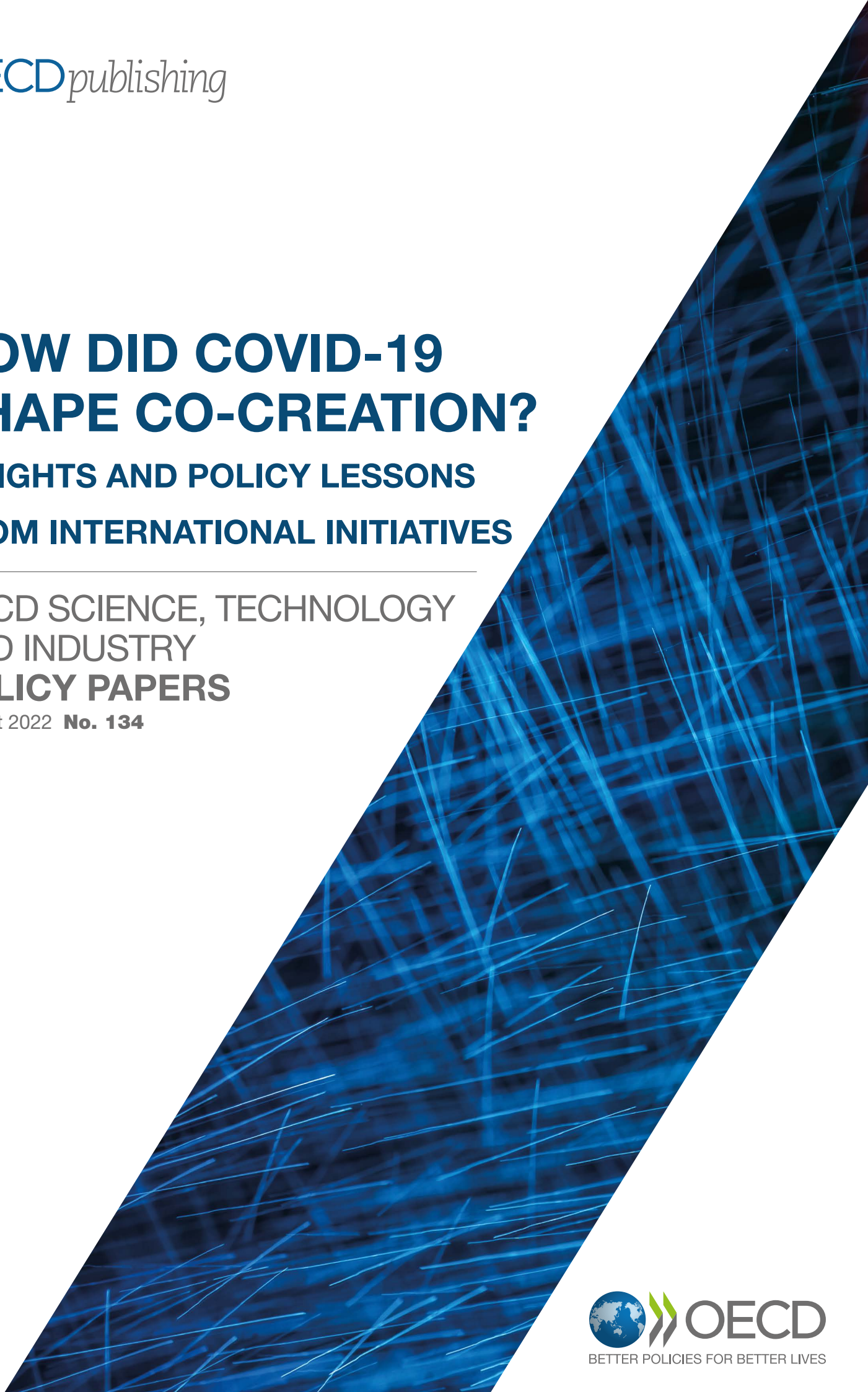
OECD publishing

HOW DID COVID-19 SHAPE CO-CREATION?

INSIGHTS AND POLICY LESSONS FROM INTERNATIONAL INITIATIVES

OECD SCIENCE, TECHNOLOGY AND INDUSTRY
POLICY PAPERS
August 2022 **No. 134**



OECD
BETTER POLICIES FOR BETTER LIVES

OECD Science, Technology and Industry Policy Papers

This paper was approved and declassified by written procedure by the Committee on Scientific and Technological Policy on 11/07/22 and prepared for publication by the OECD Secretariat.

Note to Delegations:
This document is also available on O.N.E under the reference code:
DSTI/STP/TIP(2022)14/FINAL

How did COVID-19 shape co-creation? Insights and policy lessons from international initiatives

Muthu de Silva (Birkbeck, University of London)
Nikolas Schmidt (OECD Directorate for Science, Technology and Innovation)
Caroline Paunov (OECD Directorate for Science, Technology and Innovation)
Orlagh Lavelle (OECD Directorate for Science, Technology and Innovation)

Abstract

Co-creation – the joint production of innovation between combinations of industry, research, government and civil society – was widely used to respond to COVID-19 challenges. This paper analyses 30 international co-creation initiatives that were implemented to address COVID-19 challenges. Evidence on these initiatives was gathered based on structured interviews with initiative leaders. Existing co-creation networks enabled the rapid emergence of new initiatives to address urgent needs, while digital technologies enabled establishing new – and, where necessary, socially distanced – collaborations. Aside from funding initiatives, governments engaged actively in co-creation by granting access to their networks, advising on initiative goals and offering support to improve quick delivery. The role of civil society was important as well, and the socially impactful nature of research and innovation was a motivating factor for engagement. Harnessing a similarly strong motivation is an important driver of effective future co-creation endeavours also to address the challenges of the green transition.

