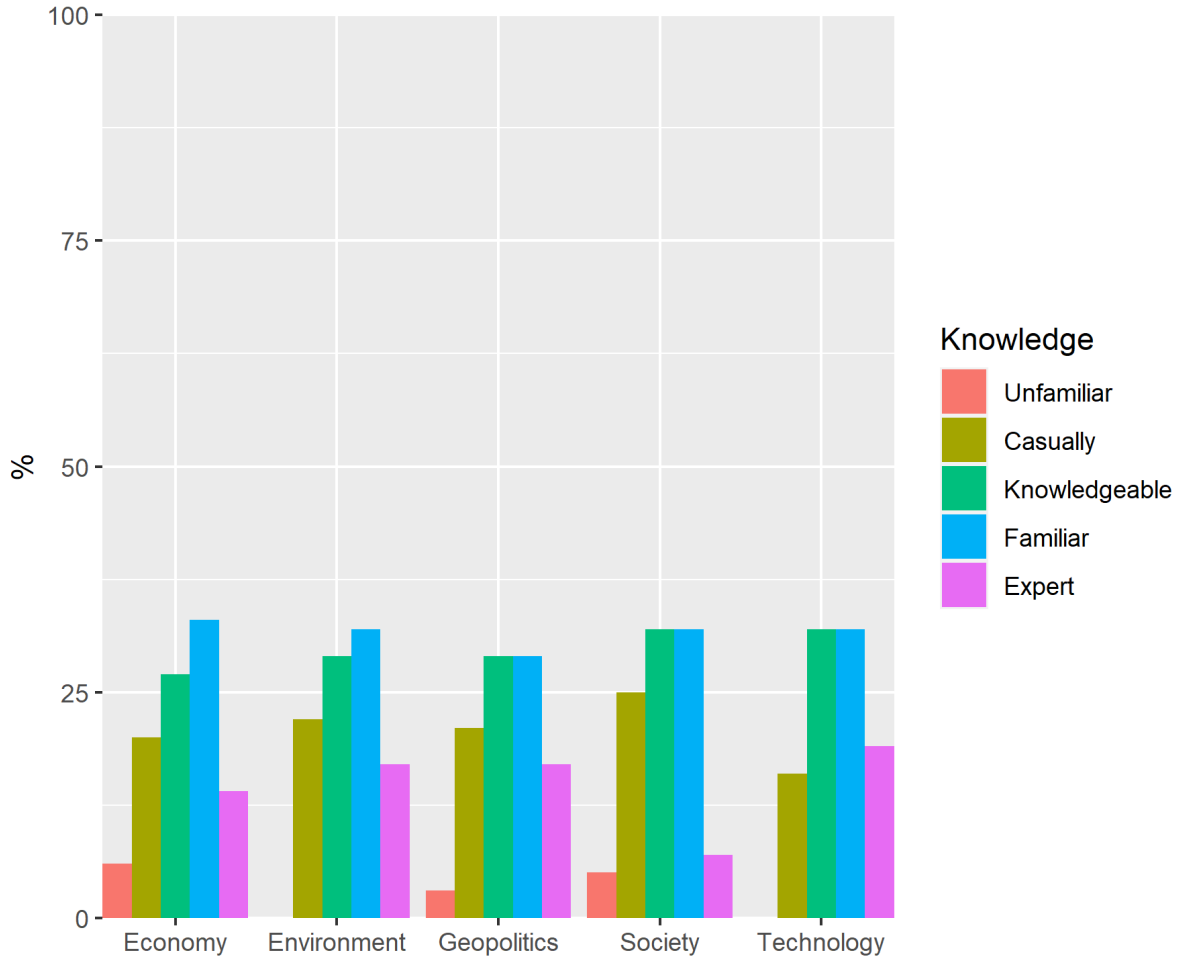


Figure A-4: Online Delphi participants – level of familiarity to open strategic autonomy Dimensions



