1 Science, technology and innovation policy in times of global crises

Longstanding trends and recent disruptions have created a new operating environment for STI policy. Climate change, growing geopolitical tensions and the COVID-19 pandemic have highlighted risk, uncertainty and resilience as conditions and concerns for STI policy. As the pandemic has shown, STI is essential to building capacity for resiliency and adaptation to shocks. However, it can only perform this role effectively if it is well-prepared to respond to known risks and unknown uncertainties. Good preparation requires long-term investments in research and development, skills and infrastructures, but this alone is insufficient. It also needs strong relationships in "normal times" among those who should mobilise rapidly to deal with crisis situations, as well as a strong "strategic intelligence" capacity to identify, monitor and evaluate emerging risks and responses. It is in the mutual interest of all countries to ensure these relationships and capacities are globally distributed to enable an inclusive scientific and technological response to future crises.

Key messages

- Multiple crises are triggering turbulence, instability and insecurity in contemporary societies, with impacts on economies, the environment, politics, and global affairs. The two most salient disruptions of the last couple of years – the COVID-19 pandemic and Russia's war of aggression against Ukraine – have had far-reaching and cascading effects, including on science, technology and innovation (STI).
- Assessment of the pandemic response provides key and actionable insights into what will likely be required of STI systems to respond more effectively to future crises. Looking back on how the pandemic has unfolded provides an opportunity to identify and resolve structural challenges to the effective operation of STI systems and support them in fostering the resilience needed to prepare for, respond and recover from, future crises and complex societal challenges.
- Research and innovation capabilities make economies and societies more resilient, but they require long-term investments in R&D, skills and infrastructures. Strong relationships in "normal times" between those who should mobilise rapidly to deal with crisis situations should be nurtured. Several OECD countries have announced substantial STI investments to improve pandemic prevention, preparedness and response. But these should be complemented by greater investment in research infrastructure as well as production capacities in low- and middle-income countries to enhance global preparedness and response.
- Geopolitical tensions led to vaccine competition between countries, creating a patchwork of vaccine approvals around the world. The global architecture to provide equitable access to vaccines has not met expectations, owing (among other factors) to insufficient funding, wealthier-country hoarding and logistical challenges. Vaccine "nationalism" and "diplomacy" raise concerns about strategic competition in other technology areas, as well as the prospects of future STI co-operation on global challenges such as climate change.
- More broadly, the pandemic and war in Ukraine have brought risk, uncertainty and resilience to the fore as conditions and concerns for STI policy. They have contributed to a growing "securitisation" of STI policies, whose definition is broadly defined to cover a range of issues beyond traditional defence concerns. These include biosecurity, for example, where promising research in fields like synthetic biology carry inherent risks.
- The concept of research security has also strongly emerged in recent years, to counter unauthorised information transfer and foreign interference in public research. OECD governments have put in place measures to improve research security, emphasising the values, norms and principles that constitute good scientific practice.
- Russia's war of aggression against Ukraine has had few direct impacts on STI activities in OECD countries. Nevertheless, OECD countries have levied unprecedented science "sanctions" on Russia and continue to support Ukrainian scientists through a range of policy measures. Ukraine has longstanding "brain drain" challenges, which the war could exacerbate. OECD countries should aim to promote genuine brain circulation and the establishment of sustainable and productive long-term partnerships with Ukrainian scientific institutions.
- The pandemic demonstrates the implausibility of anticipating and addressing all the cascading implications of ongoing and future crises as they emerge and hence the importance of focusing on improving systemic resilience. To manage crises and contribute to society's resiliency, policy needs to be more anticipatory, systemic, inclusive and innovative. Good preparation also calls for a strong "strategic intelligence" capacity to identify, monitor and evaluate emerging risks and responses. Such policy qualities also depend on government capacities that will take time and investment to develop.

Introduction

Longstanding trends and recent disruptions have created a new operating environment for STI policy. Climate change and its impacts, along with the fast pace of change implied by the digital transformation, are driving STI agendas in what is often termed the "twin transition". At the same time, the two most salient disruptions of the last couple of years – the COVID-19 pandemic and Russia's war of aggression against Ukraine – have had far-reaching, cascading effects, including on STI. During the pandemic, STI played prominent roles in understanding the virus and its transmission and designing appropriate countermeasures, notably by developing highly effective vaccines over a very short period. The pandemic has also impacted STI, for example, by introducing greater flexibility in R&D funding and boosting open science. Beyond the impacts of advanced weaponry, the role of STI in the war in Ukraine is less prominent or clear-cut. However, the war and ensuing energy crisis have highlighted the need to accelerate the transition from fossil fuels to clean energy sources. Achieving this objective will depend on the rapid deployment of existing or close-to-market green innovation solutions to improve energy security in the short term, as well as boosting investments in R&D to underpin longer-term transitions to net-zero (see Chapter 3).

The significant uncertainty arising from the war in Ukraine adds to the challenges already facing policy makers owing to unexpectedly strong inflationary pressures and imbalances related to the pandemic. In many economies, inflation in 2022 has been at its highest since the 1980s, while rising debt service burdens are also likely to compound challenges for public finances. With recent indicators taking a turn for the worse, the global economic outlook has darkened, with global growth projected to slow even further in 2023 (OECD, 2022[1]).

The chapter begins by discussing two recent disruptions – COVID-19 and Russia's war against Ukraine – and their impacts on STI. Both the pandemic and Russia's aggression have required large-scale government interventions to stave off economic crises. The pandemic resulted in the first recession where R&D expenditures have not fallen, largely because of their significant roles in tackling the crisis. It is too early to tell what impact Russia's aggression will have on R&D expenditures, but there is the possibility their growth will falter in the event of a deep or protracted economic slowdown. The chapter then describes how these disruptions, together with the climate crisis and anxieties related to technological change, have brought risk, uncertainty and resilience to the fore as conditions and concerns for STI policy. They have contributed to a growing "securitisation"[1] of STI policies, where economic competitiveness rationales for policy intervention are now combined with rationales emphasising national security, sustainability transitions and (to a much lesser extent) inclusion. The final section draws some lessons and presents a brief outlook for STI policy in times of global crisis.

STI and the COVID-19 crisis

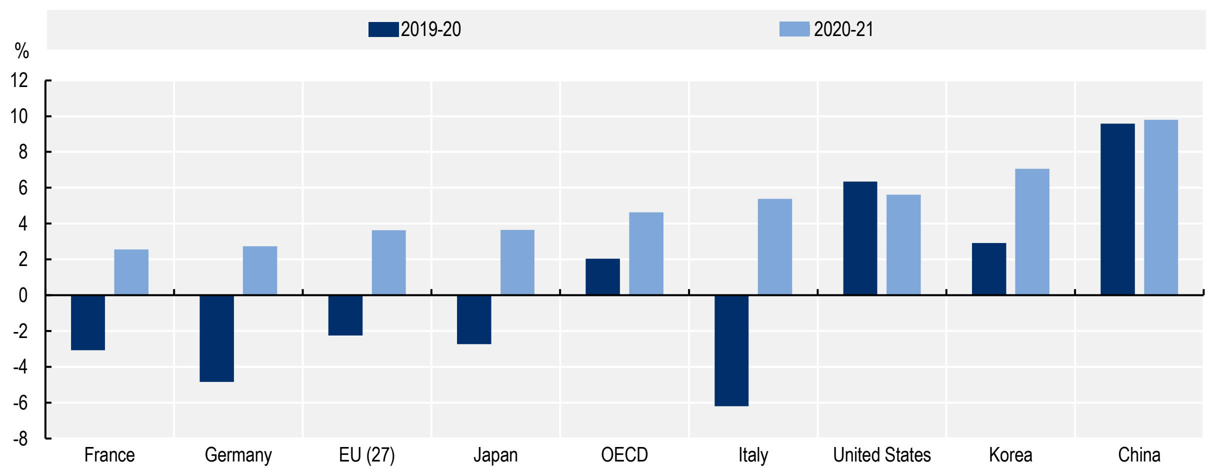
At the time of publication of the last edition of the STI Outlook (OECD, 2021[2]), the COVID-19 pandemic was less than a year old, but the science and innovation community had already responded decisively and at pace. Through multibillion-dollar public and private investments, the first vaccines had already been approved and tens of thousands of scientific articles had been openly published, many reporting on research performed by international teams. At the same time, COVID-19 restrictions were still largely in force, with more to follow during 2021-22. These were having a range of negative impacts, both directly on STI activities and indirectly through their wider social and economic effects, although these were difficult to measure at the time. Two years on, it is possible to get a better sense of the pandemic's effects on STI activities and how STI responded. Chapter 4 provides an overview of how science was mobilised to respond to the pandemic. This chapter focuses on selected key indicators of R&D expenditures and vaccine developments.

Impact of COVID-19 on R&D expenditures

OECD gross domestic expenditure on R&D (GERD) grew 2.1% between 2019-20 (Figure 1.1). While this was a sharp slowdown compared to previous years (when it was growing at around 5% annually), it was nevertheless exceptional, marking the first time a global recession has not translated into falls in R&D expenditures. This reflects how investments in R&D were an integral part of the response to the pandemic (OECD, 2022[3]). Growth in R&D in the OECD area in 2020 was primarily driven by the United States (+6.4%), in contrast to declining R&D expenditures in Germany (-4.9%)[2] and Japan (-2.7%). Provisional data for 2021 show that OECD growth rates bounced back to pre-pandemic levels, with OECD GERD growing 4.5% between 2020-21. This reflects a recovery in R&D expenditures in many countries that had experienced a decline in the previous year.