Keywords: Innovation, Industry-science Linkages, Digitalisation, Civil Society

JEL: O36, O38, I18

Acknowledgements

The paper benefitted greatly from contributions from Sandra Planes Satorra, Luke Mackle, Hunter McGuire and Kieran Jones. The rich inputs provided by co-creation initiative leaders are gratefully acknowledged. The delegates of the Working Party on Innovation and Technology Policy (TIP) and the members of the project's steering group provided substantive inputs by suggesting initiatives and commenting on various early versions of this report at the TIP Meetings in June 2021, December 2021 and June 2022. The report also benefited from insights from COVID-19 co-creation initiative leaders and TIP delegates at a co-creation community exchange event "What can we learn from COVID-19 co-creation initiatives for future collaborations?" held on 19 October 2021 and comments received.

Executive Summary

What role did co-creation play to address the COVID-19 crisis?

The socio-economic costs imposed by COVID-19 would have been much larger in the absence of many co-creation initiatives that produced solutions to COVID-19 challenges. Co-creation – the process of joint production of innovation between industry, research and other stakeholders, such as civil society – led to the development of vaccines, quickly produced ventilators for COVID-19 patient treatment and data platforms that supported research, innovation and policy in dealing with the pandemic.

Co-creating in the COVID-19 context required adjustments to established collaboration practices. Consequently, the COVID-19 crisis offered a testbed for new practices, technologies, operational models and partnership structures.

What evidence does this report on co-creation rely on?

This report builds on insights from 30 COVID-19 co-creation initiatives from 21 countries and 3 transnational initiatives. Structured interviews with the leaders of each initiative provided in-depth evidence on the respective initiatives.

What was special about co-creation during the COVID-19 pandemic?

The following specificities applied to COVID-19 co-creation initiatives:

- **Co-creation partners mobilised at speed, driven by their motivation to make a meaningful contribution to society.** This motivation engaged also civil society and entrepreneurs.
- **Existing networks, technologies, infrastructure, and policy programmes were leveraged to quickly respond to the COVID-19 emergency.**
- **Open calls for solutions that leveraged digital tools and social media engaged more diverse actors in co-creation, beyond the "traditional" innovators**. Prominent examples are hackathons, which are events involving possibly large numbers of participants in generating in teams ideas and solutions primarily through technology and innovation.
- **Governments engaged actively in co-creation** by providing funding for initiatives, connecting relevant partners from different fields, facilitating access to infrastructures, provided advice on initiatives' goals in view of COVID-19 needs and helping develop implementation plans to help enhance speed.

How did co-creation initiatives operate in the context of crisis?

Co-creation practices adapted to the context of crisis in order to speed up solutions, including by:

- **Adopting agile management practices**, such as pursuing different pathways simultaneously, implementing interim progress evaluations to adjust pathways quickly when needed and using digital communication tools for project coordination;

- **Streamlining processes,** including accelerated project approval processes for funding support and quicker regulatory approval processes for medical innovations without compromising on the necessary safeguards;
- **Setting up multidisciplinary teams** to combine a diverse range of expertise, technologies, and infrastructure in order to generate solutions;
- **Leveraging digital tools**, including collaboration platforms to operate fully digitally.

What were the key outcomes of the COVID-19 initiatives for the future?

The initiatives produced the following outcomes for the future:

- Better knowledge and capacities to deal with SARS-CoV-2 and possibly related viruses.
- Transferable skills and know-how for future innovation, going beyond the medical field.
- Knowledge about how to operate co-creation initiatives in an uncertain and quickly changing context.
- New networks and connections.
- Software, platforms and data tools for wider application.
- Widespread experience in working with new data- and digital-intensive tools.

What are the policy lessons?

The following lessons for the design and implementation of future policy programmes for co-creation, emerge:

1. Purpose is the strongest driver of co-creation; incentives to support co-creation should go beyond facilitating access to funding
2. Crisis-specific programmes may not be needed out of the crisis, but networks and infrastructures should be strengthened during "normal" times
3. There is room for building new collaborations between researchers and producers to accelerate innovation during "normal" times
4. Policy should support the wider development and use of digital tools for co-creation.
5. New approaches should be leveraged more to tap into the large pool of diverse and readily available capacities in the economy
6. Governments' involvement in co-creation activities as network builders can help speed up solutions; enhanced agility in their operations should be encouraged
7. Public engagement in co-creation can help market uptake of new solutions.

1. Introduction

The COVID-19 crisis mobilised a wide range of actors in joint innovation activities to address the urgent challenges imposed by the pandemic. Co-creation – the process of joint production of innovation between industry, research and other stakeholders, such as civil society – led to the development of vaccines, and quickly produced ventilators for COVID-19 patient treatment and data platforms that supported research, innovation and policy in dealing with the pandemic. The socio-economic costs imposed by COVID-19 would have been much larger in the absence of many co-creation initiatives that produced solutions to COVID-19 challenges.

Co-creating in the COVID-19 context required adjustments to established collaboration practices. The COVID-19 context, consequently, offered a testbed for new practices, technologies, operational models and partnership structures. Learning from these is useful for future co-creation initiatives, related policy support and public sector involvement to tackle the many future challenges ahead. However, the COVID-19 context was in many ways exceptional, due to the urgency of the situation and its quickly evolving nature. Not all new co-creation practices during the COVID-19 era will be relevant for successful future co-creation initiatives while others may not be implementable outside of this exceptional context.

This paper analyses how co-creation initiatives implemented during the COVID-19 pandemic to address COVID-19 challenges were shaped by this exceptional context. Its focus is on extracting lessons to inform policy both in and out of periods of crisis. The analysis is based on a review of 30 COVID-19 co-creation initiatives from 21 countries and 3 transnational initiatives. Case studies were developed through in-depth interviews with initiative leaders using a standardised template to allow for the comparative analysis.

The following key questions guided the analysis:

- What was special about the co-creation initiatives due to the COVID-19 context?
- What factors enabled the quick set up of new co-creation initiatives?
- How did the co-creation practices adapt to the context of crisis in order to speed up solutions?
- What role did governments play in co-creation during the COVID-19 crisis?
- What were the key outcomes of the COVID-19 initiatives for the future?

Co-creation initiatives during the COVID-19 had some peculiarities due to the atypical context in which they were conceived and implemented. This includes the unprecedented number of capacities mobilised and public and private funding made available for a common cause, which supported very diverse co-creation projects. Social distancing and mobility restrictions meant that collaboration efforts were often undertaken at a distance. The large scale experimentation with tools such as hackathons and prizes, and the use of social media to publicise them, engaged diverse actors in the initiatives.