Overall results Part I

The first part of the Online Delphi survey was designed to allow an in-depth understanding of the key priorities required to shape and secure EU's open strategic autonomy by 2040. Priorities have been identified based on the judgment of experts of all fifty (50) statements (10 per open strategic autonomy dimension). Each statement was assessed via four criteria, which are highlighted below. All statements judged relevant at either extreme of each criteria (higher/lower impact, higher/lower urgency, higher/lower capacity, and high/low likelihood of occurrence) were analysed in greater detail. These were brought to the fore (Tables X to Z below) to enable a portfolio analysis of statements that are relevant to shape and secure EU's open strategic autonomy by 2040 in a combination of at least two or more criteria:

Impact of the statement on achieving open strategic autonomy in the EU
Urgency of the EU to act on the statement
Capacity of the EU to act on the statement
Likelihood of the occurrence of the statement by 2040

Tables X to Z below depict the most relevant statements for each open strategic autonomy dimension, according to both extremes in the four applied criteria.

Main results from Online Delphi

Table A-2: Geopolitical priority statements per criteria in both its extremes

Geopolitical area of analysis of open strategic autonomy							
Impact – Most positive	**Impact – Most negative**	**Urgency – Highest**	**Urgency – Lowest**	**Capacity – Highest**	**Capacity – Lowest**	**Likely to happen by 2030**	**Likely to happen by 2040 and beyond**
The EU is able to secure the supply of critical raw materials through strategic alliances (GP1) The EU plays a leading role in international and multilateral fora (GP7) EU develops strategic alignment with like-minded countries (GP10) The EU Member States are more integrate (Gp8)	US retreats from multilateralism (Gp5) Russia becomes a systemic rival to the EU (Gp3) China's foothold in Africa and the Middle East reduces Western influence (Gp4) Global competition in standardisation reduces EU leadership (Gp6)	The EU is able to secure the supply of critical raw materials through strategic alliances (Gp1) China's foothold in Africa and the Middle East reduces Western influence (Gp4) The EU plays a leading role in international and multilateral fora (Gp7) EU develops strategic alignment with like-minded countries (Gp10)	EU membership expands to countries to the East and to the Balkans (Gp2) A EU defence force is established (Gp9) US retreats from multilateralism (Gp5) Global competition in standardisation reduces EU leadership (Gp6)	Global competition in standardisation reduces EU leadership (Gp6) EU develops strategic alignment with like-minded countries (Gp10) The EU plays a leading role in international and multilateral fora (Gp7) US retreats from multilateralism (Gp5)	A EU defence force is established (Gp9) The EU is able to secure the supply of critical raw materials through strategic alliances (Gp1) The EU Member States are more integrated (Gp8) Russia becomes a systemic rival to the EU (Gp3)	China's foothold in Africa and the Middle East reduces Western influence (Gp4) Russia becomes a systemic rival to the EU (Gp3) Global competition in standardisation reduces EU leadership (Gp6) The EU plays a leading role in international and multilateral fora (Gp7) EU develops strategic alignment with like-minded countries (Gp10)	A EU defence force is established (Gp9) The EU is able to secure the supply of critical raw materials through strategic alliances (Gp1) EU membership expands to countries to the East and to the Balkans (Gp2) US retreats from multilateralism (Gp5)

