8 Governance of science, technology and innovation for crisis and recovery

In contrast to the 2008-09 global financial crisis, science, technology and innovation is central to providing solutions to the COVID-19 crisis, and is clearly seen to be doing so. These solutions are shaped by the ways in which governments organise themselves, the sorts of relationships they have with other groups, including businesses and civil society organisations, and the resources they have at their disposal, including expertise and other capabilities. The chapter focuses on how various governance arrangements deployed by countries influence both their response to the current crisis and their scope for dealing with the challenges of the recovery phase. It covers governments' use of scientific advice to underpin COVID-19 policy, its use of digital tools to improve policy design and tackle the misinformation "infodemic", and its approaches to cross-government coordination. The chapter also covers governments' experiments with mission-oriented innovation policies and responsible innovation practices.

Key findings

- **Governments should reinforce public trust in policy through scientific advice**. Public trust is critical for ensuring support and compliance with policy measures, such as the wearing of masks and social distancing, and requires openness and transparency on the data and information underpinning these measures. Governments should carefully communicate uncertainties and provide a balanced presentation of potential scenarios. They should also draw upon multi-disciplinary advisory mechanisms to ensure they consider different types of expertise when developing policy.
- **Governments should link support for emerging technologies to broader missions that encapsulate responsible innovation principles**. This will help ensure an alignment of emerging technology development with the objectives of mission-oriented innovation policies. The responsible innovation approach seeks to anticipate problems in the course of innovation and steer technology to best outcomes, and emphasises the inclusion of stakeholders in the innovation process. This makes it well suited to mission-oriented innovation policies, which tend to target grand societal challenges, such as the 'green transition'.
- **Governments will need to renew their policy frameworks and capabilities to carry out a more ambitious science and innovation policy agenda**. Through their recovery and stimulus packages, governments have potentially more leverage to initiate a transition to more sustainable and equitable futures. Governments will also need to invest in preparedness measures, including technology platforms, infrastructures and collaborative networks that improve countries' abilities to respond effectively to a diverse range of risks. These roles and objectives require governments to acquire appropriate skills and capabilities to fulfil them, including dynamic capabilities that support learning and adaptability, which are needed for policy agility in times of great uncertainty.

Introduction

Countries' governance arrangements shape their research and innovation responses to the current COVID-19 crisis and will influence the contribution of science, technology and innovation (STI) to the recovery. These arrangements are broad in scope and include the ways governments set directions and choose priorities, their relationships with other actors in the innovation system, and the technologies they use to govern (including digital and social technologies).

The first part of the chapter primarily relates to how governments have responded to the COVID-19 crisis:

- One of the more visible – and most debated – aspects of this response is the use of scientific advice in designing policies. Previous OECD work has formulated guidelines on providing and using scientific advice in international crises like COVID-19. The chapter reviews these guidelines and considers how governments have followed them in their policy making.
- Governments are undergoing a digital transformation, which will profoundly change the ways they govern. The pandemic, its impacts, and responses to it all leave digital traces, which governments are increasingly exploiting to respond to the crisis. The COVID-19 crisis has led to unprecedented uses of new digital tools and data to inform policy, which could accelerate the digitalisation of science and innovation policy itself. This chapter highlights some of the initiatives put in place by governments to inform citizens of the latest developments on COVID-19 and tackle the "infodemic" of misinformation.
- Most parts of government are responding to the crisis in one way or another, leading to risks of duplication and insufficient scale if efforts are fragmented. Contemporary governance is highly distributed in most OECD countries, involving ministries and implementation agencies, as well as various degrees of subnational autonomy. This presents multiple co-ordination challenges for governments when responding to COVID-19. The chapter focuses on just one axis, horizontal cross-government co-ordination of STI responses to the pandemic. Most governments have set up mechanisms, for instance, to co-ordinate calls for research proposals. The chapter outlines the benefits and challenges, and highlights a few examples of how countries are trying to improve policy co-ordination.

The second part of the chapter focuses on STI governance arrangements for the recovery phase. It returns to a few of the big challenges already facing STI policy before the pandemic crisis hit, including whether and how to set directions in STI policy, how to account sufficiently for longer-term concerns in defining sound policies, and how to be inclusive in policy processes and outcomes to meet grand societal challenges. The chapter covers the following topics:

- Governments' ongoing experiments with "mission-oriented innovation policies" (MOIPs), which have tended to target "grand societal challenges", could feature more prominently in the STI policy mix, for instance as part of recovery packages targeting "green transitions". The chapter provides a simple typology of MOIPs and maps some MOIPs targeting health and healthcare.
- While science and technology will be essential to address challenges like sustainability and ageing, they can also raise societal concerns, as witnessed during previous waves of technological change. Indeed, many of the barriers to enabling emerging technologies lie not in the technology itself, but in technology governance. The OECD has developed an approach to "responsible innovation" that aims to enhance societal capacities to shape technology through its course of development, so that it might advance to market under conditions of trust. The chapter outlines how the OECD has applied this approach to the new OECD Recommendation on Responsible Innovation in Neurotechnology.
- A final section looks ahead to how STI governance and policy making may need to change if they are to play a role in redirecting economies and societies towards more equitable, sustainable and resilient futures. It considers how governments might adapt four key areas – policy goals,

frameworks, practices and capabilities – to meet the ambitious STI policy agenda that is now emerging.

Scientific advice in times of crisis

Science is informing the policy response to the COVID-19 pandemic and providing the greatest hope of a long-term solution. Even in where the role of experts has been questioned, policy makers find themselves turning to experts for advice. In some countries, the political leadership has even devolved much of the responsibility for communicating and explaining its policy choices to scientific experts. Different standing systems are in place for providing scientific advice to policy makers, often supplemented by additional ad hoc mechanisms in times of crisis. While most OECD countries rely on national expertise, many lesser-developed economies rely more on international sources of advice. As the pandemic has evolved, the requirements for scientific advice have become increasingly distributed across ministries and geographic scales – local, national and international.

The scientific evidence informing the policy response to COVID-19 is incomplete and conditional: as more data is collected, the scientific understanding of COVID-19 changes. This dynamic situation is a challenge for the scientific community, at a time when policy makers and the public seek assurances and certainty. Consensus is difficult to achieve, but communicating uncertainties and alternative views can undermine trust in scientific advice and related policies. In such circumstances, those providing advice need to be supported by an effective national (and international) scientific advisory system that complies with several basic principles (Box 8.1). Attention to these principles will both enhance the efficiency and quality of the scientific advice provided and help ensure the necessary trust between scientists, policy makers and the public.

Box 8.1. Principles for an effective and trustworthy scientific advisory system

An effective and trustworthy scientific advisory process needs to:

1. Have a clear remit, with defined roles and responsibilities for its various actors. This includes having:
    a. a clear definition and – insofar as possible – a clear demarcation of advisory vs. decision-making functions and roles
    b. defined roles and responsibilities, and the necessary expertise for communication
    c. an ex ante definition of the legal role and potential liability of all individuals and institutions involved
    d. the necessary institutional, logistical and personnel support relative to its remit.
2. Involve the relevant actors, i.e. scientists, policy makers and other stakeholders, as necessary. This includes:
    a. using a transparent process for participation, and following strict procedures for declaring, verifying and dealing with conflicts of interest
    b. engaging all the necessary scientific expertise across disciplines to address the issue at hand
    c. giving explicit consideration to whether and how to engage non-scientific experts and/or civil society stakeholders in framing and/or generating the advice
    d. having the effective procedures necessary for timely exchange of information, and co-ordination with different national and international counterparts.