Regarding the quick set up of new co-creation initiatives during the crisis, the following characteristics stand out: First, the mobilisation of co-creation partners, including civil society and entrepreneurs, was driven by their strong motivation to jointly work towards the common shared goal to help alleviate COVID-19 challenges. Second, many initiatives exploited already existing networks, technologies, infrastructure, and policy programmes

and structures to help accelerate the production of urgently needed solutions. Third, the quick mobilisation of government and private funding helped kick-start many projects.

As to ways for speeding up the production of solutions, co-creation initiatives often adopted agile management practices and leveraged digital tools for communication and coordination purposes. This involved pursuing various research pathways simultaneously, and implementing interim evaluations of progress to be able to adjust adopted pathways quickly when need.

As to governments' role, they played a critical role in helping identify specific evolving needs and matching partners, which facilitated the set-up of co-creation initiatives. They also introduced fast-track project application processes to accelerate the provision of funding, and streamlined regulatory approval processes to speed up the market entry of solutions.

The review of co-creation experiences points to several possibilities for innovation policies to support co-creation. Emphasis should be set on incentivising the expansion of networks for research and innovation across disciplinary and sectoral boundaries. Supporting the further development and use of digital tools can enhance network-building and collaborations. Expanding the use of digitally-enabled and other new approaches such as hackathons is also useful. These proved successful during COVID-19 in attracting a larger pool of more diverse partners than was the case prior to COVID-19. There is also more scope for public engagement in co-creation to help identify specific needs, co-develop and adopt new solutions. Finally, governments' active involvement in co-creation and greater agility of programmes can help speed up co-creation. Agility can be enhanced by conducting small experiments to test different approaches and tools to extend subsequently as needed.

This paper is structured as follows. Section 2 and 3 present the methodology and a descriptive overview of the case studies. Section 4 presents the main findings of the analysis. Section 4 provides main takeaways and policy implications. Section 5 concludes.

Table 1. Overview of co-creation initiatives: Umbrella programmes for co-creation initiatives

No.	Initiative name	Country	Short description
Umbrella programmes for co-creation initiatives			
1	Innovation Clusters COVID-19 Response	Canada	Canada's Global Innovation Clusters (formerly known as Canada's Innovation Superclusters Initiative) programme, established in 2018, aims to build industry-led innovation ecosystems, and leverages core funding administered by Innovation, Science and Economic Development Canada (ISED), a Canadian federal government ministry. The programme was leveraged to address the challenges of the COVID-19 pandemic and funded over 80 COVID-19-related co-creation projects, with a total investment of almost USD 173 million (CAD 220 million).
2	Pandemic Response Challenge Program (PRCP)	Canada	The National Research Council of Canada (NRC) established the COVID-19 Pandemic Response Challenge Program (PRCP) on behalf of the Government of Canada. The programme was set up to form collaborative teams of leading Canadian researchers to fast-track R&D aimed at addressing COVID-19 challenges.
3	Fondo de Investigación Científica (Scientific Research Fund) COVID-19	Chile	As part of this initiative, Chile's research and development agency, ANID, issued a call for proposals for one-year projects that were linked to diagnosis, control, prevention, treatment, monitoring of COVID-19 or other aspects related to the pandemic, that would help inform policy responses and strengthen the country's COVID-19 response capacity.
4	MEXT/RIKEN programme for COVID-19-related research	Japan	This initiative led by Japan's scientific research institution RIKEN, was a programme which promoted the joint use of the Fugaku supercomputer, research facilities and capacities of RIKEN. Universities, research institutions, and companies from all over Japan were invited to respond to an open call to use those resources for COVID-19 research.
5	COVID-19 Türkiye Platform	Türkiye	The COVID-19 Türkiye Platform initiative mobilised an existing co-creation programme – the High-Technology Platforms Call – to offer accelerated funding for researchers, entrepreneurs, and industry to develop innovative solutions to the COVID-19 pandemic, incl. therapeutics and vaccines, within a network structure and other approaches to support innovation, such as hackathons and scholarship programmes for collaborations.
6	High Performance Computer (HPC) Consortium	USA	The COVID-19 High Performance Computing (HPC) Consortium was a public-private consortium, which pooled resources to make high performance computing capabilities available to researchers across 17 countries to conduct research into solutions to COVID-19 pandemic.
7	ART-ER COVID-19 Project	Italy	The regional government of Emilia Romagna published a call for proposals inviting companies and research institutions to offer rapid solutions to the COVID-19 pandemic. ART-ER (a not-for-profit association whose purpose is to foster sustainable growth by developing innovation and knowledge, attractiveness, and internationalization) managed and supported the regional governments' call for proposals for projects that responded to COVID-19 under a special pandemic-programme.

Table 2. Overview of co-creation initiatives: Co-creation for network building initiatives

No.	Initiative name	Country	Short description
Co-creation for network building initiatives			
8	Task Force Vlaanderen Helemaal Digitaal ('Flanders All-Digital')	Belgium	Vlaanderen Helemaal Digitaal ('Flanders All-Digital') was a government-led initiative that consisted of connecting government agencies with companies and research organisations to identify digital solutions to COVID-19 challenges.
9	EUvsVirus	European Commission	The EU vs Virus was a three-day hackathon event organised by the European Commission Services (ECS) from 24 to the 26 April 2020. The hackathon aimed at mobilising solutions to challenges posed by the COVID-19 from actors from the public sector (such as government agencies and hospitals), civil society, private sector, universities, and research institutions. A follow-up matchathon event organised from 22-24 May 2020 aimed at connecting winning hackathon teams to potential private sector partners and investors.
10	Fast Expert Teams vs COVID-19	Finland	The Fast Expert Teams vs COVID-19 initiative brought together experts from universities and research institutions, companies, and the public sector (including ministries and agencies) engaged in pro bono efforts to solve various challenges caused by the COVID-19 crisis, such as decontaminating high-quality respirators for reuse and remote work arrangements.
11	COVID-19 portfolio of the Knowledge Share Platform	Italy	During COVID-19, the KS platform was mobilised to help leverage available technologies to address the COVID-19 challenge with a portfolio created specifically within the platform of existing technologies having been identified.
12	COVID Pop-up Hub	Austria	The COVID Pop-up Hub, initiated and funded by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK), enables community-based policy making by gathering experience and ideas from various actors within the innovation ecosystem. The core element was a digital discussion platform that was open to experts as well as the public for participation.
13	Tech4COVID19	Portugal	TECH4COVID19 was a national initiative that brought together start-ups and citizens, companies, non-profit organisations and built a network of community volunteers with diverse expertise to address COVID-19-imposed challenges, including support for health professionals and hospital materials (e.g. managing provisions in areas of outbreaks), health and education services (e.g. remote services) and shopping and delivery (e.g. tracking overcrowding)