Table A-3: Technological priority statements per criteria in both its extremes

Technological area of analysis of open strategic autonomy							
Impact – Most positive	**Impact – Most negative**	**Urgency – Highest**	**Urgency – Lowest**	**Capacity – Highest**	**Capacity – Lowest**	**Likely to happen by 2030**	**Likely to happen by 2040 and beyond**
The EU has sovereignty over its own data (Tc1) The EU is independent from foreign digital platforms (Tc4) Convergence of biology, engineering, computation and other sciences lead to new technological developments (Tc5) AI and new technologies are strictly regulated in the EU (Tc9)	Cyberwarfare threatens critical EU infrastructures (Tc6) A fully digital society disable our ability to shape our future (Tc8) Privatisation of space threatens established forms of governance (Tc10) AI and automation disrupt the EU labour market (Tc2)	Cyberwarfare threatens critical EU infrastructures (Tc6) The EU has sovereignty over its own data (Tc1) The EU is independent from foreign digital platforms (Tc4) AI and new technologies are strictly regulated in the EU (Tc9)	A fully digital society disable our ability to shape our future (Tc8) Convergence of biology, engineering, computation and other sciences lead to new technological developments (Tc5) Research and innovation is AI generated (Tc3) Privatisation of space threatens established forms of governance (Tc10)	The EU has sovereignty over its own data (Tc1) AI and new technologies are strictly regulated in the EU (Tc9) Cyberwarfare threatens critical EU infrastructures (Tc6) Convergence of biology, engineering, computation and other sciences lead to new technological developments (Tc5)	A new competition for enhanced humans emerges (e.g. AI advancements and bio-engineering/gene editing) (Tc7) The EU is independent from foreign digital platforms (Tc4) Research and innovation is AI generated (Tc3) A fully digital society disable our ability to shape our future (Tc8)	Cyberwarfare threatens critical EU infrastructures (Tc6) AI and new technologies are strictly regulated in the EU (Tc9) The EU has sovereignty over its own data (Tc1) AI and automation disrupt the EU labour market (Tc2)	A new competition for enhanced humans emerges (e.g. AI advancements and bio-engineering/gene editing) (Tc7) Privatisation of space threatens established forms of governance (Tc10) Research and innovation is AI generated (Tc3) The EU is independent from foreign digital platforms (Tc4)

Table A-4: Economic priority statements per criteria in both its extremes

Economic area of analysis of open strategic autonomy							
Impact – Most positive	**Impact – Most negative**	**Urgency – Highest**	**Urgency – Lowest**	**Capacity – Highest**	**Capacity – Lowest**	**Likely to happen by 2030**	**Likely to happen by 2040 and beyond**
Global supply chains to the EU are reconfigured towards resilience and sustainability (Ec1) The EU has the talent and skills it needs (Ec8) EU implements a protection mechanism to block foreign take-overs in strategic industry sectors (Ec5) EU venture capital accelerates EU innovation (Ec10)	The EU loses control of its strategic industries and assets (Ec6) Ageing and depopulation reduce the workforce in the EU (Ec3) Economic growth is deemed more important than environmental action globally (Ec4) Common and flexible work arrangements across Europe stimulate innovation (Ec2)	Global supply chains to the EU are reconfigured towards resilience and sustainability (Ec1) The EU has the talent and skills it needs (Ec8) The EU loses control of its strategic industries and assets (Ec6) Ageing and depopulation reduce the workforce in the EU (Ec3)	Common and flexible work arrangements across Europe stimulate innovation (Ec2) EU FDI stimulates economic growth in the EU (Ec7) EU implements a protection mechanism to block foreign take-overs in strategic industry sectors (Ec5) Economic growth is deemed more important than environmental action globally (Ec4)	Global supply chains to the EU are reconfigured towards resilience and sustainability (Ec1) EU implements a protection mechanism to block foreign take-overs in strategic industry sectors (Ec5) The EU has the talent and skills it needs (Ec8) The EU loses control of its strategic industries and assets (Ec6)	Ageing and depopulation reduce the workforce in the EU (Ec3) Common and flexible work arrangements across Europe stimulate innovation (Ec2) EU Member States implement fiscal reforms to adapt welfare systems to an ageing society (Ec9) The EU loses control of its strategic industries and assets (Ec6)	Global supply chains to the EU are reconfigured towards resilience and sustainability (Ec1) EU implements a protection mechanism to block foreign take-overs in strategic industry sectors (Ec5) Economic growth is deemed more important than environmental action globally (Ec4) EU FDI stimulates economic growth in the EU (Ec7)	Ageing and depopulation reduce the workforce in the EU (Ec3) The EU has the talent and skills it needs (Ec8) EU Member States implement fiscal reforms to adapt welfare systems to an ageing society (Ec9) The EU loses control of its strategic industries and assets (Ec6)