3. Produce advice that is sound, unbiased and legitimate. Such advice should:
    a. be based on the best available scientific evidence
    b. explicitly assess and communicate scientific uncertainties
    c. be preserved from political (and other vested-interest group) interference
    d. be generated and used in a transparent and accountable manner.

Source: OECD (2015[1]), "Scientific Advice for Policy Making: The Role and Responsibility of Expert Bodies and Individual Scientists", OECD Science, Technology and Industry Policy Papers, No. 21, OECD Publishing, Paris. http://dx.doi.org/10.1787/5js33l1jcpwb-en.

The OECD has identified five key areas that are particularly important in providing and using scientific advice in international crises such as COVID-19 (OECD, 2018[2]):

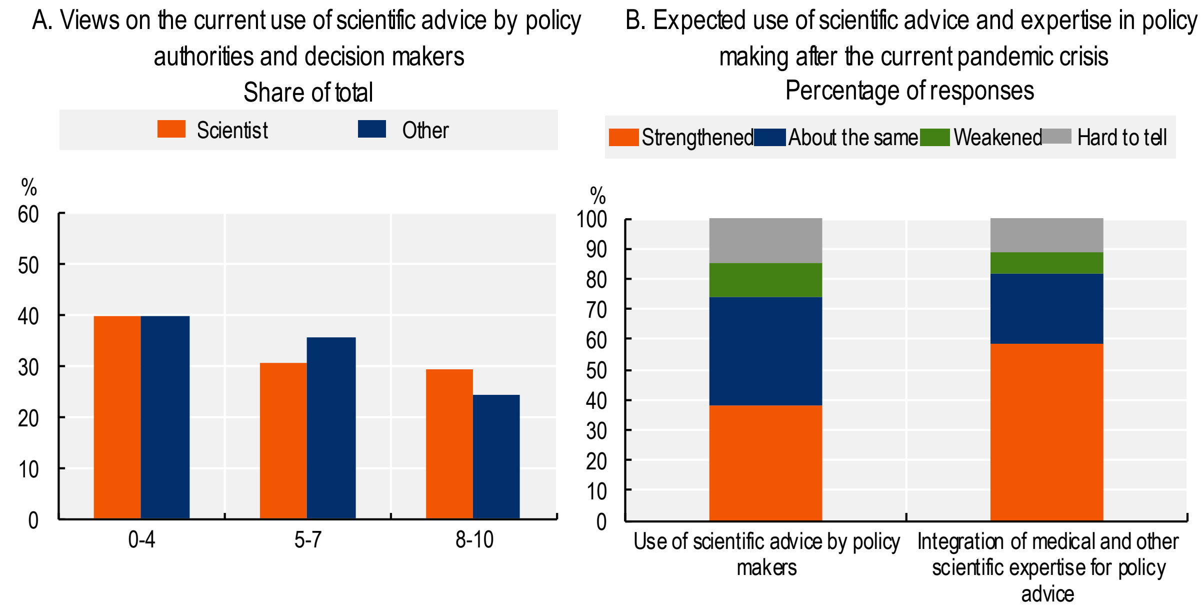
1. *Enhancing capacity to provide advice that fits the national context*: there exist differences in countries' capacity and structures, not only to develop and provide scientific evidence on the status and likely direction of a crisis, but also to provide evidence on the likely effectiveness of different policy interventions. Both aspects are important, but may require different types of expertise. Unless advisory systems are organised to bring different disciplines and perspectives together on an equal footing, there exists a danger that not all of the pertinent scientific evidence will be considered in developing policy. This is increasingly an issue in relation to COVID-19 as the longer-term effects of current policy actions, such as social distancing, become apparent. Certainly, many OECD countries do have multidisciplinary advisory mechanisms, but it is not clear that all countries are fully taking into account potentially useful scientific knowledge.
2. *International co-operation*: the World Health Organization (WHO) is the intergovernmental body with the remit to monitor and co-ordinate the response to global pandemics of infectious diseases (see Chapter 5). The WHO has its own scientific advisory mechanisms. It releases data, information and advice for all countries, which are publicly available and updated daily. The European Centre for Disease Prevention and Control also plays a co-ordination role and supports European countries with advice on responding to the epidemic. In addition, a variety of ad hoc co-ordination mechanisms have been implemented in response to COVID-19, including regular meetings of scientific advisors from Group of Seven and Group of Twenty countries. Most OECD countries consider the information emanating from international bodies as an important supplement to their own national advisory mechanisms, but certainly do not feel limited or bound by this advice (OECD, 2018[2]). The situation is somewhat different for lesser-developed economies, which are generally much more dependent on WHO advice – often in association with bilateral inputs from strategic partners. However, cultural practices and norms are critical for developing effective mitigation strategies. Policy interventions that are applicable in one country will not necessarily be as directly applicable or effective in other countries. International scientific research networks can play an important role in building and maintaining local scientific capacity that can be called on in times of crisis.
3. *Promoting mutual understanding and trust among people and networks*: promoting trust between different advisors and users of scientific data, information and advice is a long-term challenge. It requires appropriate support, mandates and incentives at the national level, and mechanisms for building mutual understanding at the international level. Openness and transparency regarding the data and information underpinning the scientific advice given in different countries is critical. This, in turn, entails support for international scientific networks and infrastructures that can complement and implement formal international frameworks – including, with specific regard to COVID-19, the WHO International Health Regulations.

4. *Being prepared and learning from past experience*: preparation for health pandemics ideally begins in times of calm, i.e. before crises occur. Most OECD countries do organise drills and exercises, involving their public health agencies and crisis management bodies, to rehearse possible scenarios during an actual crisis. Valuable as they are, such exercises may not always be given the priority they deserve and may not always engage all the necessary actors. They are more difficult to organise and more expensive at the international level – and unless conducted regularly, the turnover of individuals can mean that their value is reduced. Thus, establishing clearly defined structures with long-term responsibilities for crisis management and related scientific advisory processes is important for learning from the past to inform the present and future.
5. *Communication with the public*: no matter how good the scientific advice, and how well it is integrated into crisis management and decision-making processes, the manner in which it is communicated to the public will have a major impact on its effectiveness. This is clearly the case with regard to COVID-19, where the performance of political, medical and scientific leaders has been closely scrutinised and variously criticised or complimented. It is striking that in many countries, scientists have become national spokespersons, who are expected not only to provide scientific evidence, but also to justify policy actions. The reality is that in times of crisis, the distinction between advisor and policy maker can sometimes be blurred, and public debate about the scientific data and information accredited with determining policy can be intense.

How are countries meeting these challenges?

The available information suggests that the governments of OECD member countries are assessing and using scientific advice along the principles outlined above. However, to what extent they are meeting all of the conditions identified for optimising scientific advice varies considerably. Issues such as clarifying advisory roles vs. decision-making or communication roles and responsibilities vary across countries and over time, and are not always transparent. The engagement of many disciplines and non-academic experts in generating advice appears limited in some countries, although this may change as the public health imperative shifts to a fuller integration of socio-economic issues. Communication of uncertainties also seems to vary across countries. This is understandable in a situation where the scientific evidence is conditional, changing over time as more data and information become available. Nevertheless, when asked in the OECD Science Flash Survey 2020[1] how they would rate on a scale between 0 and 10 the way policy authorities and decision makers in their country have been using scientific advice, 40% of the responding scientists gave a score between 0 and 4 (where 0 corresponds to the worst and 10 is the best possible use) (Figure 8.1, Panel A). Two-fifths of survey respondents, however, expected the use of scientific advice and expertise in policy making to increase after the current pandemic crisis (Figure 8.1, Panel B).