Figure 1.1. Growth in gross domestic expenditure on R&D, between 2019-20 and 2020-21

Percentage growth rate in constant price



Source: OECD R&D statistics, February 2023. See OECD Main Science and Technology Indicators, http://oe.cd/msti, for most up-to-date indicators

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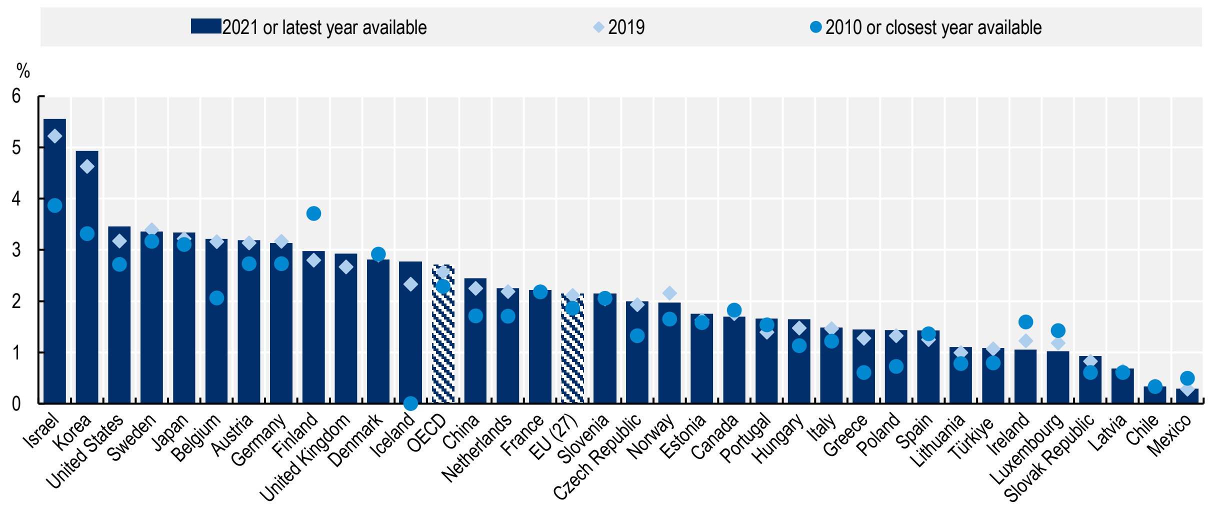
Across the OECD, Israel (5.6%) and Korea (4.9%) continued to display the highest levels of R&D intensity as a percentage of GDP (Figure 1.2). R&D intensity in the OECD area climbed from 2.5% in 2019 to 2.7% of GDP in 2021. Over the same period, R&D intensity as a percentage of GDP increased in the European Union (EU27) area from 2.1% to 2.2%, in the United States from 3.2% to 3.5%, and in the People’s Republic of China (hereafter China) from 2.2% to 2.4%.

Figure 1.2. R&D intensity: Gross domestic expenditure on R&D as a percentage of GDP



Note: 2021 data corresponds to 2020 for Chile, Colombia, Mexico, Türkiye and United Kingdom. Data for the United Kingdom only available for 2018-20 and preliminary. Following a major data revision by the UK statistical agency conducted in late 2022 and effective only from 2018, back series for previous years have been suppressed from the data available to OECD.

Source: OECD R&D statistics, February 2023. See OECD Main Science and Technology Indicators, http://oe.cd/msti, for most up-to-date indicators.

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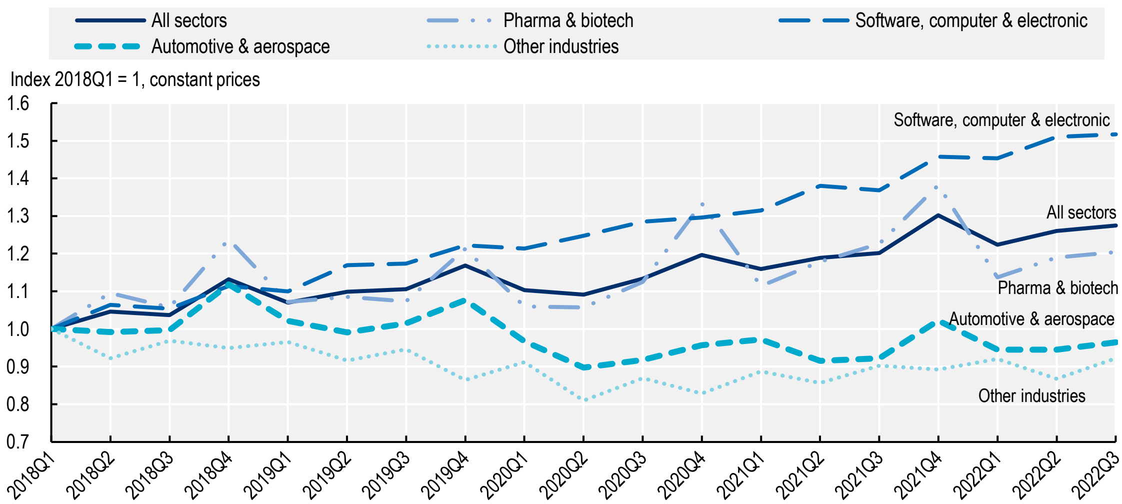
Since the private sector accounts for more than two-thirds of R&D expenditures in the OECD, a country's R&D intensity is heavily influenced by the R&D activities of its firms. The OECD Short-term Financial Tracker of Business R&D (SwiFTBeRD) dashboard delivers the timeliest possible insights on company-specific and sectoral quarterly and annual R&D data reported by several of the world's major R&D investors.[3] Analysis of R&D expense growth in 2021 confirms widespread improvement across the board for most companies following the initial pandemic shock in 2020 (Figure 1.3). Software, computer & electronic technology firms and (to a lesser extent) pharmaceutical and biotechnology firms continued to drive R&D expense growth, while automotive and aerospace (along with other industries) were still lagging in 2021. In the first half of 2022, year-on-year aggregate R&D expense growth in the software, computer & electronic technology sector remained at around 10%, while it was almost flat in other sectors. Given these trends, as Figure 1.3 shows, R&D expenses in the software, computer & electronic technology sector were more than 50% higher in mid-2022 as compared to the start of 2018. In the automotive and aerospace sector and other industries, by contrast, R&D expenses had yet to recover to their 2018 levels.

Figure 1.3. Industry R&D trends show variable growth by sector

Index 2018Q1 = 1, constant prices



Note: Reported values are deflated using the GDP price index of the OECD zone. Company reports of R&D expenses need not coincide with R&D expenditures as covered in official R&D statistics compiled according to the Frascati Manual (OECD, 2015). In order to compile the SwiFTBeRD data, the OECD implements a series of adjustments aimed at enhancing comparability, whenever the necessary information is available. Companies presenting their financial results in compliance with the International Financial Reporting Standards (IFRS) capitalise part of their development costs (under some criteria). In the data presented in SwiFTBeRD, capitalised development costs are added to reported R&D expenses, while amortisation of capitalised development expenditures are conversely excluded, provided that the information is available both in the annual and interim reports. In addition, when possible, expenses and impairment of purchased in-process R&D (as well as restructuring R&D costs) are excluded in the SwiFTBeRD figures in order to align as much as possible with R&D conducted in the reference period and deliver more meaningful indicators.
Source: OECD Short-term Financial Tracker of Business R&D (SwiFTBeRD) dashboard, Beta version, 7 December 2022, https://oecd-main.shinyapps.io/swiftberd/ (accessed 8 February 2023).

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STI policy responses to COVID-19

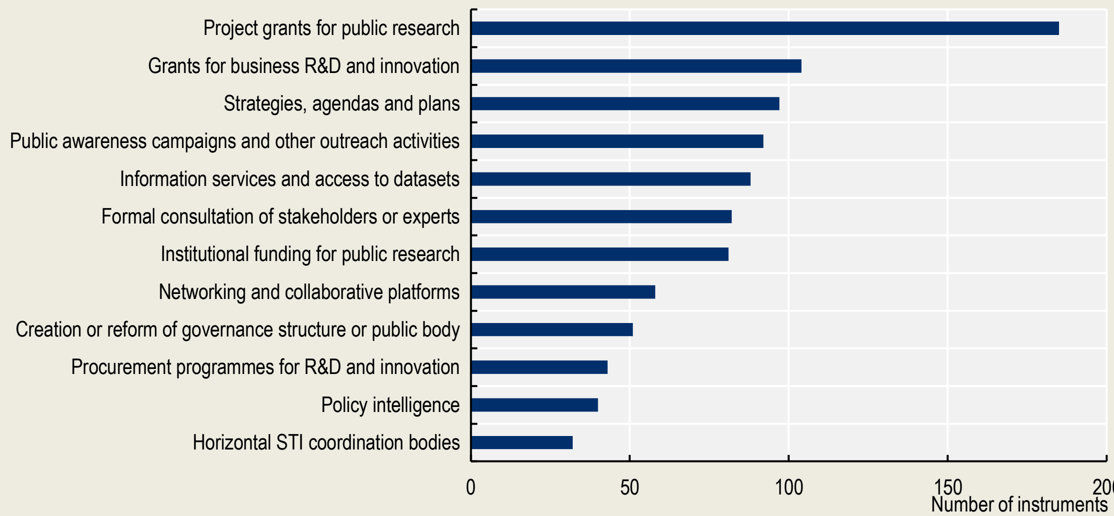
Governments launched hundreds of STI policy initiatives in the first year of the pandemic to develop research and innovation solutions. In the first six months of the pandemic, national public research-funding agencies and organisations announced they were providing more than USD 5 billion for public research-funding schemes targeting COVID-19 (OECD, 2021[2]). Box 1.1 provides a breakdown of the types of policy initiatives that were used.

Box 1.1. What sorts of STI policies did governments use to target COVID-19 and mitigate its effects?

The Science, Technology and Innovation Policy (STIP) Compass "COVID-19 Watch tracker"[1] has collected information on more than 900 STI policy initiatives launched between January 2020 and June 2021. Analysis shows these covered a wide range of target groups using a mix of policy instruments (Barreneche, 2021[4]), notably grant schemes targeting public research, as well as business R&D and innovation. "Soft" instruments, including public awareness campaigns, information services and stakeholder consultation were also used extensively (Figure 1.4).

Figure 1.4. Top 12 policy instruments used in STI policy initiatives targeting COVID-19

Number of policy instruments in the COVID-19 Watch portal of STIP Compass, by type of policy instrument



Source: EC-OECD STIP Compass, https://stip.oecd.org (accessed 7 February 2023).

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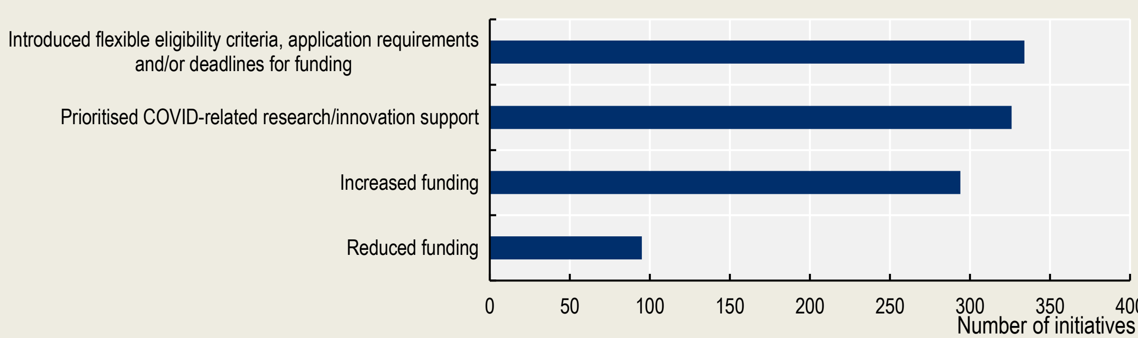
More than 90% of STI policy initiatives in the COVID-19 Watch database were launched in 2020.[2] Following this spate of standalone emergency policy measures in the early phases of the pandemic, governments shifted their response to adapting existing policy initiatives. As Figure 1.5 shows, countries participating in the EC-OECD STIP Survey in mid-2021 reported adapting around 15% of all STI policy initiatives to respond to COVID-19. Many programmes and policy initiatives introduced flexible eligibility criteria, application requirements and/or deadlines for funding. Many also prioritised support for research and innovation related to COVID-19. Finally, three times as many initiatives increased funding than decreased it.