Table A-5: Environmental priority statements per criteria in both its extremes

Environmental area of analysis of open strategic autonomy							
Impact – Most positive	**Impact – Most negative**	**Urgency – Highest**	**Urgency – Lowest**	**Capacity – Highest**	**Capacity – Lowest**	**Likely to happen by 2030**	**Likely to happen by 2040 and beyond**
Europeans change their consumption and lifestyle to support the green transition (En1) EU climate diplomacy leads to increased climate ambition in other regions (En2) EU's industry becomes more circular (En7) Resource dependencies in Europe shift from fossil-based to low-carbon technologies (En6)	Continued environmental degradation affects water and food security globally (En10) New health threats emerge in the EU due to continued environmental degradation (En5) High carbon prices in the EU lead to relocation of carbon-intensive industries to other regions (En8) China and India are the global leaders in green technologies (En3)	Europeans change their consumption and lifestyle to support the green transition (En1) Resource dependencies in Europe shift from fossil-based to low-carbon technologies (En6) Continued environmental degradation affects water and food security globally (En10) EU's industry becomes more circular (En7)	China and India are the global leaders in green technologies (En3) EU environmental standards make it more difficult to close trade deals (En4) Long-distance migration to Europe becomes commonplace due to climate change (En9) EU climate diplomacy leads to increased climate ambition in other regions (En2) New health threats emerge in the EU due to continued environmental degradation (En5)	EU climate diplomacy leads to increased climate ambition in other regions (En2) Resource dependencies in Europe shift from fossil-based to low-carbon technologies (En6) Europeans change their consumption and lifestyle to support the green transition (En1) EU environmental standards make it more difficult to close trade deals (En4)	China and India are the global leaders in green technologies (En3) Continued environmental degradation affects water and food security globally (En10) New health threats emerge in the EU due to continued environmental degradation (En5) Long-distance migration to Europe becomes commonplace due to climate change (En9)	EU environmental standards make it more difficult to close trade deals (En4) High carbon prices in the EU lead to relocation of carbon-intensive industries to other regions (En8) EU climate diplomacy leads to increased climate ambition in other regions (En2) New health threats emerge in the EU due to continued environmental degradation (En5)	Continued environmental degradation affects water and food security globally (En10) EU's industry becomes more circular (En7) Resource dependencies in Europe shift from fossil-based to low-carbon technologies (En6) Europeans change their consumption and lifestyle to support the green transition (En1)

Table A-6: Social priority statements per criteria in both its extremes

Social area of analysis of open strategic autonomy							
Impact – Most positive	**Impact – Most negative**	**Urgency – Highest**	**Urgency – Lowest**	**Capacity – Highest**	**Capacity – Lowest**	**Likely to happen by 2030**	**Likely to happen by 2040 and beyond**
EU's social market economy expands leaving no one behind (Sc3) Active citizenship, solidarity and respect for the environment are dominant values worldwide (Sc1) High burden of communicable and non-communicable diseases lead to the inclusion of health in EU competence (Sc6) Open governance in the EU enables it to set standards on social fairness (Sc7)	Social inequalities and poverty threaten EU's stability (Sc2) Migration to the EU fuels right-wing populism (Sc5) Misinformation and disinformation weaken EU democracy (Sc9) Brain drain within the EU weakens cohesion (Sc10)	Misinformation and disinformation weaken EU democracy (Sc9) Social inequalities and poverty threaten EU's stability (Sc2) Migration to the EU fuels right-wing populism (Sc5) Active citizenship, solidarity and respect for the environment are dominant values worldwide (Sc1)	The EU implements a minimum income (Sc4) Social fabric and sense of community break down due to automation and personalised services (Sc8) Open governance in the EU enables it to set standards on social fairness (Sc7) High burden of communicable and non-communicable diseases lead to the inclusion of health in EU competence (Sc6)	Misinformation and disinformation weaken EU democracy (Sc9) Brain drain within the EU weakens cohesion (Sc10) Social inequalities and poverty threaten EU's stability (Sc2) EU's social market economy expands leaving no one behind (Sc3)	Active citizenship, solidarity and respect for the environment are dominant values worldwide (Sc1) Migration to the EU fuels right-wing populism (Sc5) The EU implements a minimum income (Sc4) High burden of communicable and non-communicable diseases lead to the inclusion of health in EU competence (Sc6)	Misinformation and disinformation weaken EU democracy (Sc9) Migration to the EU fuels right-wing populism (Sc5) Brain drain within the EU weakens cohesion (Sc10) High burden of communicable and non-communicable diseases lead to the inclusion of health in EU competence (Sc6)	Active citizenship, solidarity and respect for the environment are dominant values worldwide (Sc1) Social inequalities and poverty threaten EU's stability (Sc2) The EU implements a minimum income (Sc4) EU's social market economy expands leaving no one behind (Sc3)