Figure 8.1. Scientists' assessment of the use of science in policy making



Note: For Panel A, scoring on a scale between 0 and 10, where 0 corresponds to the worst and 10 is the best possible use, respondents were asked, "How would you rate the way in which policy authorities and decision makers in your country have been using scientific advice?" For Panel B, respondents were asked, "How do you expect the world of science to emerge out of the current crisis, in terms of (i) use of scientific advice by policy makers and (ii) integration of medical and other scientific expertise for policy advice?" Besides scientists, "other" respondents refers to science policy advisors (20%), professionals involved in science (15%), science communicators (10%) and individuals carrying out science-related administrative work (10%).
Source: OECD Science Flash Survey 2020, https://oecdsciencesurveys.github.io/2020flashsciencecovid/, (accessed 12 October 2020).

StatLink https://doi.org/10.1787/888934223555

Whether or not the policy actions currently being implemented in different countries to limit the effects of COVID-19 are ultimately judged optimal, they must be based on and reinforce trust across the science community, between scientists and policy makers, and within the public at large. Trust is critical to enhance support and compliance with policy measures such as the wearing of masks and social distancing. In the longer term, it will be important to garner solidarity and broad public support for interventions to ensure socio-economic recovery.

In the age of social media, openness and transparency are critical. Governments have been criticised for not providing rapid access to the primary scientific data and models underpinning their decision-making. Careful communication of uncertainties and balanced presentation of potential scenarios – including worst-case scenarios – appear to be broadly appreciated and understood by most of the public. The promise – and hype – associated with potential scientific or medical breakthroughs, such as reports of effective treatment with chloroquine, can also be managed with careful communication and explanation of scientific uncertainties by trusted experts.

Digital technologies and data for government decision-making

Digitalisation is profoundly affecting the public sector and the evidence base on which it formulates, implements, monitors and evaluates public policy. The STI policy field is no exception. In recent years, many countries have begun to develop initiatives around digital science and innovation policy to build a picture of the incidence and impact of their science and innovation activities, and formulate better policies.

The COVID-19 crisis has led to an unprecedented use of new data and digital tools to inform policy, possibly accelerating a process of innovation in policy making. For example, real-time granular data – such as daily evidence on COVID-19 cases, hospitalisations, deaths and scientific information on the COVID-19 pandemic – have helped inform policy actions. New data sources, e.g. data from job portals, have been used to provide quick information on the sectors and professions most affected by the COVID-19 crisis, while new tools from data science, computer science and machine learning are being used to automatically collect and analyse those types of data.

Such tools and data allow for entirely new policy approaches (OECD, 2020[3]; Paunov and Planes-Satorra, forthcoming[4]). The contact-tracing applications implemented in many OECD countries, which follow the movement of infected people and alert those who have come into close contact with them, are perhaps the most striking example. The rich granularity of the information collected (e.g. real-time data on the exact location of individuals), compared to typical statistical data, allows much more targeted evidence-based policy approaches, though it also raises challenges related to data quality and privacy (OECD, 2020[5]). Another prominent example is the proliferation of national COVID-19 portals that monitor the pandemic and its impacts, typically linking granular data from across government and providing information services on a variety of issues. In many cases, these portals include open-data application programming interfaces that allow other portals to download the data for other applications and analyses. Many of these portals have also been instrumental in tackling the torrent of misinformation and disinformation around COVID-19 (OECD, 2020[6]; OECD, 2020[7]) (Box 8.2).

Box 8.2. Tackling misinformation and disinformation on COVID-19

The global spread of COVID-19 has been accompanied by a wave of disinformation that undermines policy responses and amplifies distrust and concern among citizens. Online platforms are a key channel for this disinformation, but they can also play an important role in limiting its circulation (OECD, 2020[6]). At the same time, governments around the world are using various public communication tools to counteract disinformation and support policy (OECD, 2020[7]).

Centralising official information in a single website: most countries have created an official website to provide up-to-date information about COVID-19. Such websites are often a one-stop-shop where citizens can find official health-related advice (e.g. measures they can take in their daily lives to prevent the spread of the virus and how to react if they have symptoms.) and information regarding all the measures taken by national public authorities. Governments also issue statements about COVID-19 through social-media channels (e.g. Twitter, Facebook, Instagram). They also operate official websites on the coronavirus (e.g. in Australia,[2] Denmark,[3] Finland,[4] France,[5] Korea, New Zealand,[6] the United Kingdom,[7] Brazil,[8] Greece[9] and Italy).[10] Other information websites are operated by national or regional health services (e.g. in Finland,[11] Norway)[12] or organisations for science diffusion (e.g. the Danish Videnskab.dk and United Kingdom Research and Innovation's Coronavirus: the science explained).[13]

Fact-checking services to counter the spread of false information: some countries have created specific websites to alert the public to the spread of inaccurate and false information. In Germany, the Federal Ministry of Education and Research's webpage about fake news related to COVID-19[14] is updated regularly, and findings are diffused through social-media channels. In the United States, the Federal Emergency Management Agency has developed a Coronavirus Rumor Control website[15] to help the public distinguish between rumours and facts regarding the COVID-19 pandemic. Japan's Ministry of Health, Labour and Welfare[16] and the Flemish Agency of Care and Health[17] have also created fact-checking webpages.

Official chatbots, apps and other tools developed in collaboration with technology firms: the WHO launched the WHO Health Alert,[18] a free service on WhatsApp that answers questions from the public about COVID-19, as well as the "Verified" service offering prompt and reliable responses based on the latest official health information.[19] Several countries have developed (in collaboration with technology firms) automated chatbots on WhatsApp, e.g. "MyGov Corona Helpdesk" in India. Some governments have also launched their own COVID-19 app (e.g. Brazil's "Coronavírus-SUS" and Ireland's "HSE COVID 19") allowing citizens to monitor their symptoms and stay up-to-date on the latest official information and advice.

Source: Paunov and Planes-Satorra (forthcoming[4]).

The increasing public availability of project-level funding data, often set in the context of public transparency measures, is enabling related efforts looking specifically at data about R&D funding. It is currently very difficult to respond to requests for fine-grained information or categories of R&D funding that do not align with established classifications. This is manifest today with regard to COVID-19 research funding. It also applies to policy requests for information on research targeting particular technology fields (e.g. artificial intelligence) and grand challenges (e.g. the Sustainable Development Goals), where there exists widespread demand for data resources, tools and methods that help identify features of R&D funding. Funding organisations, and a growing number of commercial providers of research support services, have been not only compiling and offering access to data, but also providing semantic search and analytical functionalities using machine learning. However, this remains a fragmented landscape (OECD, 2018[8]; OECD, 2020[3]) and data could be better shared and exploited, both nationally and internationally.

Horizontal co-ordination to help fight COVID-19

The virtues of policy co-ordination are well-known and widely accepted. Whole-of-government co-ordination mechanisms – within and across levels of government – are essential to resolving discrepancies between sectoral priorities and policies. By concentrating resources towards common objectives, they also promote coherent and mutually supporting actions across sectors and institutions. Yet policy co-ordination and coherence remains one of the oldest and most prevalent challenges for governments, made even more difficult by multidimensional systemic problems such as climate change, ageing societies – or a pandemic. Such societal challenges involve institutions far beyond those responsible for STI policies.