Figure 1.5. Shifts in existing STI policies in response to COVID-19

Number of policy initiatives as reported in the EC-OECD STIP Survey, June 2021



Note: Data based on country responses to the EC-OECD STIP Survey 2021, specifically the following question in the "policy initiative fiche": "*Any shifts related to COVID-19*"?

Source: EC-OECD STIP Compass, https://stip.oecd.org (accessed 7 February 2023).

1. https://stip.oecd.org/stip/covid-portal.
2. Of the 932 policy initiatives in the COVID-19 Watch database, just 76 were initiated in the first 6 months of 2021.

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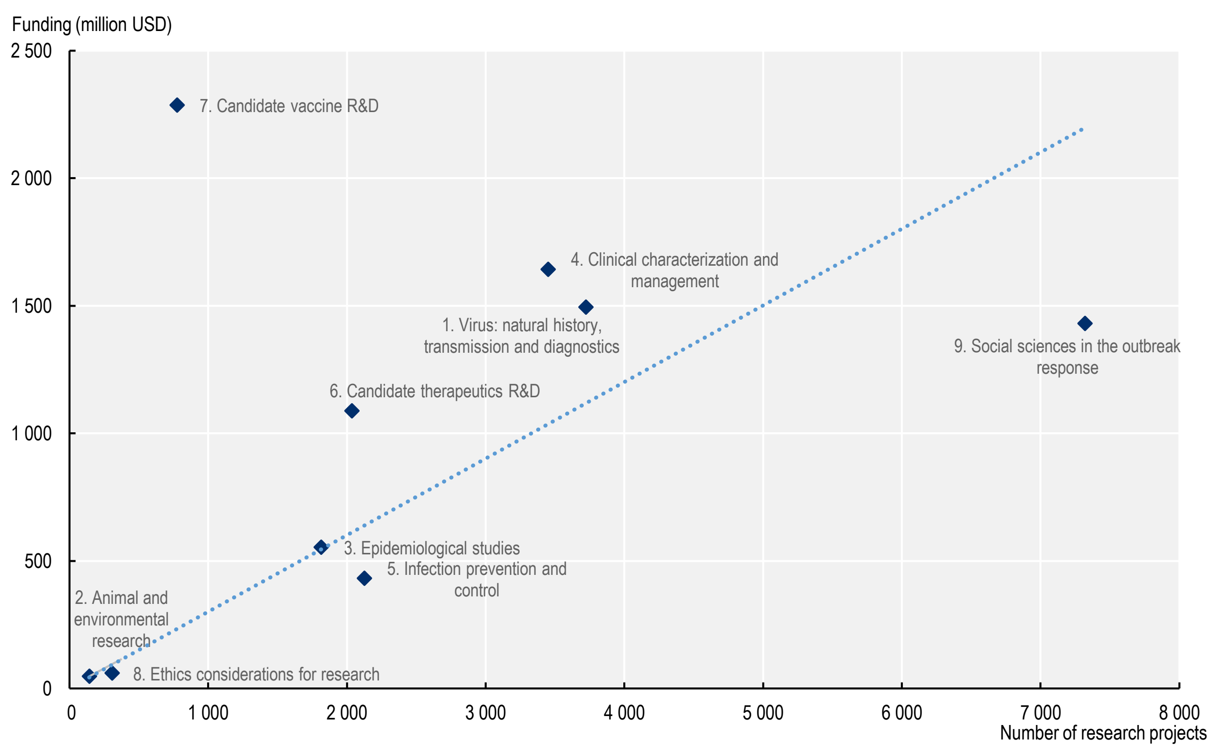
Translating policy initiatives into research funding

The research community translated much of this COVID-19 policy support into funded research projects covering a variety of topics. The UK Collaborative on Development Research (UKCDR)[4]/GloPID-R COVID-19 Research Project Tracker has collected data on almost 18 000 research projects with funding of over USD 8 billion between the start of the pandemic and September 2022.[5] The tracker maps research projects against the priorities identified in the World Health Organization (WHO) Coordinated Global Research Roadmap for COVID-19 (WHO, 2020[5]) to help funders and researchers prioritise resources for underfunded areas with the greatest research need. This mapping against the WHO priorities shows that 4% of research projects in the database target vaccine R&D yet account for 25% of the awarded funding, while 36% target the social sciences yet account for 16% of funding (Figure 1.6).[6]

Such comparisons should be interpreted with care. For example, it is well established that social science projects typically rely on less funding than their science, technology and engineering counterparts. There also exists evidence that the social sciences and humanities were less well organised than their biomedical counterparts to respond effectively to the demands of a complex crisis like COVID-19 (see Chapter 4 for further discussion on the subject). The real outlier, however, is the scale of support for vaccine research, as compared, for example, to research on candidate therapeutics, which accounted for around 12% of total funding (approximately USD 1 billion) and 10% of research projects, with an average project size of approximately half a million USD. This reflects the high priority given to the development and availability of vaccines, particularly in the early phases of the pandemic, where infection prevention was greatly emphasised. Ongoing OECD work on mapping government R&D project funding for COVID-19 provides a picture consistent with these findings (OECD, forthcoming[6]).

Figure 1.6. COVID-19 funded research projects mapped against WHO "research priorities"



Note: Some projects have been assigned to more than one WHO priority area. There are 20 272 projects included in total.
Source: OECD calculation, based on data from the UKCDR and Global Research Collaboration for Infectious Disease Preparedness (GloPID-R) COVID-19 Research Project Tracker, https://www.ukcdr.org.uk/covid-circle/covid-19-research-project-tracker/ (accessed 15 February 2023).

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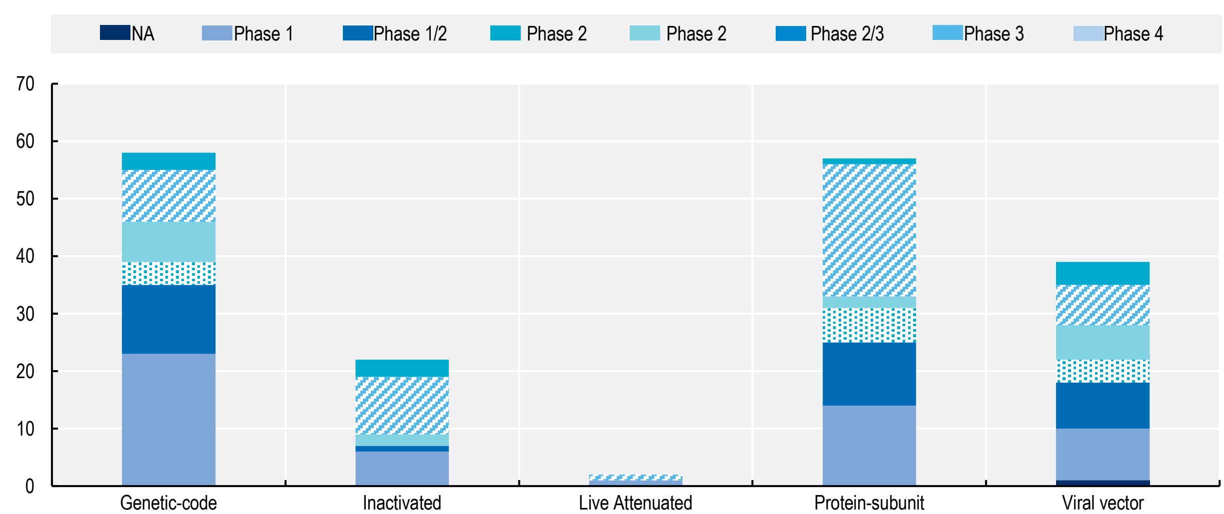
Translating research into COVID-19 knowledge and vaccines

The 2021 edition of the STI Outlook (OECD, 2021[2]) highlighted the rapid and massive response of the research community to the pandemic, as measured by bibliometric analysis and the progress of clinical trials. Already at the time of writing in late 2020, the first COVID-19 vaccines were in the final stages of approval and about to be launched. Two years on, several effective vaccines have been developed using different technologies (Figure 1.7) and tested and rolled out in record time. This is an outstanding demonstration of what can be done when academia and industry effectively combine resources (see Chapter 4). The creation of different – and often novel – vaccine platforms is also a welcome development that could have far-reaching benefits across medical science. It is estimated that COVID-19 vaccines had saved 20 million lives by mid-2022, although this number could have been greater if vaccine coverage had been more equitable (Watson et al., 2022[7]). The earliest COVID-19 vaccines continue to dominate the marketplace and there are now fewer new vaccines under development than in the first half of 2022 (Figure 1.8).

Figure 1.7. COVID-19 vaccine candidates, by technology platform and clinical trial phase

Number of vaccines under development



Note: The "live attenuated" technology platform corresponds to vaccines that use a weakened version of the virus that replicates without causing disease. "Inactivated" vaccines are a version of the actual virus grown and chemically inactivated. "Viral vector" vaccines are based on another virus with spike protein which has been disabled from replication. "Protein-subunit" vaccines are based on viral subunits expressed via various cell lines to stimulate immune response. "Genetic-code" vaccines use deoxyribonucleic acid (DNA) or ribonucleic acid (RNA) to create antigens for the immune system to target. Definitions taken from https://sidp.org/resources/Documents/COVID19/Jeannettee%20Bouchard%20General%20Information%2012.28.2020.pdf.

Source: OECD calculations based on WHO, https://www.who.int/teams/blueprint/covid-19/covid-19-vaccine-tracker-and-landscape (accessed 6 February 2023).