Table 3. Overview of co-creation initiatives: Co-creation for medical innovation initiatives

No.	Initiative name	Country	Short description
Co-creation for medical innovation initiatives			
14	Fab Helmet	Costa Rica	The Fab Helmet initiative was a collaboration of individuals from a diverse range of backgrounds (medical, legal, prototype design, art, engineering etc.) and diverse sectors (academia as well as public and private institutions in medical and legal sectors) to develop ventilation equipment for the treatment COVID-19 patients.
15	Respira	Costa Rica	The Respira project was led by the University of Costa Rica in collaboration with the pharmaceutical company, Roche, the Central American Pharmaceutical Laboratory Association and a national hospital, which aimed at producing mechanical ventilators needed to treat COVID-19 patients.
16	Exscalate4COV	Transnational	Exscalate4COV is a transnational European private-public sector consortium composed of universities and research institutions that previously collaborated in EU grant funded projects, as well as private companies and not-for-profit-organisations. The initiative was set up to identify and develop drugs to treat COVID-19 infections by leveraging state-of-the-art experimental computing facilities and AI tools.
17	Oxford-AstraZeneca Vaccine	UK	The Oxford-AstraZeneca vaccine against COVID-19 was developed and brought to the market as a result of a co-creation process that brought together the government's vaccine taskforce, InnovateUK, research from the University of Oxford and the pharmaceutical company AstraZeneca.
18	Ventilator Challenge Programme	UK	The Ventilator Challenge Programme was a large consortium established by the UK government to design and produce of ventilators for COVID-19 treatment. The consortium, which was made up of leading UK industrial, technology and engineering companies from across the aerospace, automotive and medical sectors, collaborated to design and produce medical ventilators for the UK health service.
19	Protective Mask Consortium CIIRC RP95-3D	Czech Republic	The research team of the Czech Institution of Informatics, Robotics and Cybernetics, Czech Technical University in Prague (CIIRC CTU) developed the "CIIRC RP95-3D" Protective Mask to address the shortage of protective equipment for professionals and created a university-industry consortium, supported by the government, to prototype, produce and distribute the masks.
20	PRONAII	Mexico	The Proyecto Nacional de Investigación e Incidencia COVID-19 ('National Research and Incidence Project COVID-19' – Pronaii) was a government-funded co-creation initiative designed to build manufacturing capabilities to produce ventilators and respiratory devices for COVID-19 treatment.
21	COVID-19 Moonshot	Transnational	The COVID-19 Moonshot is a non-profit, open-science, global consortium of scientists that aims to develop antiviral drugs against COVID-19 and future viral pandemics that are affordable and can be easily manufactured. The initial phase, co-funded by participating institutions and from crowd-sourced funds, consisted of collaborative efforts to find identify new molecules that could block SARS-CoV-2 (the virus causing COVID-19). The initiative subsequently engaged in further steps needed for drug development.

Table 4. Overview of co-creation initiatives: Co-creation for data-related innovation initiatives

No.	Initiative name	Country	Short description
Co-creation for data-related innovation initiatives			
22	MASC: Digital platform for managing stock and supply of personal protective equipment (PPE)	Estonia	The MASC (Management of Acute Supply During Crises) project established a real-time digital inventory and demand monitoring platform with a distribution tool to manage personal protective equipment (PPE) logistics in Estonia.
23	Base de Datos COVID-19 (Database)	Chile	The Base de Datos COVID-19 (database) is an integrated database of national COVID-19 data at regional and city level, including data on the COVID-19 incidence, the health system, on mobility and on vaccination campaigns. The Ministry of Science, Technology, Knowledge and Innovation led the initiative that was implemented by research teams from eight research institutions in response to the lack of real-time COVID-19 health-related data available in Chile so as to inform policy decision.
24	Apturi COVID-19	Latvia	Initiated by a small group of tech professionals and developers, Apturi COVID-19 developed a mobile contact tracing application (aimed at identifying persons who may have come into contact with an infected person) to manage the population's exposure to COVID-19.
25	Rapid-App	Spain	The Rapid App is an employee movement-tracing app to identify potential exposures to COVID-19 and manage risks of in-person work environments. IT was developed in a collaboration of three Spanish research institutions (Ikerlan, Vicomtech and Tecnalia) and received support of the Basque Government.
26	GRAPH Network	Switzerland	The Global Research and Analyses for Public Health (GRAPH) Network initiative developed a data platform that provides real-time evidence on the evolving situation of the COVID-19 pandemic for countries in Sub-Saharan Africa. The initiative involves data management, visualisations (via a dedicated data platform, which was developed for this purpose) and analyses of country-specific pandemic developments.
27	CORD-19	USA	The COVID-19 Open Research Dataset Challenge (CORD-19) initiative created an open access database of research articles on COVID-19 and developed by a collaboration of universities, government (White House Office of Science and Technology Policy), public sector agencies (National Institutes of Health's National Library of Medicine), research institutions, and the private sector (including Amazon Web Services, Google, Microsoft Research and IBM) as well as academic publishers and philanthropic organisations. The CORD-19 initiative benefited from contributions from the wider innovation ecosystem as AI inputs and expertise to develop CORD-19 was sought under an open challenge.
28	Wastewater Surveillance for COVID-19	Australia	Researchers at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) partnered with the University of Queensland and regional public health authorities, Queensland Health, to investigate whether wastewater surveillance could detect COVID-19 prevalence in a community. The partnership resulted in a wastewater surveillance system across Queensland that involved wastewater catchments covering ~80% of the population.
29	Dutch ICU Data Warehouse	Netherlands	The Dutch ICU Data Warehouse (DDW) developed an electronic health record (EHR) database integrating full-admission data from critically ill COVID-19 patients from multiple hospitals in the Netherlands. The initiative gathered and analysed pseudonymised such data from 25 large hospitals in Netherlands.
30	Corona-Warn-App	Germany	Corona-Warn-App was developed by SAP and Deutsche Telekom subsidiary T-Systems, following a request by the Federal Ministry of Health and with expert advice provided by the Robert Koch Institute (RKI). The app enabled users to trace proximity to other users with confirmed COVID-19 infections, to manage SARS-CoV-2 PCR and rapid antigen tests and to store COVID-19 test and vaccine certificates.