Overall results Part II

Asked to assess the EU's position in the supply chain for several technologies in 2040, respondents are mainly divided between two camps. One majority considers that EU's position could be "strong/very strong" regarding several technologies, while almost the same number of respondents take a "neutral" position regarding other technologies. EU's position is considered to be "weak" only regarding two supply chains.

The respondents of the Online Delphi are positive about EU's strong and very strong future position in the supply chain for the following technologies: batteries, low-carbon mobility, smart grids, renewable energy, robotics, automation and machine learning, Internet of Things, health diagnosis and treatment.

A second large majority prefers to stay "neutral" regarding: hydrogen, drones, 3D printing, semiconductors and chips, cloud and quantum computing, 5G/6G, virtual reality, cryptocurrency and blockchain.

At the same time, there are four supply chains considered to be strong/very strong by some, but fall under "neutral" for other respondents. These are: AI, big data analysis, gene editing and bio-engineering, convergence of bio-, nano- and information technology.

On the contrary, EU's future position could be weak for space exploration and military supply chains.

Asked to outline which region will dominate the same technologies in 2040, the answers that we received clarify the position of respondents towards the four supply chains in which EU's position could be "strong/very strong" or questionable, doubtable, unknown ("neutral" position).

All respondents taking a neutral position have chosen the US as the top region which will dominate in AI, big data analysis, gene editing and bio-engineering, convergence of bio-, nano- and information technology in 2040. If for gene editing and bio-engineering, convergence of bio-, nano- and information technology, Europe is closely following the US, China represents the second dominator regarding AI and big data analysis (Europe occupies the third position).

Regarding the two technologies where EU's position is considered weak in 2040 – space exploration and military – the leading region is the US, with China being a very distant second.

The overall results emphasize:

1. Top five technologies that the EU should invest in today in terms of R&D and production to build its open strategic autonomy;
2. Five most relevant sectors for EU's open strategic autonomy in 2040;
3. Five issues that the EU should invest today to build its open strategic autonomy.

Please select up to five technologies the EU should invest today in terns of R&D and production to build its open strategic autonomy:

AI: 7.45 %

Renewable energy: 6.67 %

Health diagnosis and treatment / Hydrogen: 5,88%

Batteries: 5.49 %

Convergence of bio-, nano- and information technology: 4.71 %

Semiconductors and chip manufacturing / Big data analytics: 3.92 %

Please select the five most relevant sectors for EU's open strategic autonomy in 2040:

Renewable energy: 12.16 %

Digital: 9.41 %

Mobility - Transport – Automotive / Health: 9.02 %

Electronics: 8.24 %

Aerospace & defence: 7.84 %

Please select up to five issues that the EU should invest today to build its open strategic autonomy:

Access to Critical Raw Materials required for the green and digital transitions: 12.55%

Research and Innovation (R&I): 9.8%

Education and a skilled workforce: 7.84%

Rollout of digital technologies / Security and defence 6.27%

Rollout of low-carbon technologies: 5.88%

Overall results Part III

The insights provided via the open questions were organised in terms of EU strengths (i.e. capacities, capabilities and both soft and hard power) and weaknesses (i.e. dependencies vulnerabilities and risks).