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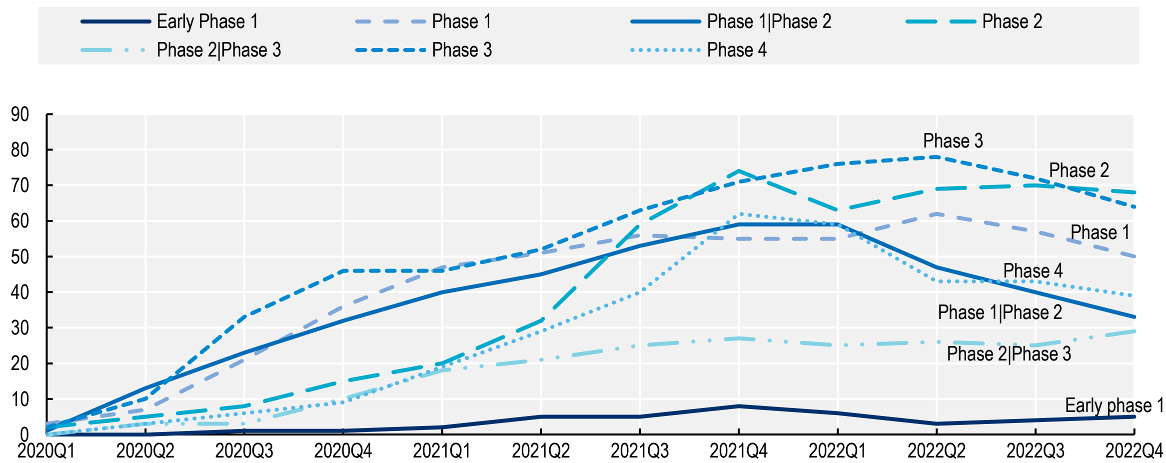
Figure 1.8. Trends in registered COVID-19 vaccine studies, by clinical trial phases

Numbers of clinical trials by phases, January 2020 to December 2022



Note: Biomedical clinical trials of experimental drug, treatment, device or behavioural intervention may proceed through four phases. Phase 1: Clinical trials test a new biomedical intervention in a small group of people (e.g. 20-80) for the first time to evaluate safety (e.g. determine a safe dosage range and identify side effects). Phase 2: Clinical trials study the biomedical or behavioural intervention in a larger group of people (several hundred) to determine efficacy and further evaluate its safety. Phase 3: Studies investigate the efficacy of the biomedical or behavioural intervention in large groups of human subjects (from several hundred to several thousand) by comparing the intervention to other standard or experimental interventions, as well as monitoring adverse effects and collecting information that will allow the intervention to be used safely. Phase 4: Studies are conducted after the intervention has been marketed. These studies are designed to monitor the effectiveness of the approved intervention in the general population and collect information about any adverse effects associated with its widespread use. Definition of phases from the WHO glossary: https://www.who.int/clinical-trials-registry-platform.
Source: OECD calculations based on United States National Institutes of Health (NIH), ClinicalTrials.gov, https://clinicaltrials.gov/ct2/results/map?term=AREA%5BInterventionType%5D+%28Drug+OR+Biological%29&cond=COVID-19&intr=vaccine (accessed 18 January 2023).

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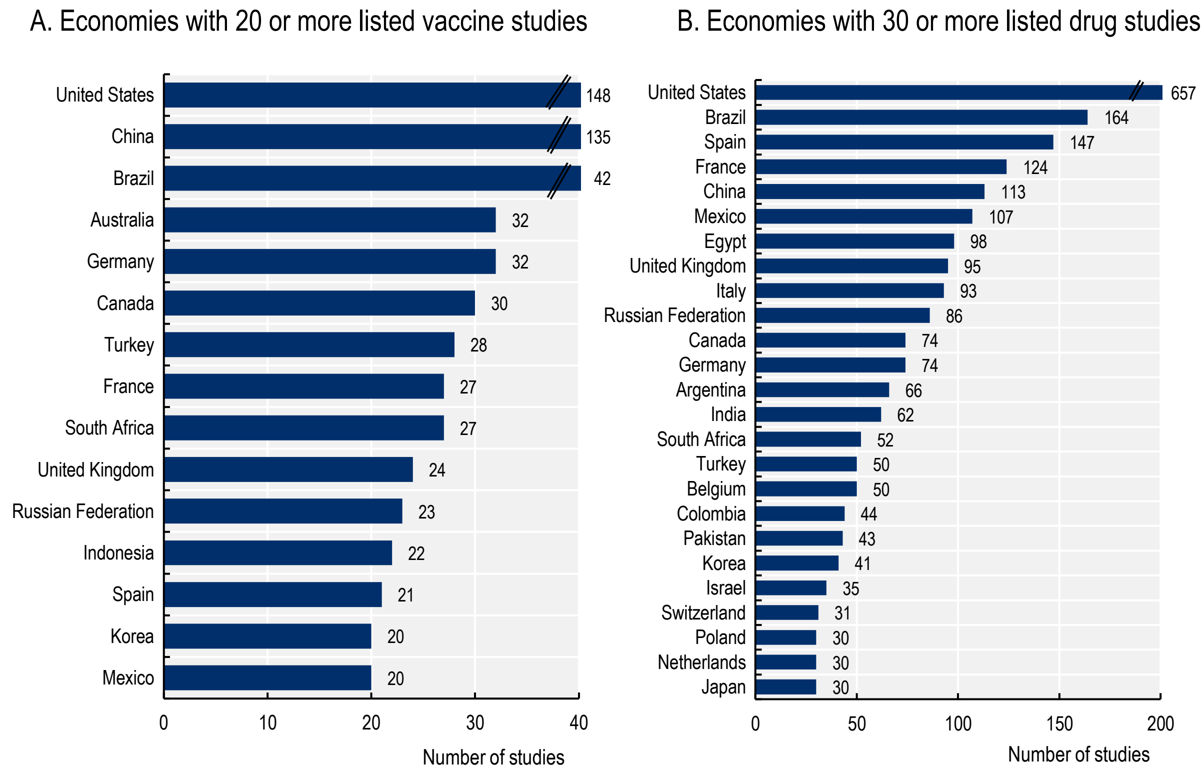
Figure 1.9 shows the number of COVID-19-related clinical studies, as registered with the United States National Institutes of Health (NIH) by September 2022. Panel A shows that the United States, followed by China, have by far the most COVID-19 vaccine clinical studies. Between them, they have more vaccine studies than the next nine ranked countries combined. Panel B shows the United States to be an outlier on COVID-19 drug studies with more than 650 studies, compared to 164 studies for second-placed Brazil. This concentration is partly explained by country size, but the data also show that clinical trials have been carried out widely across the world. A criticism of the biomedical response to COVID-19 is that there were too many uncoordinated clinical studies and too few clinical trials with sufficient participants to draw statistically significant conclusions (see Chapter 4). So the large number of clinical studies shown in Figure 1.9 should not necessarily be interpreted as a wholly positive development.

Figure 1.9. Registered COVID-19 vaccine and drug studies by economy, as of 6 February 2023



Note: The charts show the numbers of COVID-19 studies registered at the NIH (ClinicalTrials.gov). The International Committee of Medical Journal Editors requires trial registration as a condition of the publication of research results generated by a clinical trial. Multi-economy registered studies are counted in each economy. Note that the number of studies is not necessarily indicative of the breadth or depth of the studies conducted within each territory.
Source: NIH, ClinicalTrials.gov (accessed 6 February 2023).

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At the same time, vaccine competition between governments has been rife and influenced in part by geopolitical tensions, creating a global patchwork of vaccine approvals. By mid-2022, China had approved eight vaccines, all but one developed domestically; Russia had approved six vaccines, all developed domestically; and France, Japan and the United States had yet to approve any Chinese, Indian or Russian-developed vaccines (Table 1.1). The dominant vaccine narrative has been compared to the historical space or nuclear arms "races", despite the pandemic being a global challenge (Wilson Center, 2022[8]). The vaccine "nationalism" and "diplomacy" that some countries pursued raises serious concerns about strategic competition in other technology areas and the prospects for future STI co-operation on global challenges (like climate change). Chapter 2 further discusses this issue.

Table 1.1. Approval of selected vaccines in selected countries, as of July 2022

	United States	France	Japan	Mexico	Brazil	China	India	Indonesia	Russia	South Africa
Johnson & Johnson (USA)	√	√	√	√	√		√	√		√
Moderna (USA)	√	√	√	√			√	√		

Pfizer/BioNTech (USA/Germany)	√	√	√	√	√	√		√		√
Oxford/AstraZeneca (UK)		√	√	√	√			√		
Sinopharm/Beijing (China)				√		√		√		√
Sinovac (China)				√	√	√		√		√
CanSino (China)				√		√		√		
Covaxin (India)				√	√		√			
Sputnik V (Russia)				√	√		√	√	√	

Note: USA = United States; UK = United Kingdom.
Source: OECD analysis based on UNICEF COVID-19 Market Dashboard data, https://www.unicef.org/supply/covid-19-market-dashboard (accessed 25 September 2022).

Outlook on COVID-19 and STI

The COVID-19 pandemic is not yet over, and its far-reaching consequences will unfold well into the future. Further variants of concern could emerge, requiring a continuous stream of updated vaccines until vaccinology develops more universal protection (International Science Council, 2022[9]). Disparities in access, distribution and uptake of vaccines remain a major source of uncertainty, given that new variants are more likely to arise from unvaccinated and immunocompromised people. By mid-2022, the WHO estimated that almost one billion people in low-income countries remained unvaccinated.[7] This was not due to a lack of vaccine supply – as was the case in much of 2021 – but to rollout problems caused by operational and financial capacity gaps, insufficient political commitment, and vaccine hesitancy driven by misinformation and disinformation.

Multilateralism is key for effective responses to the pandemic

Effective multilateral actions are still required to provide technical and financial assistance that will help overcome the myriad domestic logistical hurdles facing COVID-19 vaccine deployment. To review experiences gained and lessons learned from the international health response to COVID-19, the WHO set up an Independent Panel for Pandemic Preparedness and Response in late 2020. The panel published its main report in May 2021, identifying weak links at every point in the chain and recommending a package of reforms to transform the system to enhance pandemic prevention, preparedness and response. A one-year review of progress that followed in May 2022 lamented the lack of investment, co-ordination and ambition to transform the system, resulting in limited and inequitable access to COVID-19 vaccines, tests and therapies (Johnson Sirleaf and Clark, 2022[10]). Estimates vary, but recent research suggests that more than one million lives could have been saved in 2021 alone if COVID-19 vaccines had been shared more equitably with low- and middle-income regions (Ledford, 2022[11]). More recently, limited supplies and the high costs of COVID-19 antivirals have similarly restricted their flow to low-income countries (Ledford, 2022[12]).

Efforts have been made to expand equitable access to COVID-19 vaccines, notably through firms' non-profit agreements (e.g. the Oxford-AstraZeneca partnership), voluntary licensing arrangements (e.g. the Medicines Patent Pool), and the scale-up of local manufacturing capacity in low- and middle-income countries (e.g. plans by Moderna and BioNTech to set up manufacturing in Africa). However, the global architecture to provide access to vaccines, diagnostics and genomic sequencing – notably the Access to COVID-19 Tools (ACT) Accelerator, which includes COVAX – has not met expectations, owing to insufficient funding, wealthier-country hoarding and logistical challenges, among other factors (Johnson Sirleaf and Clark, 2022[10]).