2. Methodology

The analysis provided here required identifying and gathering evidence on 30 COVID-19 co-creation initiatives from 21 countries and 3 international cases, an overview of which is given in Tables 1 to 4.

The initiatives analysed were identified through a variety of sources. Some were identified from the OECD policy database and country contributions to ongoing projects. Delegates of the OECD's Working Party on Innovation and Technology Policy (TIP) also provided support in identifying relevant initiatives, facilitating contacts for interviews and participating in interviews.

To reflect the diversity of COVID-19 initiatives, four types of initiatives were included in the analysis. The first of these four categories, '*umbrella programmes for co-creation projects*', covers large initiatives and institutionalised co-creation initiatives and platforms. The remaining three categories are more granular and are largely differentiated by their thematic project focus and orientation. These categories are '*projects for co-creation network building*', '*projects for co-creation in medical innovation*', and '*projects for co-creation in data-related innovation*'. Table 5 presents an overview of the key characteristics of these categories. The cases are discussed in Section 3. More detailed information on each case can be found in the complementary paper (De Silva et al., 2022[1]).

Importantly, while covering a variety of COVID-19 co-creation initiatives from different countries, the 30 cases identified for this analysis are not representative of all co-creation activities during the pandemic. As a consequence, descriptive statistics are mainly used to explain the nature of the sample rather than to claim representability. Moreover, we focus on shared insights across a large number of these cases and validate those insights with other available evidence, but we do not extrapolate lessons from any single experiences.

To gather the necessary information in a comparable way, case studies were developed based on interviews with initiative leaders. These interviews were conducted from March 2021 to March 2022. The cases followed a template organised across six key areas of co-creation, which are summarised briefly in Table 6 (find the full template in (De Silva et al., 2022[1]), and which reflect the key points of interest for the analysis. For validation, initiative leaders were asked to validate their respective templates and comment on the overall conclusions of the report, including a dedicated workshop entitled "*What can we learn from COVID-19 co-creation initiatives for future collaborations*?" held on 19 October 2021.

Table 5. Categories of initiatives

Type	Description	Case study initiatives
Umbrella programmes for co-creation	These are large programmes, often government-led, that offer funding, expertise, and/or resources to support the ecosystem to co-create. As these programmes are complex, they are often managed by a core team who administers the support via an open call to which several co-creation projects can apply. A key characteristic of these programmes is the combination of top-down and bottom-up approaches: on the one hand, the government, in close collaboration with national research councils, defines broader challenges to be addressed by projects supporting the programmes; on the other hand, the respective projects bring in their individual innovative approaches in developing specific solutions.	1. Canada: Global Innovation Clusters COVID-19 response 2. Canada: Pandemic Response Challenge Programme 3. Chile: Fondo de Investigación Científica (Scientific Research Fund) COVID-19 4. Japan: MEXT/RIKEN programme for COVID-19-related research 5. Türkiye: COVID-19 Türkiye Platform 6. United States: HPC Consortium 7. Italy: ART-ER COVID-19 Project
Projects for co-creation network building	Network building for co-creation projects aim at connecting individuals/organisations to engage in co-creation to solve COVID-19 related challenges. The core task of the initiatives is consequently promoting new connections between industry, research and civil society actors and providing conditions for them to co-create.	8. Belgium: Task Force Flanders All-Digital Initiative (Platform) 9. Transnational: EUvsVirus (Hackathon) 10. Finland: Fast Expert Teams vs COVID-19 (Ad-hoc team formation/digital organising) 11. Italy: COVID-19 portfolio of the Knowledge Share Platform (Patent / technology exchange platform 12. Austria: COVID-19 Pop-Up Hub (Community platform) 13. Portugal: Tech4COVID19 (Ad-hoc team formation)
Projects for co-creation in medical innovation	Collaborative innovation projects aimed at developing medical product innovations to address the COVID-19 pandemic such as vaccines or ventilators. These required combining different skills, resources and production capacities to quickly deliver usable products (such as reducing vaccine discovery times) as well as easing regulatory procedures where possible.	14. Costa Rica: Fab Helmet (Ventilators) 15. Costa Rica: Respira (Ventilators) 16. Transnational: Exscalate4CoV (Drug development) 17. United Kingdom: Oxford-AstraZeneca (Vaccine) 18. United Kingdom: Ventilator Challenge Programme (Ventilators) 19. Czech Republic: Protective Mask Consortium CIIRC RP95-3D (Medical masks) 20. Mexico: PRONAII Solicitud Respuesta (Ventilators) 21. Transnational: COVID-19 Moonshot (Drug development)
Projects for co-creation in data-related innovation	These are collaborations aimed at providing access data and evidence, such as real-time statistics related to COVID-19, as well as research results to support innovation and policy decisions to address the COVID-19 crisis. Access was provided via online platforms and mobile apps, to government, scientists, companies, journalists, and citizens.	22. Estonia: MASC digital platform (Digital platform) 23. Chile: COVID-19 database (Data/information platform) 24. Latvia: Apturi COVID-19 (App) 25. Spain: Rapid-App (App) 26. Switzerland: GRAPH Network (Data platform) 27. United States: CORD-19 (Data/information platform) 28. Netherlands: Dutch ICU Data Warehouse (Database) 29. Australia: Wastewater Surveillance Initiative (Database) 30. Germany: CoronaWarnApp (App)