Two factors are particularly detrimental to ensuring an effective policy response to the COVID-19 pandemic, making the need for policy co-ordination even more acute:

- *Uncertainty*: despite a wealth of information and scientific advice, there still exists little consensus on how the spread of the virus could evolve and how it may be treated. Policy makers must therefore take decisions amid changing – and at times conflicting – evidence.
- *Urgency*: when faced with an urgent need to react (as with the COVID-19 situation), decision makers across all sectors tend to act without sufficient consultation or exchange of information. Many research and innovation actors have reoriented some of their previously funded activities towards COVID-19, but often with little guidance from policy makers, or with different signals and incentives from different organisations.

Greater policy co-ordination within governments can enhance responses to COVID-19 by limiting the duplication of efforts, ensuring a sufficient scale of efforts, enabling a wider and more sustainable exploration of potential solutions, and providing greater visibility to initiatives that offer funding for COVID-19 (OECD, 2020[9]). Co-ordination of STI policies can be achieved in several ways, from top-down strategic co-ordination led by a cabinet office (as in Japan), to agency-level co-ordination (as in Norway). There exists no single best approach, and co-ordinating STI activities to tackle COVID-19 must be adapted to each country's specific governance structures.

Co-ordinating STI policy with other policy fields

While many countries have rightly allowed health authorities to lead the initial response to COVID-19, governments have followed the WHO guidance for national pandemic preparedness plans by establishing various cross-sectoral mechanisms to co-ordinate actions with other ministries. These have different activity portfolios aimed at containing, delaying and mitigating the virus, depending on the country's strategy and current public health situation.

Co-ordinating COVID-19 research initiatives

Many countries have also established specific governance structures and initiatives to co-ordinate activities within the STI system itself. One of the goals is to reduce silos between authorities overseeing research and innovation policies – including in the health area, which remains somewhat separated from the rest of the STI system in many countries. These efforts vary in scope and focus. They range from collaborative networks and working groups to integrated programmes and joint calls for research or innovation proposals, which are commonly used when two or more research agencies or councils pool resources to solicit and select proposals. These joint initiatives typically cover shorter research and knowledge-transfer horizons, with results expected in 3 to 12 months. A few are used to support later stages of the innovation process – for example, developing and rapidly manufacturing new technologies and services for detection and treatment. A notable example is the Accelerating COVID-19 Therapeutic Interventions and Vaccines (ACTIV) public-private partnership, led by the United States, which promotes a co-ordinated research strategy at the federal level to prioritise and speed the development of the most promising treatments and vaccines. This initiative is headed by the National Institutes of Health, together with other relevant US agencies, philanthropic organisations and biopharmaceutical companies. It is also linked with the European Medicines Agency for greater coherence with international efforts (see Chapter 5).

Co-ordinating efforts to communicate about funding opportunities

To complement these initiatives, governments have invested to communicate about research and innovation funding opportunities from different agencies. Initiatives include inventories and maps of relevant STI projects, as well as various online platforms and portals that list all the relevant information on COVID-related STI funding opportunities. Better collection and dissemination of such information facilitates formal and informal co-ordination across government. For example, the European Commission has launched the European Research Area (ERA) corona platform, a one-stop shop for information on coronavirus research and innovation funding (e.g. calls and funded projects). In France, the REACTing consortium monitors and encourages data sharing, promotes good practices and standardisation of data collection, and assembles and co-ordinates the French research actors working on COVID-19.

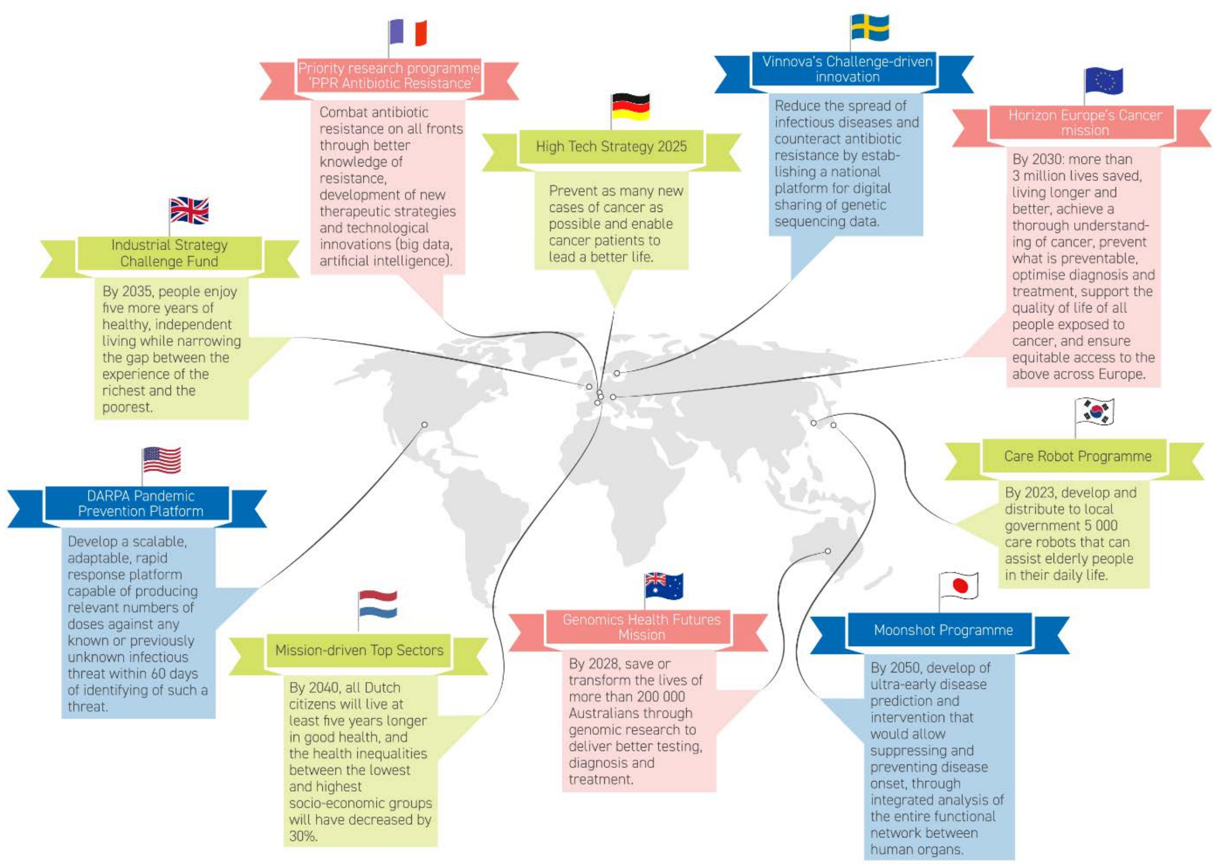
Governments leading collective action: Mission-oriented innovation policies

In parallel to co-ordinated early policy responses, more comprehensive approaches are needed to tackle COVID-19 in the longer run and prevent future pandemics. Governments' ongoing experiments with MOIPs could offer useful lessons in this regard. MOIPs bundle together a range of complementary public interventions to achieve ambitious goals for which traditionally fragmented STI policies have produced (at best) mixed results. These co-ordinated "packages" of research and innovation policy and regulatory measures can span different stages of the innovation cycle, from research to demonstration and market deployment. They can mix supply-push and demand-pull instruments, and cut across various policy fields. Several countries are currently experimenting with different types of MOIPs to tackle a broad range of societal challenges. This section focuses on MOIPs targeting health challenges.