Several OECD countries have announced substantial STI investments to improve pandemic prevention, preparedness and response. For example, Japan recently set up the Strategic Center of Biomedical Advanced Vaccine Research and Development for Preparedness and Response (SCARDA), which will invest in vaccine research on a range of pathogens (including coronaviruses) using a range of technologies for vaccine delivery. With an initial investment of USD 2 billion over five years, SCARDA aims to produce diagnostic tests, treatments and vaccines that will be ready for large-scale production within the first 100 days following the identification of a pathogen with pandemic potential (Mallapaty, 2022[13]). Investments have also been made in antiviral therapeutics. For example, the US National Institute of Allergy and Infectious Diseases launched the Antiviral Drug Discovery Centers for Pathogens of Pandemic Concern in 2021, endowed with USD 1.2 billion to fund basic research on developing antivirals for seven virus families (Kozlov, 2022[14]). Drawing on a philanthropic donation of AUS 250 million (Australian dollars), the Cumming Global Centre for Pandemic Therapeutics in Australia was launched in 2022 to create drugs within weeks or months of future infectious disease outbreaks (Nelson, 2022[15]). What characterises these new centres is the range of drug platforms they plan to exploit to deal rapidly and in multiple ways with an array of microbial threats.

These are welcome new investments in OECD countries, but a co-ordinated response is also needed to promote longer-term vaccine and therapeutic innovation that includes technical, production and quality-control capacities in low-income countries (International Science Council, 2022[16]). The uneven distribution of research infrastructure capacities at the global level has prevented equitable access to resources and data in many parts of the world, contributing to a disconnect between needs and resources (see Chapter 4). Moreover, the study of COVID-19 variants is largely concentrated in high-income and upper-middle-income countries, even though several dominant variants were first identified in low- and middle-income countries.[8] If global vaccination coverage remains unequal, it will be important to develop research capacity that includes more low-income countries, in order to investigate the emergence of variants (UKCDR and GloPID-R, 2022[17]). Research funders have recognised the problem, allocating around USD 200 million globally for COVID-19 projects aiming to strengthen research capacity. Most of these projects focus on reinforcing laboratory capacity in low- and middle-income countries (UKCDR and GloPID-R, 2022[18]). Such a strengthening of research capacity is an important contribution to health-crisis preparedness, but should be extended to provide effective global action for other ongoing and future crises, notably the climate crisis and the need for green transitions. As highlighted in Chapter 4, many countries and organisations have started their own evaluations of their response to COVID-19, and STI performance and future preparedness should be an important focus of such exercises.

The pandemic is a sociopolitical challenge that creates multiple risks and uncertainties

Like all health crises, COVID-19 is a broader sociopolitical challenge, but was widely perceived at the outset as a mainly biomedical challenge. In most countries, the biomedical community and its relevant research-funding institutions took the lead in establishing national research agendas. These were too narrowly focused and failed to address all aspects of the crisis from a scientific perspective (see Chapter 4). Furthermore, the pandemic's health impacts have gone well beyond those associated with the SARS-CoV-2 virus: public health interventions targeting COVID-19 often caused disruptions in healthcare delivery for other conditions, including cancer and heart disease, while access to immunisation services for common childhood illnesses fell in many low- and middle-income countries (UKCDR and GloPID-R, 2023[19]). The WHO (2022) also estimates that the global prevalence of anxiety and depression increased by 25% during the first year of the pandemic.

"Long COVID" is another uncertainty, with a persisting lack of consensus on a clear definition of the condition, its clinical characterisation and management, and appropriate support for sufferers. According to data from UKCDR and the GloPID-R COVID-19 Research Project Tracker (UKCDR and GloPID-R, 2022[20]), at least USD 218 million targeted long COVID research as of September 2022, with projects largely concentrated in Europe (48%) and North America (39%).

Finally, mis- and disinformation have been particularly problematic globally (see Chapter 4 and (OECD, 2022[21]), with studies showing a directional relationship between online misinformation and vaccine hesitancy (e.g. (Pierri et al., 2022[22]). As highlighted in Chapter 4, this is a complex problem with no easy solution. Policy responses range from improving the digital and scientific literacy of citizens and policy makers, to promoting active involvement by behavioural and social scientists to provide the necessary background for communicating relevant and useful information to different communities.

STI and Russia's war of aggression against Ukraine

Both Russia and Ukraine are relatively minor players in the international STI landscape, so that the war has had few direct impacts on STI activities in OECD countries. Russia's relative scientific decline in recent decades has made it easier for OECD countries to sever their ties without seriously undermining their own scientific efforts (Johnson Sirleaf and Clark, 2022[10]). The European Union quickly excluded Russia from Horizon Europe following the invasion. Some months later, the United States announced its intention to wind down government-to-government research collaboration with Russia, and advised US agencies and government labs to curtail interaction with the leadership of universities and institutions affiliated with the Russian government (Hudson, 2022[23]).

Science "sanctions" like these are unprecedented, and form part of a wider campaign of economic and trade penalties that are meant to deter Russia (Hudson et al., 2022[24]). It is too early to assess their impacts on Russian science, but there exist STI areas where Russia excels and has strong ties with STI activities by OECD countries, which have been adversely affected by these sanctions. In the space sector, for example, where Russia has deep and extensive capabilities (Undseth and Jolly, 2022[25]), the ExoMars project, a EUR 1.3 billion (euros) joint Europe-Russia mission, has been severely delayed. In Arctic research – much of which is crucial to understanding and monitoring climate change – European scientists have had to suspend collaboration with their Russian counterparts owing to restrictions imposed by their funding agencies or institutions (Gaind et al., 2022[26]).

Besides these disruptions in particular STI fields, the indirect impacts on STI are far greater. The projected economic slowdown in 2023, and the highest rates of inflation seen since the 1980s, could impact STI expenditures. Rising debt service burdens are also set to compound challenges for public finances (OECD, 2022[1]), which could put further pressure on public funding of R&D. The goal of reducing reliance on fossil-fuel supplies from Russia has also lent new urgency to STI investments in clean energy and energy efficiency. Fossil-fuel dependency on Russia has more immediate impacts, however, with scientific infrastructures in Europe – notably particle accelerators, high-power lasers, gamma beams, and supercomputing facilities and data centres – facing massively increased energy bills. This is leading some infrastructures to cut back on experiments (Owens, 2022[27]), (Zubașcu, 2022[28]). The spectre in late-2022 of energy rationing and even rolling blackouts has not materialised, however, although it has drawn greater attention to reducing the carbon footprint of science.[9]

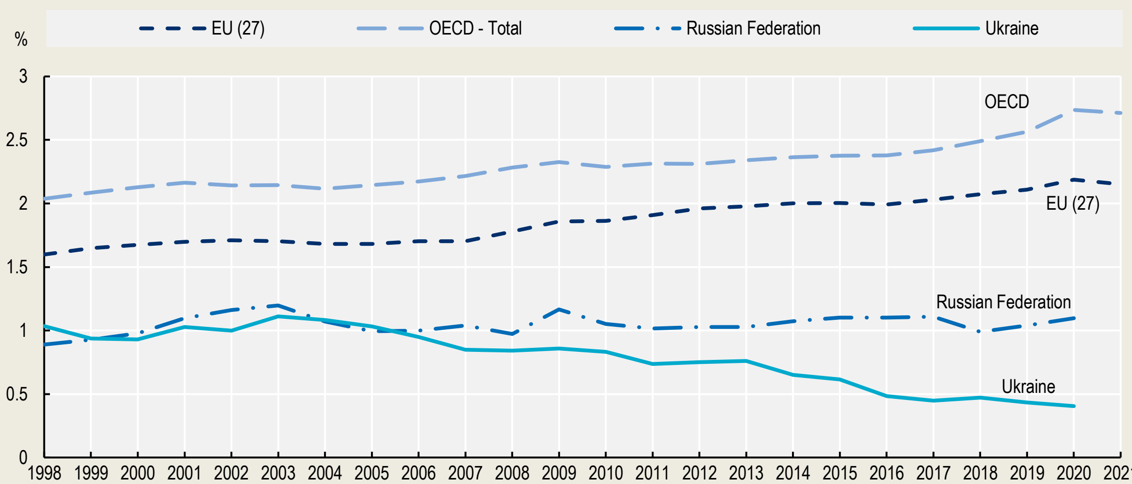
Impacts on STI activities in Ukraine

The impacts of the war on Ukraine's STI activities have been devastating. Many of its research institutions have been bombed, and around one-quarter of its research workforce fled the country in the early months of the conflict (Nature, 2022[29]). By October 2022, with Russian attacks on Ukraine's critical civilian infrastructures, like electricity and water, scientific experiments had become almost impossible. Box 1.2 provides a snapshot of Ukraine's science system in recent years, showing a system in transition prior to Russia's aggression.[10]

Box 1.2. Ukraine: A science system in transition, with core strengths

For several years prior to Russia's war of aggression in Ukraine, science and research in Ukraine had been in transition, with significant structural changes taking place in the face of strong budgetary pressure. Domestic expenditure on R&D as a percentage of GDP fell by about one-third between 2013 and 2018 (Figure 1.10). The number of researchers shrank from over 52 000 full-time equivalents in 2013 to 41 000 in 2018. This evolution was marked by a steep drop in researchers working in business and government institutions, which was only partly offset by an increase in researchers from higher education institutions.

Figure 1.10. Domestic R&D expenditure as a percentage of GDP (Ukraine, Russia, EU27 and OECD)



Note: OECD R&D statistics and UNESCO Institute for Statistics (UIS) for Ukraine, February 2023.

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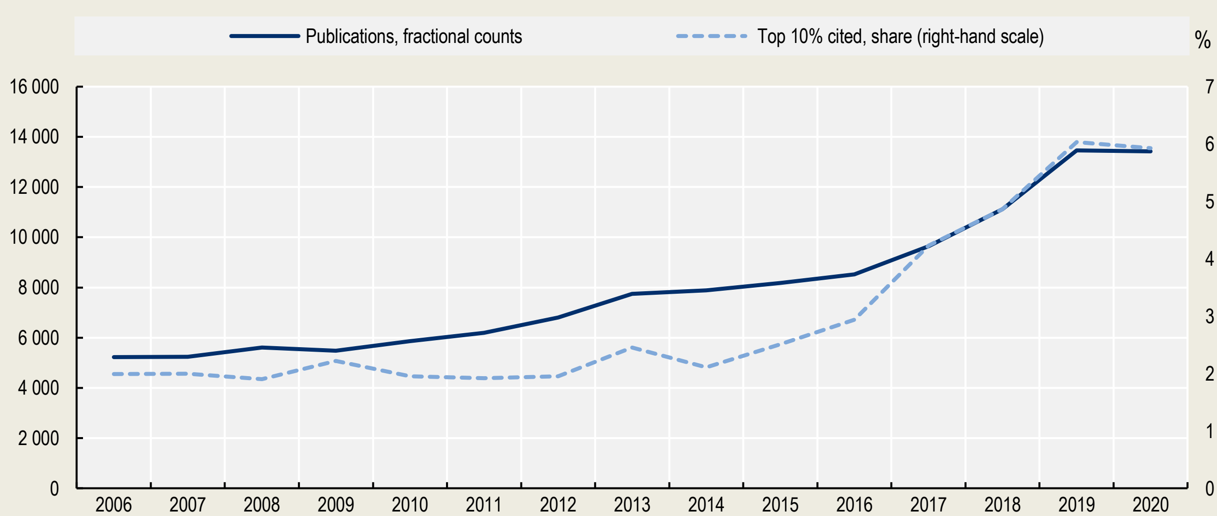
This reorientation towards higher education, together with an increase in international collaborations, helps explain an impressive rise in both the number and quality of Ukrainian scientific publications, from only 2% among the global top 10% most cited in their fields in 2006 to 6% in 2020 (Figure 1.11).