Table 6. Areas covered in the template used for case study interviews

Sections	Brief overview
1. General information	Description, timeline of key milestones, aims
2. Objectives and contributions of actors	Partners and their objectives, contributions, and role; initiative's engagement with broader society
3. Co-creation outcomes	• Direct and indirect outcomes • Ability to use those outcomes for non-COVID-19 circumstances
4. Success criteria	• Partner selection and management, engagement with broader environment/ecosystem, collaboration mechanisms/models, digital infrastructure, intellectual property, and incentives • The use of the learning about success criteria for future crisis and non-crisis environments
5. Role of government/policy landscape	• The roles of regional, national and cross-national policy for co-creation during COVID-19 • Impacts of these roles on the success of co-creation
6. Lessons for future initiatives	Lessons learned from co-creation during Covid-19 that could be applied to future (co-creation) initiatives during (non-) crisis times

3. Descriptive overview of initiatives

This section provides a descriptive overview of the case studies included in this paper concerning initiating organisations, sources of funding, partners involved and their respective roles, key outputs and the timeframe of projects.

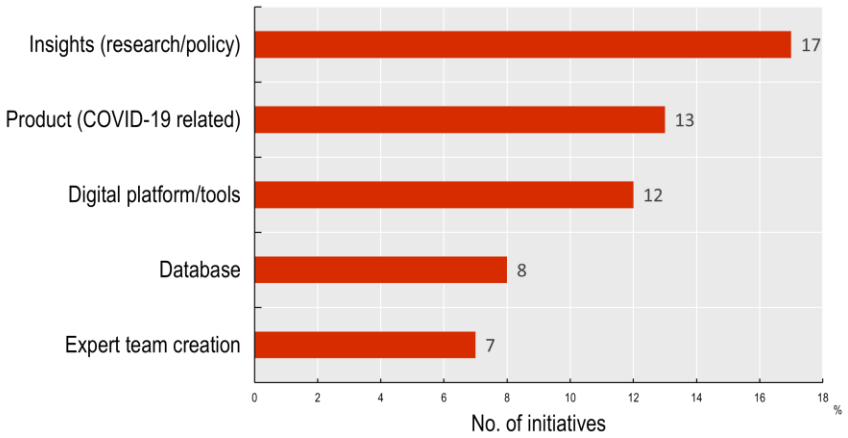
3.1. Key project characteristics

Most of the initiatives were established specifically for COVID-19 in the course of the COVID-19 pandemic in 2020. In some instances, however, existing initiatives were leveraged and refocused towards addressing pandemic challenges. In a number of cases, projects have since concluded for a variety of reasons, including the completion of initiatives' goals, the changing COVID-19 pandemic, as well as initiative-specific factors (funding, new collaborations, etc.).

Interestingly, follow-up activities have been created that directly build on the co-creation initiative, often with a modified agenda focussing on priorities only indirectly related to COVID-19 (e.g. in Canada's Pandemic Response Challenge Program (Case 2), the COVID Pop-up Hub, Austria (Case 12) and the Dutch ICU Data Warehouse (Case 29)), a consequence of the development of the pandemic and the waxing and waning sense of urgency. In many other initiatives, networks have been created and intensified, bearing potential for future use (see section 4.5).

As to the outcomes, more than half of the thirty initiatives (seventeen) produced insights to support research or policy on COVID-19 (Figure 1). Thirteen initiatives developed products related to COVID-19 such as ventilators, drug therapies and vaccines. Thirteen initiatives produced digital platform or tools to address a COVID-19 challenge. Eight of the cases produced databases, mostly in addition to producing also insights, such as the data platform as well as in-depth analyses of country-specific pandemic developments by the Swiss GRAPH Network (Case 26). Another recurrent contribution of eight initiatives was to build experts teams.

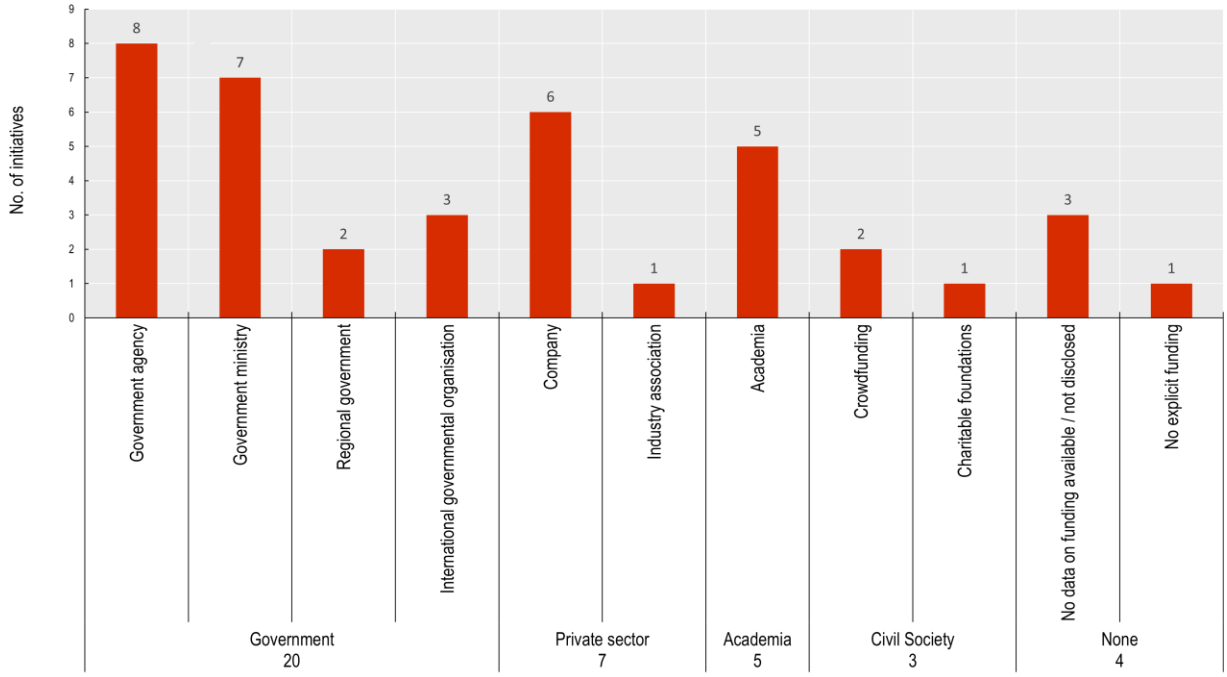
Figure 1. Overview of key outcome types from initiatives in the sample



Note: Initiatives can contribute multiple outputs. Consequently, the total adds up to more than 30.