A range of tailor-made systemic policies for different missions

While some models have begun to emerge as countries learn from one another and emulate good practices, each MOIP is tailored to its objectives, most often combining imperatives to tackle selected societal challenges and strengthen national competitiveness in new growth areas. Several of these systemic initiatives are currently implemented in health and healthcare, in pursuit of various goals or mission statements (Figure 8.2).

Figure 8.2. International map of selected missions in health and healthcare



Note: DARPA refers to Defense Advanced Resarch Projects Agency and PPR refers to Programme prioritaire de recherche (research priority programme).

The mission-orientation imperative

The need for new approaches to better orient and co-ordinate health-related STI policies arises in the context of several specific challenges:

- Several intersecting transformations are affecting the sector, notably emerging or evolving threats such as the COVID-19 pandemic or issues related to an ageing population, the digital transformation of health and health care, and new trends towards personalised medicine. These transformations are driven in part by STI developments, but also demand directed STI responses.

- While health research and innovation is cross-sectoral, it is still often governed by its own "system" in many countries, with specific institutional structures and funding channels. The system itself is typically fragmented, with multiple actors operating at different stages of the innovation cycle and at different governance levels (national, regional or local) through a great variety of support measures and initiatives. This fragmentation is a challenge to co-ordinate efforts around national health strategic goals and missions.

The main MOIP models

Scanning the worldwide landscape of MOIP initiatives, two main models are apparent: "national mission-oriented strategic frameworks" and "challenge-based programmes". These are briefly summarised in Table 8.1.

Table 8.1. Basic characteristics of the main MOIP models

Type	Leadership	Missions	Examples
National mission-oriented strategic frameworks	• Centre of government (high-level committee, cabinet, prime minister)	• Multiple missions or mission areas • Pursue ambitious challenges, including transformative change • Long-term horizon	• Horizon Europe (European Union) • Mission-driven Top Sectors policy (Netherlands) • High Tech Strategy 2025 (Germany) • Moonshot R&D Programme (Japan)
Challenge-based programmes	• Policy implementation body (ministry, agency)	• Focused • Seek incremental or breakthrough results • Better fit for "accelerator" missions • Mid- to long-term horizon	• Pilot-E (Norway) • Industrial Strategy Challenge Fund (United Kingdom)

- *National mission-oriented strategic frameworks are broad initiatives launched at the highest level of policy making*. They provide concrete and ambitious targets within an overall strategic framework that helps co-ordinate actions among a wide array of public and private actors. In Japan, for example, the Moonshot R&D Programme was established in 2020 at the national level to solve six "Moonshot goals", including the development of ultra-early disease prediction and intervention by 2050. A characteristic of this programme is its multi-layered governance structure. At the overall programme level, it is governed by the Moonshot Strategy Council, which gathers different ministries and agencies to fund and implement the activities. A programme director is assigned to each goal and is responsible for all projects towards that goal, enabling portfolio management; project managers are in charge of designing the best team to carry out their project. At the European Union (EU) level, the "Conquering Cancer" mission – one of the five missions included in the future Horizon Europe Framework Programme for Research and Innovation (2021-2027) – has a target of saving more than 3 million lives, and living longer and better by 2030. A dedicated group of experts, the Cancer Mission Board, is engaged in extensive consultations with Member States, members of the European Parliament and several Directorates-General of the European Commission. One novelty of this initiative is its consultation and engagement of EU citizens, including cancer patients and survivors. This process resulted in a portfolio of European Commission and Member States actions to be implemented in five main intervention areas. The next step will be the design of a relevant governance and implementation framework for effective portfolio management that enables cross-sectoral and cross-institutional coordination. An important challenge for these overarching frameworks is to engage a wide range of actors without broadening or multiplying the missions, and enlisting high-level political actors without sacrificing the long-term time horizon and boldness of missions.

- *Challenge-based programmes focus on solving specific problems and are implemented by dedicated agencies or programmes*. They often pursue ambitious technological or even scientific challenges, in line with their narrower scope and focus. One of their main objectives is to embed support for selected projects throughout the innovation chain, from research to market introduction, to increase the chance of innovation success and accelerate development through closer linkages between researchers, business firms and users (including patients). Several of these programmes are implemented by funding agencies and draw on the well-known experience of DARPA in the United States. An early application of this model in the health area took place in the early 1990s, when USD 300 million were allocated to the Department of Defense to fight breast cancer. Rather than apply a bottom-up, curiosity-driven research approach, the Department of Defense used a directed approach, with significant participation of patient-activists in the planning process and the final selection of the scientific projects to be funded. The programme funded research that is credited with developing drugs and therapies considered among the most important advances in breast cancer treatment in recent decades (Sarewitz, 2016[10]). In a more recent example, the United Kingdom's Industrial Strategy Challenge Fund targets four health-related challenges. These include inventing new ways of detecting and preventing the development of diseases, and the "healthy ageing challenge", which asks industry and researchers to develop products and services to help people remain independent, productive, active and socially connected for longer. Each challenge mobilises a tailor-made range of instruments to reach its objectives. In Norway, building on the experience of Pilot-E, a cross-agency integrated scheme aiming to accelerate the development of sustainable energy solutions, the government plans to set up a Pilot-H scheme to co-ordinate focused and joined-up interventions in the health area. As of today, many agency-led challenge-based initiatives are experimental pilots. To have a significant transformational impact, they will need to be evaluated appropriately. There also needs to be political willingness to scale them up and elevate them to the national level. Countries such as Austria, Norway and Sweden are currently at this pivotal stage.

Several of these ambitious systemic policies are created out of a sense of urgency related to the challenge to be solved, enlisting the high-level political support that is essential to create initiatives of such scale and scope. However, designing and endowing these policies with the proper resources and governance structures takes time. The outbreak of the COVID-19 pandemic has not been the best time to establish MOIPs, beyond the co-ordinated responses identified in the previous section. Nevertheless, as government recovery packages embrace longer time horizons, some MOIPs have turned to COVID-19 and post-COVID-19 challenges. In response to the COVID-19 pandemic, Japan's Moonshot programme added a seventh goal in July 2020, namely, establishing a sustainable medical and care system to overcome major diseases by 2040, and living until the age of 100 without health concerns. The programme has also launched a consultation in September 2020 to create a new Moonshot goal to tackle the challenges facing society and the economy in post-crisis Japan.

Technology governance

Science and technology will be essential to increase resilience and address the challenges of our time, such as pandemics, sustainability and ageing. Yet they also raise societal concerns, as witnessed during previous waves of technological change in industry and current debates around nuclear power, gene editing, neurotechnology and artificial intelligence. Traditional means of governing science and technology, whether through institutionalised research ethics, government regulation or market mechanisms, are increasingly ill-equipped to capture the pace and depth with which innovations are reshaping societies.

Developments in emerging technologies have triggered a global debate about the consequences of the resulting commercialisation and the potential need for new oversight mechanisms (Jasanoff and Hurlbut, 2018[11]). Under conditions of uncertainty, traditional regulatory instruments – e.g. risk assessment, product-based standard-setting, export controls and liability – tend to focus on managing the immediate or readily quantifiable consequences of emerging technology, or are put into play only after key decisions about technology design have been made. Yet many of the issues raised by emerging technologies are more fundamental and long-term.