Figure 1.11. Quantity and citation impact of scientific production in Ukraine, 2006-20



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 5.2021, September 2021, https://public.flourish.studio/story/1266872/; https://public.flourish.studio/story/1458190/; and https://public.flourish.studio/story/1458190/ (accessed on 23 November 2022).

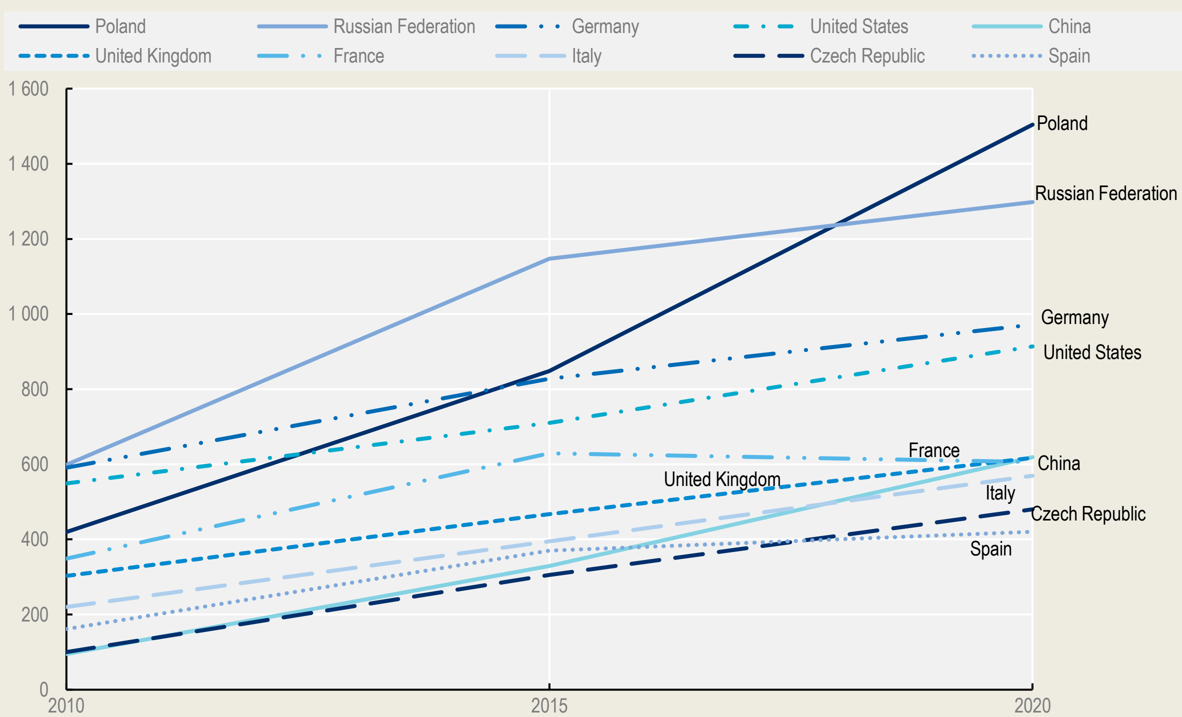
StatLink https://stat.link/mcr19n

Ukrainian scientific output shows above-average specialisation and expertise (proxied by citation impact) in areas such as computer science and energy (Ukrainian nuclear engineers are involved in new nuclear build programmes around the world). Although less specialised, Ukrainian scientific output also excels in the areas of Earth and planetary sciences and environmental science, although engineering is the largest field in terms of total output. All these domains are closely linked to Ukrainian industry and are crucial to economic development. As reported in the EC-OECD STIP Compass, Ukraine's main thematic STI policy strategies in 2021 focused on aerospace[11] and artificial intelligence (AI).[1]

A significant proportion of Ukraine's scientific publication output has resulted from international collaborations and partnerships. Since 2014, Ukraine has managed to halt the progressive decline in international collaboration seen in previous years, which likely played an important role in raising the overall competitiveness of its science. There has been a strategic focus in Ukraine on building international partnerships, as well as shifts in collaboration patterns. Russia-based scientists used to be the most frequent partners for Ukraine-based authors, but Polish-based scientists have emerged more recently as preferred partners (Figure 1.12).

Figure 1.12. Ukraine's top scientific collaboration partners, 2010, 2015 and 2020

Whole counts: Number of documents co-authored with partner country



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 5.2021, September 2021, https://public.flourish.studio/visualisation/9410350/ (accessed 23 November 2022).

StatLink https://stat.link/tuh5mf

As reported in the 2021 edition of the EC-OECD STIP Compass,[2] one of the key structural problems hindering Ukrainian research and innovation activity prior to the war was the persistent net outflow of talented scientists and inventors. This led to a debate on ways to support these valuable human resources in the country and prevent "brain drain". Indeed, analysis of changes in affiliations of scientific authors over 2010-20 reveal that Ukraine had a bilateral deficit with most countries where high mobility was observed, particularly Russia. The war is certain to change the longer-term mobility patterns of many Ukrainian students and scientists, with long-lasting impacts.

1. https://stip.oecd.org/stip/interactive-dashboards/policy-initiatives/2021%2Fdata%2FpolicyInitiatives%2F99993318.
2. https://stip.oecd.org/stip/interactive-dashboards/countries/Ukraine.
Source: (OECD, 2022[30]).

International support for Ukrainian STI

Many countries and scientific institutions have put in place various arrangements to support Ukraine's science system (OECD, 2022[30]). These include temporary measures to host Ukrainian students and researchers, providing safe havens in which they can continue their studies and conduct research. For example, the European Commission's Horizon Europe programme made available EUR 25 million early in the crisis to facilitate and enable this support, and address the immediate and urgent humanitarian challenge.[12] The European Commission has also launched a one-stop-shop for information and support services provided to Ukraine-based researchers and researchers fleeing Ukraine.[13] On the innovation front, the European Innovation Council has agreed to provide a total EUR 20 million in funding to the Ukrainian innovation community. It will provide up to EUR 60 000 in direct financial support to at least 200 Ukrainian technological start-ups that remain and work in Ukraine, as well as to those that relocate to the European Union during the war (Council, 2022[31]).

Solidarity is pervasive at the global level, as demonstrated by the inventory of offers of assistance and statements of support from science organisations.[14] For instance, the Polish Academy of Sciences, with support from the US National Academies of Science, has launched an initiative to help Ukrainian researchers settle in neighbouring Poland.[15] Many refugee scientists and students have already been accepted into Polish research institutions. This offers an opportunity to step up scientific partnerships between these two countries, with immediate benefits for Poland and longer-term possibilities for Ukraine. However, Poland will require support and solidarity from other countries and the European Union if it is to effectively perform this temporary hosting role. This includes support for those who choose to return to Ukraine and promoting new sustainable, long-term partnerships between research institutions, to be maintained once the war is over (OECD, 2022[30]).

As highlighted in Box 1.2, Ukraine has longstanding "brain drain" challenges, which the war could exacerbate. There is a long history of scientists leaving their home countries during times of conflict or political crisis, and then struggling to return or contribute effectively as a diaspora once the crisis is over. In an ultra-competitive international science system, where talent is at a premium, many of the best Ukrainian scientists or students may be tempted to stay in their new homes rather than return to institutions that have been subjected to the ravages of war. At the individual level, this would be a very legitimate and understandable choice. The long-term policy aim should be to support genuine brain circulation and partnership between neighbouring countries, rather than pursuing brain gains at the expense of other countries (OECD, 2022[30]).

The OECD has highlighted the following key considerations for policy makers (OECD, 2022[30]):

- Considering the risks posed by "brain drain" to the future of science in Ukraine, OECD countries should aim to promote genuine brain circulation, and the establishment of sustainable and productive long-term partnerships with Ukrainian scientific institutions.[16]
- Individual mobility and international networks can provide the basis for productive future partnerships between Ukrainian research institutes and universities and their counterparts across the world.

- Policy measures to support refugee scientists from Ukraine should be designed from the outset to ensure they are able to maintain strong links with their home institutions and colleagues, so that the current brain exodus can be rapidly reversed once the war is over.
- Members of the Ukrainian scientific diaspora should be considered as a strategic asset both for their country of origin and their country of destination. With appropriate support, they can play an important role in brokering or building partnerships.
- Digital tools and open access to scientific data and publications can provide the basis for much research to continue remotely, even when research institutions are closed or scientists are also contributing to the war effort.

A growing “securitisation” of STI policy?