The primary funders of the co-creation initiatives were government institutions (Figure 2). Twenty initiatives received funding from government, including from ministries, agencies or trans-national government bodies. The private sector provided funding to nine of the thirty cases. Conversely, research institutions or universities provided direct funding in six cases. This, however, does not take into account in-kind contributions – including expertise and infrastructures – to initiatives, and reflects limited funding resources for such projects by those actors. In three cases, non-profit organisations such as foundations as well as donations/crowdfunding from civil society were sources of funding.

Figure 2. Funding sources for COVID-19 co-creation initiatives in the sample

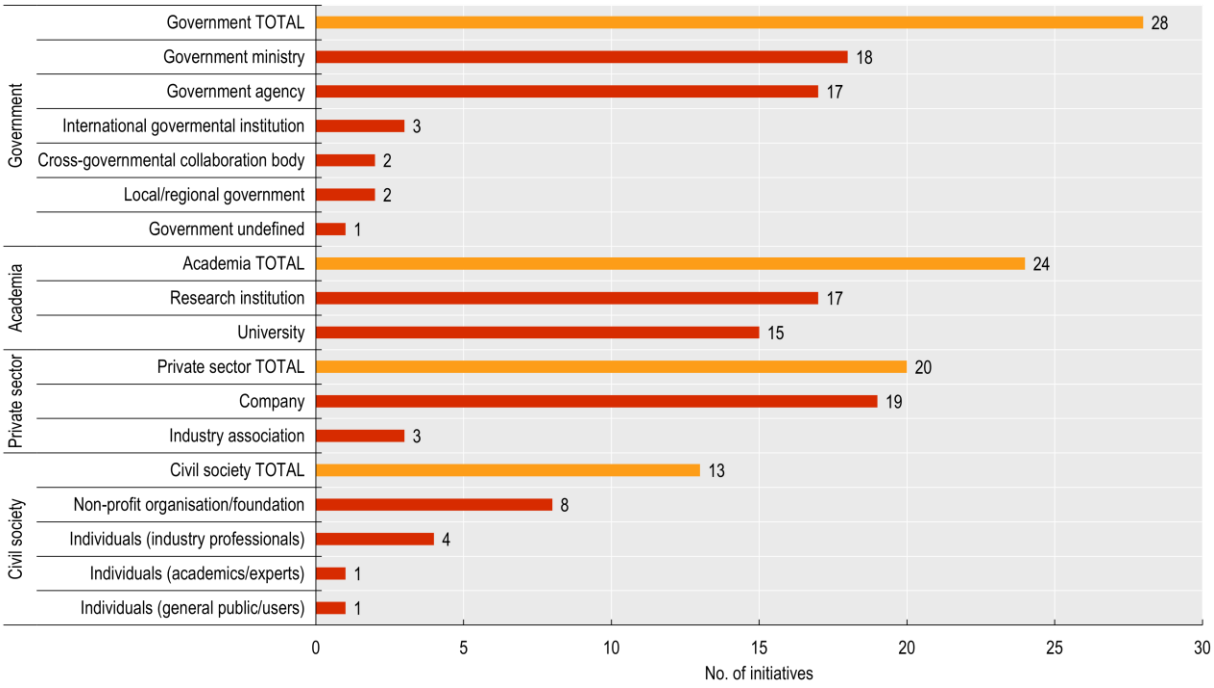


Note: Initiatives can be funded by multiple institutions. Consequently, the total adds up to more than 30.

3.2. Characteristics of co-creation partners

Co-creation partners in the COVID-19 initiatives are from government, academia, private sector and civil society (Figure 3). Government bodies were involved in 28 initiatives, in 24 of the initiatives they also had other functions than the provision of funding. Academia and the private sector were involved in 24 and 20 initiatives respectively. These three groups are the more traditional actors in co-creation. 13 initiatives, however, differed from the norm in that they involved members of civil society – non-profit organisations, industry professionals, experts or academics and members from the general public – who engaged in efforts to help addressing the crisis.

Figure 3. Key partners involved in COVID-19 co-creation initiatives in the sample