The governance of emerging science and technologies poses a well-known puzzle: the so-called Collingridge dilemma holds that early in the innovation process – when interventions and course corrections might still prove easy and cheap – the full consequences of the technology, and hence the need for change, might not be fully apparent. Conversely, when the need for intervention becomes apparent, changing course may become expensive, difficult and time-consuming (Collingridge, 1980[12]). Uncertainty and lock-ins are at the heart of many governance debates. What is needed is a novel approach to technology governance that anticipates concerns early on, addresses them through open and inclusive processes, and steers innovation trajectories in a socially desirable direction. Alternatives to the existing paradigms of governance must emerge alongside a form of innovation that is more responsible and responsive to the needs of society.

Several new approaches in science and technology policy seek to overcome the Collingridge dilemma by addressing concerns with technology governance upstream. The key idea is to make the innovation process more anticipatory, inclusive and purposive, injecting public good considerations into innovation dynamics and ensuring that social goals, values and concerns are integrated as they unfold. Process governance shifts the locus from managing the risks of technological products to managing the innovation process itself: who, when, what and how. It aims to anticipate concerns early on, address them through open and inclusive processes, and steer the innovation trajectory in a desired direction.

Reaping the benefits of emerging technologies while preventing or mitigating their potential negative effects is a critical challenge for science and society today. Many of the barriers to emerging technologies lie not in technology itself, but in technology governance. Technology governance can be defined as the process of exercising political, economic and administrative authority in the development, diffusion and operation of technology in societies. It can consist of norms (e.g. regulations, standards and customs), but can also be operationalised through physical and virtual architectures that manage risks and benefits. Technology governance pertains not only to formal government activities, but also to the activities of firms, civil society organisations and communities of practice. In its broadest sense, it represents the sum of the many ways in which individuals and organisations shape technology and conversely, how technology shapes social order.

Responsible research and innovation

A persistent but misguided view is that resistance to technology stems mostly from public ignorance about the benefits of particular technologies or innovation in general. Social science research shows that such resistance might be steeped more in basic value conflicts, distributive concerns and failures of trust in governing institutions, such as regulatory authorities and technical advisory bodies (Gaskell, 1999[13]); (Bauer, 2009[14]). As a general rule, governments and innovators should take into account inasmuch as possible social goals and concerns from the beginning of the development process.

Neurosciences and neurotechnology are a case in point: they have dramatic potential for promoting human health and well-being. At the same time, they raise complex ethical, legal, and policy questions, including on (brain) data privacy, cybersecurity, human enhancement, the regulation and marketing of direct-to-consumer devices, the vulnerability of cognitive patterns for commercial or political manipulation, new inequalities of access, and implications for human rights (Ienca and Andorno, 2017[15]; Wexler and Reiner, 2019[16]). Such questions do not exclusively pertain to the field of science: policy choices around innovation and regulation will also steer these technologies. Thus, science and society more broadly must address these issues together in order to realise the full potential of neurotechnology.

Drawing from country practices around responsible research and innovation (Stilgoe, Owen and Macnaghten, 2013[17]) and "ethical, legal and social implications" frameworks, the OECD has been developing an approach to responsible innovation, culminating in the Recommendations on Responsible Innovation in Neurotechnology (OECD, 2019[18]) (Box 8.3). The Recommendation embodies a "responsible innovation" approach, drawing inspiration from the field of science and technology studies (Stilgoe, Owen and Macnaghten, 2013[17]) and recent work funded by the European Union (European Commission, 2020[19]). This approach seeks to anticipate problems during the course of innovation and steer technology to best outcomes, involving many stakeholders in the innovation process (OECD, 2018[20]). The OECD has also published the Recommendation on Artificial Intelligence (OECD, 2019[21]), which promotes artificial intelligence that is innovative and trustworthy, and that respects human rights and democratic values.

Box 8.3. OECD Council Recommendation on Responsible Innovation in Neurotechnology (2019)

1. Promote responsible innovation
2. Prioritise safety assessment
3. Promote inclusivity
4. Foster scientific collaboration
5. Enable societal deliberation
6. Enable capacity of oversight and advisory bodies
7. Safeguard personal brain data and other information
8. Promote cultures of stewardship and trust across the public and private sector
9. Anticipate and monitor potential unintended use and/or misuse

Source: OECD (2019[18]), OECD Recommendation of the Council on Responsible Innovation in Neurotechnology, https://legalinstruments.oecd.org.

Good governance can actually enable, rather than constrain, technology. This insight, focusing on governance from the perspective of innovation, is a touchstone of the Recommendation. In creating a responsible innovation system, at least five overarching elements stand out: (i) directionality, (ii) inclusivity, (iii) anticipation, (iv) deliberation, and (v) the role of the private sector. Each is gaining traction in innovation policy.

- *Directionality*. The Recommendation responds to calls to better align research, commercialisation and societal needs. In other words, it promotes "mission-oriented" and "purposive" technological transformation to better connect innovation to mental health.
- *Inclusivity*. Discussions about inclusive innovation usually focus on technological divides and access inequality. The Recommendation highlights further forms of inclusivity, i.e. how the inclusion of stakeholders, citizens, and systematically excluded actors within the innovation process can help drive innovation (OECD, 2018[20]).
- *Anticipation*. From an innovation perspective, end-of-pipe-approaches can be inflexible, inadequate and even stifling. In the realm of technology governance, governments and policy makers are currently experimenting with test beds, sandboxes, new technology assessment methods and foresight strategies.

- *Deliberation*. More demanding than public participation, deliberation implies an iterative exchange of views in hopes of achieving reasoned discourse and even finding common ground. The approach requires enhancing societal capacities to understand, communicate on and shape technology through the course of development so that technology might advance under conditions of trust, enabling their development to market. A good example of public engagement and deliberation is the process followed by the Human Fertilisation and Embryology Authority (HFEA) in the United Kingdom during its examination of a controversial technology (Box 8.4).
- *Role of the private sector*. Whereas many ethics of technology codes place duties on scientists and clinicians, the Recommendation also advances an institutional approach directing guidance to funding agencies, oversight bodies and companies. Firms in particular have a critical role to play in governance. They are on the front lines of product development, regulation, diffusion and marketing, and should commit themselves to a responsible innovation framework.

Box 8.4. An example of deliberation and technology uptake: The Human Fertilisation and Embryology Authority

The HFEA was established in 1990 to license and monitor in vitro fertilisation and insemination clinics throughout the United Kingdom, as well as institutions conducting embryonic research and storing gametes and embryos (Jasanoff, 2005[22]). In 2007, the HFEA launched a public consultation to explore the public's views on whether or not research scientists should be allowed to create embryos containing animal DNA (HFEA, 2007[23]; Starza-Allen, 2007[24]). The programme, entitled Hybrids and Chimeras, was supported by Sciencewise, a programme currently run by UK Research and Innovation, which aims to assist policy makers in conducting public engagement activities.

The consultation ran from April to July 2007 and involved a range of approaches to consultation. A public opinion poll gathered the general views of a representative sample of the public. Public deliberations expanded upon these general findings and opened up new questions, focusing on the effects of deliberation and new information on participants' views. A written consultation and a public meeting then took place. The HFEA analysed the results of the public consultation and decided that cytoplasmic hybrid research should be allowed to move forward, with caution and careful scrutiny (HFEA, 2007[23]).

More recently, the HFEA conducted a public consultation and submitted a proposal to the UK Parliament on whether to allow mitochondrial replacement in embryos intended for implantation. The parliament accepted the recommendation, with high public approval.

Participatory technology assessment

Technology assessment is another mechanism enabling responsible innovation. Initiated in the 1960s, technology assessment has been increasingly adopted in many countries and has evolved over time, based on the lessons learned. Innovation policy in many OECD countries is now guided by forms of societal technology assessment carried out by a mix of actors, including national ethics committees and other government bodies charged with considering wider social effects, and health and safety risk assessment. Some of these assessments are more broadly participatory, and include procedures involving stakeholder and public input (Durant, 1999[25]).