Russia’s war of aggression against Ukraine is expected to lead to increased expenditures on defence R&D. However, perceived security threats go well beyond traditional defence concerns, extending to a range of issues that have implications for STI policy. These include:

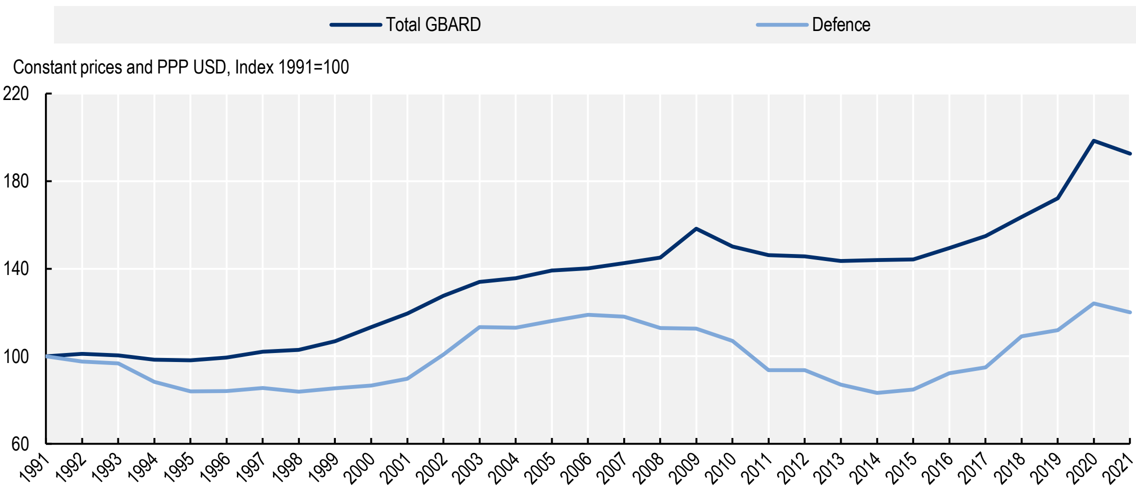
- using STI to reduce systemic risks, e.g. to enhance food security, energy security, health security and cybersecurity
- managing technological change responsibly to reduce a range of risks, e.g. those associated with AI, synthetic biology and neurotechnology
- mitigating and adapting to the climate crisis, which is increasingly framed in terms of the threats it poses to national security
- reducing vulnerabilities from trade dependencies in high-tech and other strategic goods, leading to a push for “technology sovereignty” and “open strategic autonomy”.

Together with the impacts of the pandemic, these pressures have drawn attention to risk, uncertainty and resilience as conditions and concerns for STI policy. They have contributed to a growing “securitisation” of STI policies, where economic competitiveness rationales for policy intervention interact with rationales emphasising national security, sustainability transitions and (to a much lesser extent) inclusion. Chapter 3 discusses the rationales for sustainability transitions and their implications for STI policies. This chapter discusses selected security concerns, specifically regarding defence R&D expenditures, biosecurity and research security. Chapter 2 covers how security concerns related to technology dependencies are increasingly framing STI policy agendas through concepts such as “technology sovereignty” and “open strategic autonomy”.

Defence R&D spending

Russia’s war of aggression against Ukraine has cast a spotlight on the role of science and technology in defence. Discovering, developing and utilising advanced knowledge and cutting-edge systems is fundamental to maintaining or achieving a technological edge for purposes of defence and deterrence. OECD statistics on GBARD (OECD, 2022[3]) provide some insights on the extent to which governments direct public funds to R&D for military purposes. They show that defence R&D, which has grown the least in real terms since 1991, has been experiencing a sustained recovery in recent years (Figure 1.13). With total defence expenditures expected to increase in several OECD countries in the coming years, the recovery in defence R&D expenditures could gather pace.

Figure 1.13. Trends in total and defence government R&D budgets 1991-2021



Note: The OECD estimation includes all Member countries of the OECD except Costa Rica.
Source: OECD R&D statistics, September 2022 (accessed 27 November 2022). See OECD Main Science and Technology Indicators Database, http://oe.cd/msti, for most up-to-date OECD indicators.

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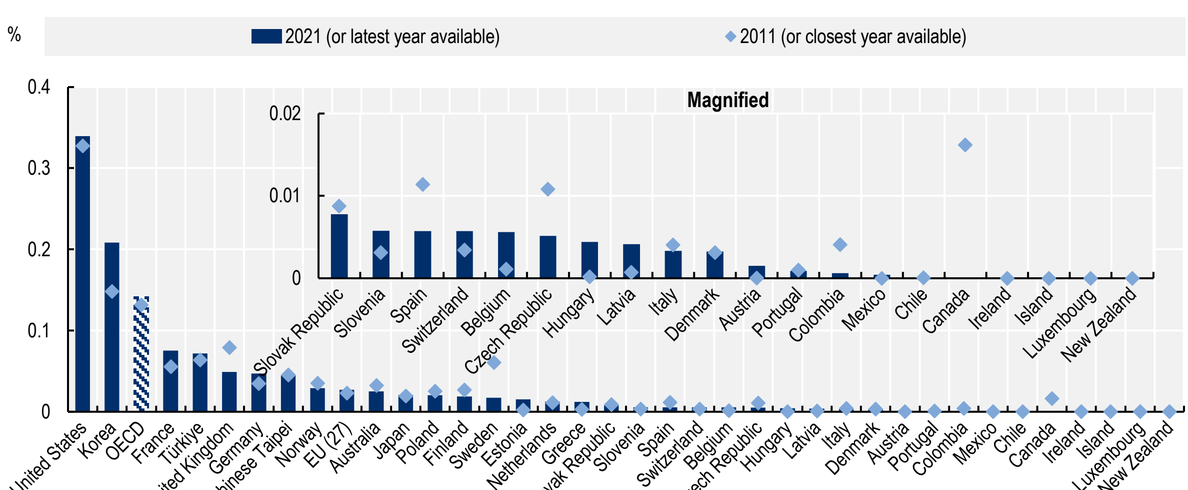
Across the OECD, an estimated 0.15% of GDP is dedicated to defence R&D budgets (OECD, 2022[3]). To put this figure in context, this represents about 7.5% of the North Atlantic Treaty Organisation guideline for total defence expenditure as a share of GDP.[17] The distribution of military R&D budgets is highly skewed: the United States reports the largest R&D budget support for defence as a percentage of GDP, followed by Korea, France and the United Kingdom (Figure 1.14). In Europe, many countries are planning to increase expenditure on defence; a few countries, such as Germany and Poland, have already announced a large increase (0.5-1% of GDP per year) for 2022/23 (OECD, 2022[32]).

Figure 1.14. R&D budgets for defence in selected countries

Percentage of GDP



Note: The OECD estimation includes all Member countries of the OECD except Costa Rica,
Source: OECD calculations based on OECD R&D statistics, September 2022 (accessed 23 November 2022). See OECD Main Science and Technology Indicators Database, http://oe.cd/msti, for most up-to-date OECD indicators.

StatLink https://stat.link/9nzbpl

Biosecurity

Synthetic biology[18] is a promising field that could help tackle current and future challenges, including through treating infectious and genetic diseases (Khan et al., 2022[33]), preventing food shortages (Mudziwapasi et al., 2022[34]) and mitigating the impacts of climate change (DeLisi, 2019[35]). At the same time, the field comes with inherent risks, centred on dual-use research and deliberate misuse. These risks cannot be eliminated – only managed. Yet there is consensus across the academic literature that public bodies are underprepared for the risks stemming from rapid advances in synthetic biology (OECD, forthcoming[36]). An engineered pandemic-class agent (Bakerlee, 2021[37]) with a higher case fatality rate and transmissibility than SARS-CoV-2 could overwhelm the insufficient detection and response systems that exist today (Bell and Nuzzo, 2021[38]), potentially leading to a breakdown of critical food, water and power distribution systems, and local civilisational collapse. Possible countermeasures include untargeted metagenomic sequencing to enable early detection of emerging pandemics[19] and improvements in response capacities – for example, by stockpiling personal protective equipment, and using safe pathogen-killing lights and improved ventilation to block pathogen transmission.[20] Besides detection and response capacities, prevention countermeasures are also required, including measures to delay the proliferation of pandemic-class agents (Box 1.3). Managing these risks is a balancing act between supporting scientific advancements for the betterment of humanity and implementing appropriate measures against biosecurity threats (OECD, forthcoming[36]).

Box 1.3. Preventive measures to counter risks from synthetic biology

Part of the concern around rapid advances in synthetic biology is that non-state actors may have easier access to technologies or viral agents. Following the 1995 chemical weapon attack in the Tokyo subway and the 2001 Anthrax attack in the United States, the discourse shifted to non-state actors yet regulatory gaps remain, primarily relating to prevention (Rabitz, 2014[39]). Additionally, dual-use research that can serve civil and defence aims remains largely unaddressed, and there currently exist no internationally recognised guidelines for covering high-risk dual-use research.

Key technologies of concern include DNA synthesis and virus assembly, gene editing and gene drives, and cell-free and life-similar biotechnology. Taking just DNA synthesis and virus assembly as an example, detailed step-by-step virus assembly protocols (Xie et al., 2021[40]) allow an increasing number of individuals to assemble numerous viruses from a genome sequence. Today, perhaps 30 000 individuals can generate infectious samples of influenza viruses using standard laboratory equipment, and perhaps one-tenth as many can generate corona-, adeno- and paramyxoviruses.

Viral agents are far more accessible than nuclear arms, but apart from smallpox — which due to its size and complexity, can only be assembled by perhaps 100 individuals globally — there exist no credible blueprints for pandemic-capable agents that a malicious actor could use to ignite a new pandemic. However, this information could soon be provided by well-meaning scientists. For example, ongoing efforts such as the Global Virome Project[1] are working to discover and characterise novel viruses (Sandbrink et al., 2022[41]) by performing identification experiments that assess whether a virus is capable of causing a pandemic, then sharing them in a public list rank-ordered by perceived threat level (SpillOver, 2022[42]). Other labs aim to enhance the infectiousness of highly lethal but poorly transmitted viruses through "gain-of-function" experiments (Herfst et al., 2012[43]), without independent oversight. If the genome sequences of sufficient pandemic-capable pathogens are shared publicly, many thousands of individuals will immediately gain the ability to kill many millions.

Countermeasures are possible to prevent this scenario from happening. For example, a well-designed "pandemic test-ban treaty" could ban pandemic virus identification experiments globally, preventing respectable laboratories from sharing credibly hazardous results. In an era when scientists can design nucleic acid vaccines in a couple of days – as was the case with the COVID-19 Moderna and BioNTech vaccines – these experiments are arguably unnecessary to develop vaccines rapidly.

Another counter-measure would be to introduce universal and secure screening of synthetic DNA orders. The assembly of engineered pathogens requires synthetic DNA that can be ordered by mail. The International Gene Synthesis Consortium,[2] a group of gene synthesis companies that voluntarily vet their customers and screen synthetic gene orders to identify potentially dangerous sequences, is only responsible for 80% of such orders. Establishing universal and secure DNA synthesis screening could prevent unauthorised access to dangerous sequences. Ongoing efforts are under way to provide a freely available screening system,[3] which could then be integrated into all DNA synthesis devices.

1 https://www.globalviromeproject.org.
2 https://genesynthesisconsortium.org.
3 https://www.securedna.org/main-en.
Source: (OECD, forthcoming[36]).

Research security

Some governments and non-state actors are making increasingly forceful efforts to unfairly exploit and skew the open research environment towards their own interests. Such efforts have become more apparent as geopolitical tensions have mounted, and many countries now consider unauthorised information transfer and foreign interference in public research as serious national and economic security risks. Governments are implementing measures to improve research security (see Box 1.4) while at the same time emphasising the norms and principles that constitute good scientific practice – such as academic freedom, openness, honesty and accountability – and regulate international research collaboration – including reciprocity, equity and non-discrimination. A lack of shared and respected international regulations and norms can lead not only to a misappropriation of research, but also to certain types of research being selectively conducted in countries that do not impose legal or ethical restraints (OECD, 2022[44]).