EU weaknesses:

The survey results confirmed a number of areas we had already identified, such as the risk of growing dependencies on raw materials for manufacturing, as well as hardware and digital infrastructure, in particular from China.

Results from the survey have also reiterated the EU's future dependence on foreign talents (labour force) as a consequence of demography trends such as ageing population and overall population decline.

Other existing and potential future dependencies signalled in the survey concern advanced technologies (from US and China), AI and software (in particular from the US), robotics (in particular from Japan) and energy security if the EU does not gear its green energy transition towards greater autonomy. Lack of EU control over critical trade routes, like the Panama or Suez canals, or emerging new routes, was also mentioned.

EU strengths:

The most important horizontal capacity that was stressed by a number of survey responses is human capital, the investment in a skilled work force amidst global competition and rapidly changing labour market. In particular, fields mentioned where more skills are needed include AI, Big Data, genetics, cyber, robotics and STEM generally. In relation to human capital, better talent management was also signalled, for the EU to attract global talent.

Apart from that, respondents stressed research and innovation, the application of cutting edge technologies and AI, renewables and climate change mitigation and adaptation, space and defence technologies and food security.

In terms of social capacities, the survey underlines the importance of ensuring social support and building trust among people and institutions to achieve EU's open strategic autonomy. Emphasis here is on democracy, accepting diversity in all forms, promoting a human-centred approach to technologies and digital society, and promoting sustainability. The need for more vocal and coherent EU diplomacy, as a vehicle to promote and defend EU values and responsible leadership, was also mentioned as an important capacity.

A number of responses to the open questions stress the need for EU leadership in human-centred approach to technologies. The ethical use of Artificial Intelligence, as a general purpose technology, features particularly highly in survey responses, as does the ethical use of data and date protection. Other technologies where continued or greater EU leadership is called for is in quantum technologies, biotechnology, and low-carbon technologies, especially in mobility.

Finally, other survey replies stress the EU's continued global leadership in mitigating climate change and strengthening its global commitment to supporting and managing socio-economic green transitions, improving crisis management, including in the area of climate migration, addressing global health challenges, and promotion of human rights.

References and endnotes

1 COM (2021) 66 final open strategic autonomy emphasises the EU's ability to make its own choices and shape the world around it through leadership and engagement, reflecting its strategic interests and values. COM (2021) 350 final emphasises on open strategic autonomy to deal with dependencies.

2 Strategic foresight draws useful insights for strategic planning, policymaking and preparedness (European Commission, 2017, Strategic Foresight Primer). It is not about predicting the future but about exploring different plausible futures that could arise and the opportunities and challenges they could present. It involves identifying trends and emerging issues, using them to create scenarios, visions and associated pathways to make better decisions and act in the present in order to shape the future we want (https://www.sciencedirect.com/book/9780128225967/science-for-policy-handbook).

3 The five areas mirror the STEEP categories (societal, technological, economic, environmental, political) that are widely used in systematic foresight analysis. The political category is in this report specified with 'geopolitics' to better address the specificities of open strategic autonomy. In the 2020 Strategic Foresight Report of the Commission (European Commission (2020) Strategic Foresight – Charting The Course Towards A More Resilient Europe. COM/2020/493 final) analysed resilience enhancing policies across four areas: social and economic resilience, geopolitical resilience, green resilience and digital resilience. These are another adaptation of the STEEP concept, according to the specific needs of the resilience analysis in the respective report.

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564 To achieve at the final set of questions and statements several meetings took place with JRC experts in the different OSA dimensions as well as capacities, capabilities, dependencies, vulnerabilities and risks. These were refined with SG to ensure clarity and policy relevance.

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