These societal technology-assessment processes involve formal risk analysis. Beyond the immediate health and safety risks, they can also be mindful of the longer-term social implications of technological adoption. Questions to consider relate to the distribution of the possible benefits and costs, the consequences of intellectual property in the field, the existence of particular pathways of greatest social benefit, the sources of uncertainty in assessing the technology, and the potential benefits of innovation.

Generally speaking, there has been a shift from more expert-based forms of assessment to more participatory models (see below). Born out of controversies around technologies like nuclear energy, technology assessment in the United States initially focused rather narrowly on providing objective, probabilistic knowledge about future trajectories of emerging technologies. Over time, it was increasingly recognised that framing assumptions (e.g. problem definitions, scope and methodologies) shaped the conclusions of technology assessment (Wynne, 1975[26]; Ely, Stirling and Van Zwanenberg, 2011[27]). In particular, an overemphasis on technical consequences could overshadow important issues associated with the social, ethical and political impacts of technologies. For these reasons, countries began to shift towards more inclusive, open and deliberative forms of technology assessment.

Some mechanisms of technology assessment involve formal public procedures that feed directly into innovation policy and governance decisions, particularly through consultation with expert advisory bodies. One approach consists in relying on scientific academies or regulatory authorities to assess the more technical aspects of emerging technologies; another is to establish public advisory bodies. Examples of these approaches include the Danish Board of Technology Foundation, the Nuffield Council on Bioethics in the United Kingdom, and presidential bioethics committees in the United States. Such groups might be charged with gathering evidence on particular technologies through research and public testimony, and writing reports that can inform public reasoning. Other methods include using public surveys and stakeholder interviews to assess emerging technologies and gauge current opinion, as well as holding hearings to collect input from various publics and inform regulatory agencies.

Recent efforts to introduce participatory technology assessment have variously been termed “constructive technology assessment” (Schot and Rip, 1997[28]), “participatory technology assessment” (Guston and Sarewitz, 2002[29]) and “real-time technology assessment”, among others. These approaches emphasise the value of engaging citizens and stakeholders alongside experts, based on the notion that technology assessment is inherently value-laden and citizens should therefore have a voice in the process. There is also growing recognition that non-experts and other stakeholders possess relevant knowledge that would otherwise be missed.[20]

More participatory modes of technology assessment recognise that the public is more likely to accept assessments of which they have been a part, and that the knowledge produced during these assessments will likely be more robust if diverse stakeholders are engaged. These approaches might include socio-technical mapping, which combines stakeholder analysis with plotting of recent technical innovations; early experimentation to identify and manage unanticipated impacts; greater dialogue between the public and innovators; public opinion polling and focus groups; and scenario development (Guston and Sarewitz, 2002[29]).

Future outlook

This chapter has reviewed a diverse range of issues facing the governance of STI. It has touched on lessons learned from recent OECD studies and highlighted outstanding policy challenges. Looking ahead, periods of crisis can offer opportunities to revisit existing policy goals, models and practices, as well as redirect economies and societies towards more equitable, sustainable and resilient futures. This final section explores some of the options available to countries when pursuing such policy goals, using currently underutilised policy frameworks and theories to guide policy action. It discusses policy practices in light of the pandemic crisis, and highlights the importance and challenges of developing the capabilities within government to successfully implement the ambitious STI policy agenda that is now emerging.

Revisiting policy goals

In contrast to the 2008-09 global financial crisis, STI is clearly central to providing solutions to the COVID-19 crisis. It is playing a prominent role in shaping policies to contain the virus through scientific advice, and the race to develop effective vaccines and therapeutics is drawing on the latest cutting-edge medical research and innovation. Such highly visible contributions could play a decisive role in the positioning of STI in the future.

The pandemic crisis has pushed the issue of "resilience" (i.e. the ability to recover from and adapt to disruption, and if need be, shift towards transformative paths) centre stage in policy agendas. While STI policy may need to adjust to this new emphasis, STI already makes important contributions to socio-economic resilience, by generating new knowledge and furthering its applications through innovation. In the COVID-19 context, new technology platforms are facilitating the development and production of vaccines and therapeutics at a rate that would have been unimaginable only a decade ago (see Chapter 5). The emphasis on resilience may therefore bring with it increased attention on supporting flexible platforms such as these and furthering collaborative partnerships that provide STI systems with greater agility to respond to future challenges.

It also seems likely that STI policy will continue to lean towards a more proactive "systems transformation" orientation, particularly to address the challenges of the climate emergency. While this shift has been under way for some time in several OECD countries, it could well accelerate in response to COVID-19 and the ambitious goals (e.g. green transitions) contained in many countries' recovery and stimulus packages (OECD, 2020[30]). Similarly, STI policy agendas may emphasise more the need to ensure an inclusive recovery (OECD, 2017[31]). Given that the COVID-19 crisis has had highly unequal effects, with a higher impact on many vulnerable groups in society and on some regions more than others, working towards greater inclusiveness could become as important a goal for STI policy as supporting national competitiveness and growth (Paunov and Planes-Satorra, forthcoming[4]).

Revisiting policy theories and frameworks

Reorienting policy goals towards sustainability, inclusiveness and resilience in the recovery period will require altogether different policy frameworks and practices. In their efforts to "build back better", STI policy makers and analysts could usefully deploy a range of novel and emerging frameworks and concepts. Some of these are well established in other policy fields, but largely overlooked by STI policy. Others have been at the fringes of STI policy for a decade or more, but have yet to be mainstreamed. The socio-technical transitions multi-level perspective (MLP), which emerged in sustainability research in the 2000s, is a prominent example. MLP underpins much contemporary discussion around the need for a new "transformative STI policy" (Schot and Steinmueller, 2018[32]) and is increasingly being promoted by international organisations (OECD, 2015[33]; European Environment Agency, 2019[34]; Pontikakis et al., 2020[35]) as an encompassing policy framework to promote sustainability transitions. However, despite many notable examples over the last decade (e.g. the Challenge-driven Innovation and Strategic Innovation programmes operated by Vinnova in Sweden, the Academy of Finland's Flagship initiative, the Pilot-E programme in Norway, and the Grand Solutions programme in Denmark), the framework has yet to be widely applied.

Such transformations call for system-level interventions to enact "systems innovations" – which, in turn, have highlighted the complexity of systems and the need to shift away from "command-and-control" notions of policy intervention (Hynes, Lees and Müller, 2020[36]). Furthermore, the COVID-19 crisis has exposed both the strengths and vulnerabilities resulting from strong interdependencies across countries and sectors, where changes in one component may directly or indirectly shape impacts in other parts of complex systems. Thus, the pandemic has emphasised the relevance of designing and implementing policies as components of a complex system (Paunov and Planes-Satorra, forthcoming[4]). As with MLP, while policy discussions of complex systems are more prominent than ever, there remains a sizeable gap in putting this thinking into STI policy practice.

Transformations and transitions create winners and losers. They can threaten powerful incumbents, who may seek to maintain some semblance of the status quo (Geels, 2014[37]). Power is ubiquitous in science and innovation, yet tends to be predominantly framed in narrow competition terms. Other policy fields, such as developmental aid (Whaites et al., 2015[38]), use broader concepts of power, deploying tools like political-economy analysis to better understand and map the drivers of change, and using these insights to design policies with greater chances of success.