Box 1.4. Measures supporting research security and integrity

Responsibilities for research security and integrity are distributed across multiple actors, operating at different scales in the international research ecosystem. These include national governments, research-funding agencies, research institutions, universities, academic associations and intergovernmental organisations.

Many governments have developed guidelines and checklists to increase awareness of risks to research security and integrity, frequently accompanied by policies and measures to mitigate these risks. It is important these are proportionate and based on sound risk identification and assessments, as not every research institution or research project will face the same level or type of risk. These guidelines should also be regularly revisited and revised, as necessary. Some national policies identify specific "sensitive" countries they consider liable to foreign interference, but many take country-agnostic approaches.

In some countries, intelligence agencies, law enforcement agencies, research institutions and universities have increased co-operation and information exchange to help researchers identify and manage risks, and strengthen security in international collaboration. However, maintaining institutional autonomy in risk management and decision-making is key, not only to effectively identify risk but also to gain crucial buy-in across the research sector. Several funding agencies have integrated risk assessment and management in their funding application and review processes. Meanwhile, universities are developing rules and guidelines to mitigate risks to research security, and protect the integrity and freedom of scientific research.

At the intergovernmental level, the OECD has published a report on integrity and security in the global research ecosystem (OECD, 2022[44]) and launched a web portal on research security.[1] Group of Seven (G7) countries, for their part, have established a working group on the security and integrity of the research ecosystem. The G7 is also planning to develop a common set of principles to help protect the research and innovation ecosystem from risks to open and reciprocal research collaboration (G7-Summit, 2022[45]). Finally, the European Commission recently published a toolkit on how to mitigate foreign interference in research and innovation (European Commission, 2022[46]).

1. https://stip.oecd.org/stip/research-security-portal.
Source: (OECD, 2022[44]).

Maintaining the balance between open and trust-based scientific collaboration, and protective but potentially restrictive regulations, is a major challenge. Over-regulation or excessive intervention can undermine the freedom of scientific enquiry and exchange. For example, while national governments have routinely defined research on chemical, biological, radiological, nuclear and explosive technologies as dual-use, and historically used conventional export control systems to prevent knowledge transfer, it is less easy to control the transfer of data, information and know-how from scientific research carried out without a specific practical aim. This means that basic research has traditionally been exempt from export controls. At the same time, knowledge from many areas of fundamental research can arguably be considered as potentially dual-use. For instance, AI or quantum computing have the potential for both civilian and military use, in addition to being the focus of intense economic competition between companies, countries and regions.

Outlook

There is a growing sense of multiple crises triggering turbulence, instability and insecurity in contemporary societies. Crises are building up one after another and interacting in unpredictable ways, with impacts on economies, politics, the environment and global affairs. Even seemingly singular crises like the COVID-19 pandemic are complex, with cascading effects that have proven difficult to predict and resolve. This "polycrisis" (Homer-Dixon et al., 2022[47]) or "permacrisis"[21] situation has presented decision makers with a high degree of volatility, uncertainty, complexity and ambiguity. Policy needs to be more anticipatory, systemic, inclusive and innovative to manage crises, and contribute to society's capacity for resiliency and adaptation to shocks. However, such policy qualities depend on government capacities which are often lacking, and will take time and considerable investment to develop.

To a significant extent, STI provides economies and societies with built-in resiliency capacity. However, it can only perform this role effectively if it is well-prepared to respond to known risks and unknown uncertainties. Of course, good preparation requires long-term investments in R&D, skills, and research and technical infrastructures, but these alone are insufficient. It also needs strong relationships in "normal times" among those who should mobilise rapidly to deal with crisis situations (de Silva et al., 2022[48]), as well as a strong strategic intelligence capacity to identify, monitor and evaluate emerging risks and responses.

The global nature of crises also calls for vibrant multilateralism and international solidarity. The COVID-19 response experience was mixed in this regard, demonstrating what could be done rapidly through international co-operation but also its limits, particularly in the uneven international rollout of vaccines and therapeutics. Vaccine nationalism and diplomacy are perhaps emblematic of international co-operation-competition dynamics that are likely to characterise the response to other crises, notably climate change (see Chapter 3). Such dynamics will continue to shape the ways in which research and innovation can contribute to global crisis responses.

Finally, growing securitisation of STI offers opportunities, but also risks. On the one hand, framing global problems like climate change, biodiversity loss and food insecurity as national security risks – on account of their wide-ranging and unpredictable effects – further raises their profiles as problems requiring urgent domestic action, including in STI. On the other hand, it could divert STI from targeting other goals related to sustainability transitions and social inclusion, as well as escalate international tensions. Part 2 discusses this issue further.

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Notes

[1] In the context of this chapter, “securitisation” refers to the reframing of regular policy issues, such as climate change, migration, and emerging technologies, into matters of “security”.

[2] In the EU27 area, business R&D performance was the main reason for an aggregate fall in R&D expenditures. This is because the structure of business R&D in the European Union is more concentrated in industries that were more negatively impacted by the COVID-19 crisis (see below).

[3] Estimates of real growth in R&D expenses for the ensemble of firms in the OECD SwiFTBeRD panel map very closely the evolution of official business expenditure on R&D estimates over periods in which these are available. For example, the final 2020 estimates of the September 2022 MSTI release confirm the “nowcasts” made in the March 2021 release for 2020.

[4] UKCDR (https://www.ukcdr.org.uk/) is a group of UK Government departments and research funders working in international development research. UKCDR aims to amplify the value and impact of research for global development by promoting coherence, collaboration and joint action among UK research funders.

[5] This makes the UKCDR/GloPID-R COVID-19 Research Project Tracker (https://www.ukcdr.org.uk/covid-circle/covid-19-research-project-tracker/) one of the most comprehensive databases on COVID-19 research projects, covering a wide breadth of research disciplines. However, because of limited data availability on funding, it significantly underestimates the awarded total research funding.

[6] 776 projects targeting “candidate vaccine R&D” were awarded USD 2.3 billion, with another USD 1.4 billion going to 7 320 projects targeting “social sciences in the outbreak response”. This means that the average project size for vaccine research was USD 3 million, compared to USD 195 000 for social sciences project – i.e. more than 15 times larger.

[7] The development of oral or nasal vaccines could be a game-changer for promoting global access. It could prevent even mild cases of illness and block onward transmission (Waltz, 2022[53]).

[8] As Omicron spread across the globe, South African labs were the first to detect it and flag it to the world. The Network for Genomic Surveillance in South Africa first spotted the mutated variant in sequencing data from Botswana (Adepoju, 2022[52]).

[9] In France, for example, the Agence Nationale de la Recherche is drawing up an “energy sobriety” plan that will incorporate sustainability criteria in its project funding assessments.

[10] In the context of the preparation of Ukraine’s National Recovery and Development Plan in May-June 2022, the OECD contributed ideas on how Ukraine’s science, technology and innovation system could be reformed to better contribute to the post-war reconstruction of its economy and society. These are summarised in (OECD, 2022[54]).

[11] https://stip.oecd.org/stip/interactive-dashboards/policy-initiatives/2021%2Fdata%2FpolicyInitiatives%2F99993866.

[12] https://euraxess.ec.europa.eu/ukraine.

[13] This European Research Area for Ukraine (ERA4Ukraine) portal brings together initiatives at the EU level, per country and from non-governmental groups (https://euraxess.ec.europa.eu/euraxess/news/era4ukraine-one-stop-shop-support-researchers-ukraine).

[14] This is being compiled by the International Science Council (https://council.science/current/news/statements-international-scientific-community-conflict-ukraine/).

[15] https://www.nationalacademies.org/supporting-ukraines-scientists-engineers-and-health-care-workers.

[16] An example of promoting brain circulation with Ukraine is an initiative of the German Federal Ministry of Education and Research (BMBF), which aims to establish "German-Ukrainian Cores of Excellence" (CoE), i.e. centres for cutting-edge research in Ukraine. The goal is to establish bilateral research units under the leadership of a top researcher (preferably of Ukrainian origin) with the involvement of young Ukrainian scientists, and to transfer them to Ukraine, provided that the security situation is safe. The initiative aims to integrate Ukrainian scientists as a group while maintaining close ties with Ukrainian partner institutes. In this way, the CoE aim to counteract the current brain drain and contribute to the stabilisation and recovery of Ukrainian science. An initial call was published in 2019, and since 2021, 12 German-Ukrainian scientific teams have been developing concepts for establishing future CoE. The best of these will be funded in an implementation phase, which is expected to start in 2024. This BMBF initiative will be complemented by other (medium-term) co-operation approaches. These aim to enhance research cooperation, develop local scientific capacities, support reform processes and promote the integration of Ukrainian science into the European Research Area. A major priority is research co-operation in the field of energy and green hydrogen to facilitate the rapid (re)construction of a sustainable energy system in Ukraine.

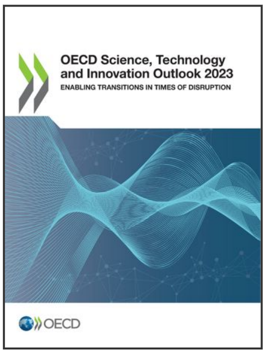
[17] Distinguishing R&D from other military expenditures is challenging, partly because public procurement contracts for defence systems may not allow disentangling sums allocated for R&D purposes from sums spent on actual deliveries. Spending on classified military R&D projects is also likely to go unreported, leading some OECD countries not to report any defence R&D figures at all.

[18] Synthetic biology is defined as a multidisciplinary field that "integrates systems biology, engineering, computer science, and other disciplines to achieve the 'modification of life' or even the 'creation of life' via the redesign of existing natural systems or the development of new biological components and devices" (Sun et al., 2022[49]).

[19] For example, the Nucleic Acid Observatory project (https://www.naobservatory.org/) aims to build a reliable early warning system by looking for exponentially increasing nucleic acids in wastewater from travel hubs, using untargeted metagenomic sequencing.

[20] Passive mechanisms such as improved ventilation using HEPA filters (Thompson, 2021[50]) or pathogen-killing lights are a proven way to reduce transmission. Applying sufficient low-wavelength germicidal lights to inactivate over 90% of viruses within a second would reliably block the spread of the most contagious known pathogens. Preliminary studies have shown that low-wavelength germicidal lights are safe for humans and other multicellular organisms while efficiently killing pathogens like SARS-CoV-2 (Biasin et al., 2021[51]).

[21] This is the Collins Dictionary's "Word of the Year 2022", which they define as "an extended period of instability and insecurity" (https://blog.collinsdictionary.com/language-lovers/a-year-of-permacrisis/).



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