The significance of values informing policy choices, including in the STI policy field (Bozeman, 2020[39]; Mazzucato and Ryan-Collins, 2019[40]), and the role of narratives and collective mobilising visions (Jasanoff and Kim, 2015[41]) in enacting transformations are increasingly recognised, yet rarely considered or mainstreamed in STI policy. STI should be a source of "collective hope" for societies (Mulgan, 2020[42]), but existing techno-economic visions will likely need to be renewed to serve a positive, sustainable and fairer socio-technical transition. While strategic foresight exercises can contribute to building such visions, these alone will be insufficient. Sustained, multifaceted and multi-stakeholder actions will likely be required, involving government, civil society organisations, the media and business.

Revisiting policy practices

The COVID-19 crisis has obliged governments to engage in "forced experimentation", from organising new ways of working from home, to using new data, policy tools and partnerships to formulate, design and implement policies. It is difficult to assess the long-term impacts these experiments will have on policy practice, but some will no doubt be scaled-up and diffused more widely. The new emphasis on building greater socio-economic resilience to dynamic change and future shocks means that various preparedness measures – including support for public-private networks, platforms and infrastructures that improve countries' abilities to respond to diverse risks – will likely be designed and implemented.

Ambitious recovery and stimulus packages may give policy more leverage to initiate a transition towards more sustainable and equitable futures. For example, the aviation and automotive industries require public subsidies as part of the recovery, which could be tied to various sustainability targets. Initial steps in that direction have already been taken. The bailout package for Air France requires the company to cut its emissions on all flights by 2030 (OECD, 2020[43]; Paunov and Planes-Satorra, forthcoming[4]). Thus, the crisis may strengthen the role of governments in both shaping the recovery and signalling the direction of desirable socio-technical transitions.

On the other hand, whether and to what extent ambitious recovery packages spur structural change remains uncertain. Government intervention needs to be affordable, which will be a major concern for many countries as the pandemic raises costs to the economy. Government debt for all countries is unprecedentedly high, far above the levels reached during the global financial crisis. Such unfavourable fiscal conditions could severely restrict the scope and scale of STI policy, reducing its ambition (see Chapter 1). Fiscal constraints will also leave STI policy facing some hard choices about the research and innovation areas and activities it should prioritise. Given the current pandemic crisis, more resources are likely to be directed towards health research and innovation. But if the total amount of funding remains unchanged or even decreases, this implies a decline of public resources for other research and innovation areas (see Chapter 2).

If STI policy is to apply some of the frameworks mentioned above, particularly MLP and systems approaches, an even greater use of new digital tools and data would be highly beneficial. Big-data analytics and artificial intelligence can help map entire systems at granular levels and in real time, allowing a better capture of system dependencies and improving understanding of how policies targeting one area can affect others. However, as with approaches to technology governance, such mapping and assessment activities should be performed with citizen and stakeholder engagement. Stakeholders and non-experts possess different types of knowledge and values that are relevant to STI policy. Even if it were technically feasible to capture or model such knowledge and values, the act of engaging stakeholders and citizens at different stages of the policy cycle brings process benefits that will make STI policies more robust and effective.

Revisiting government capabilities

The governance topics covered in this chapter, from using scientific advice and big-data analytics, to driving mission-oriented policies and governing technology, assume that sophisticated capabilities exist within the public sector. This section has highlighted the possibility of establishing new goals, new frameworks and new practices for STI policy, which will require expanding such capabilities. Beyond the skills of public servants (important as they are), organisational capacities and routines will also be needed. These are not easy to develop quickly – nor can successful organisational capacities and routines be simply replicated, given their embeddedness in organisational histories and cultures.

Developing the capabilities to deliver on a more ambitious policy agenda will become an increasingly significant concern for STI policy. Increased policy emphasis on building resilience, which calls for policy agility, highlights the need for governments to possess "dynamic capabilities", which (Teece, Pisano and Shuen, 1997[44]) define as the "ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments". Dynamic capabilities are distinct from the ordinary routines and capabilities organisations possess to exploit existing strengths and opportunities. They refer to an organisation's ability to adapt and learn, essential traits for effective governance.

Dynamic capabilities need to be distributed across the public sector, rather than focused in just a few agencies or innovation labs. Non-governmental actors, such as businesses, universities and civil society organisations, also possess knowledge and competencies that governments will need to leverage in order to fulfil ambitious policy agendas. This calls for developing both co-ordinative and absorptive capacities, to understand and act on knowledge generated by others. This can be challenging, particularly in leading-edge technologies like artificial intelligence, where the public sector competes against higher-paying businesses to hire technical experts. Government capacities have also been somewhat "hollowed out" in many OECD countries over the last decades, and some countries may need to rebuild them.

Thus, building capabilities in governments to meet the challenges ahead will be a major challenge in itself. While it has been beyond the scope of this chapter to explore this challenge in any detail, it is common to all governance topics covered here, and deserves greater attention in STI policy agendas.

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Notes

[1] This survey has been implemented through an online open-link questionnaire, inviting scientists or any other individuals with an interest in science or science policy on the impact of the COVID-19 crisis from a science perspective. The survey has been initially promoted through the network of the OECD Committee for Scientific and Technological Policy and former participants of the 2018 OECD International Survey of Scientific Authors (ISSA). It is being carried out in collaboration with the Inter-American Development Bank. As of 12 October 2020, over 2 600 responses from nearly 100 countries had been collected. 45% of responses correspond to individuals that identify themselves as scientists, with the rest comprising science policy advisors (20%), professionals involved in science (15%), science communicators (10%) and individuals carrying out science-related administrative work (10%). The survey does not request any information that can identify the respondents. As a result, results cannot be considered to be representative of a well-defined population and should be treated with extreme caution and considered as a complementary view to other evidence.

[2] https://www.australia.gov.au/.

[3] https://politi.dk/corona/.

[4] https://valtioneuvosto.fi/en/information-on-coronavirus.

[5] https://www.gouvernement.fr/info-coronavirus.

[6] https://covid19.govt.nz/.

[7] https://www.gov.uk/coronavirus.

[8] https://coronavirus.saude.gov.br/.

[9] https://eody.gov.gr/neos-koronaios-covid-19/.

[10] http://www.salute.gov.it/nuovocoronavirus.

[11] https://thl.fi/en/web/infectious-diseases/what-s-new/coronavirus-covid-19-latest-updates.

[12] https://helsenorge.no/.

[13] https://coronavirusexplained.ukri.org/en/.

[14] https://www.bmbf.de/de/faktencheck-zum-coronavirus-11162.html.

[15] https://www.fema.gov/coronavirus-rumor-control.

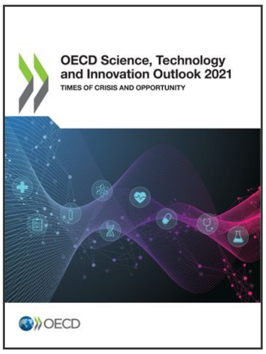
[16] https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000164708_00001.html.

[17] https://www.gezondheidenwetenschap.be/dossiers/coronavirus.

[18] https://www.who.int/news-room/feature-stories/detail/who-health-alert-brings-covid-19-facts-to-billions-via-whatsapp.

[19] https://shareverified.com/en.

[20] Toxicological risks are a good example. It is the users of potentially toxic substances in their places of work that are well positioned to provide knowledge of how workers might become exposed in particular workplaces, given normal habits, etc. To give another obvious example, an assessment of the risks of pesticides would have to take into account the everyday practices of field workers, for example, whether protective clothing is in fact routinely used.



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