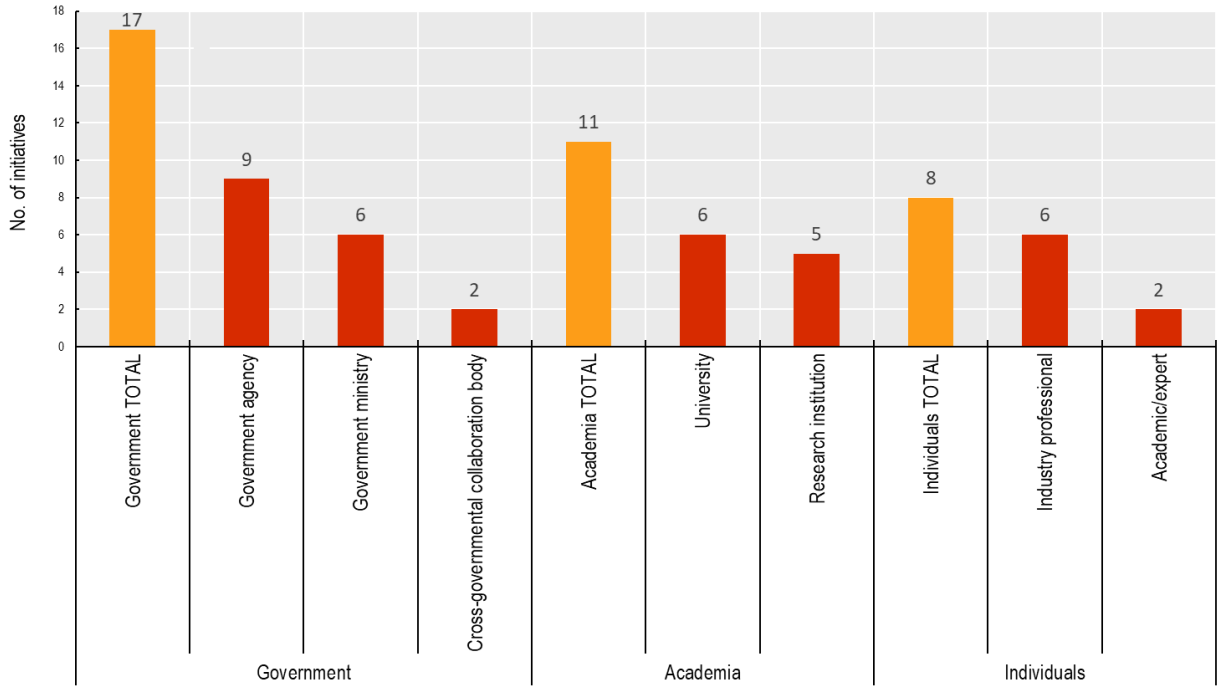


Note: Initiatives can feature in several categories so that the sum across categories is lower than if one was to sum the categories within a category.

The partner starting the projects often plays a key role in defining the co-creation activity by shaping an initiative's core goals and set-up. Across the 30 initiatives, the public sector played a dominant role in initiating co-creation cases (Figure 4). Fifteen initiatives were started by government agencies or ministries (nine and six), and two by cross-governmental collaborative bodies, namely the European Commission Services (EUvsVirus (Case 9)) and a specific COVID-19 taskforce in the UK (Ventilator Challenge Programme (Case 17)). Research institutions and universities were initiators in eleven cases overall. While no company initiated a project, industry professionals, academics and/or experts set up eight of the co-creation initiatives reviewed. The latter are examples of bottom-up co-creation initiatives.

The private sector is an important factor in co-creation as it provides capabilities, capacity and resources, and is critical during the pandemic for turning inventions into products that address COVID-19 challenges (Table 7). Of the 20 initiatives that involved the private sector, most comprise large companies (12) or large companies and SMEs (12Larger companies frequently got engaged to offer the production capacities and resources to develop COVID-19 solutions at scale, such as ventilators, masks, and vaccines. While only four initiatives involved start-ups, they were the initiatives' driving forces. This includes the Tech4COVID19 initiative in Portugal (Case 13) where Startup Portugal, a public-private initiative for designing the national strategy for entrepreneurship, supported a large network of volunteers. In the Latvian Apturi (Case 24) initiative, the founders of a local start-up community started the project and coordinated the development of a mobile contract-tracing app.

Figure 4. Initiating organisations of COVID-19 co-creation initiatives in the sample



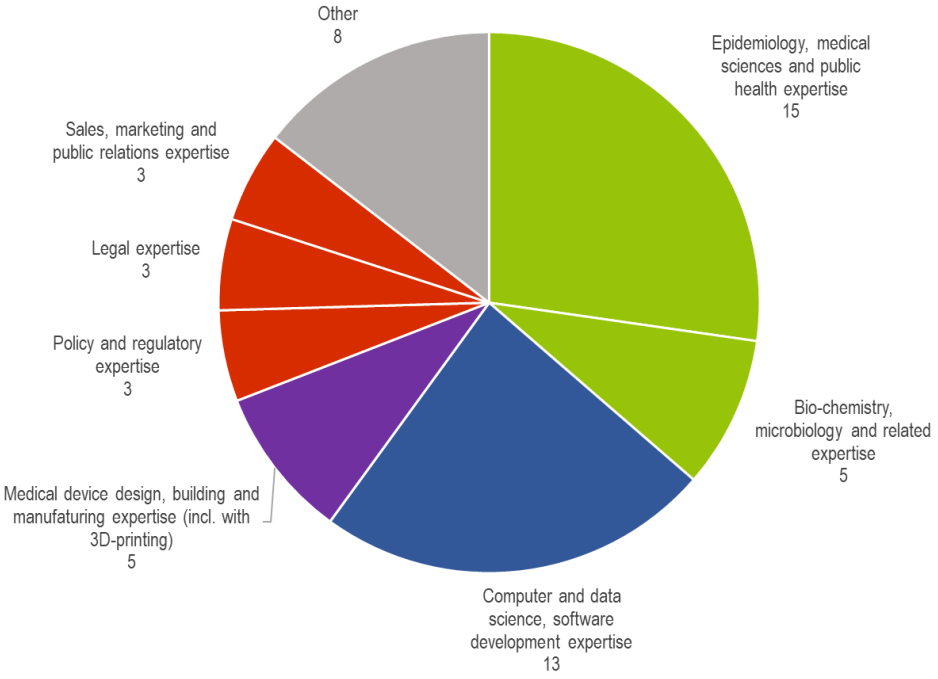
Note: In six cases, projects were initiated by multiple different organisations

Regarding the sectoral composition of the companies involved in the co-creation initiatives reviewed, out of the 20 cases almost a third were technology and digital/software firms. The medical and pharmaceutical industry also had significant involvement in the initiatives, with specific regard to medical/drug innovations against COVID-19. Manufacturing and logistics companies were involved in the production of medical devices, vaccines and other products, and managed tight supply chains and bottlenecks. Service providers, including management, legal and communications firms, also played important roles, such as overseeing questions of intellectual property, contracting technologies and organising data sharing and work processes. An overview of the disciplines of all partners (not only from the private sector), is provided in Figure 5.. For example, in the Czech Protective Mask Consortium (Case 19), scientific and manufacturing expertise in healthcare, 3D printing, data management, moulding, design, sterilisation and disinfection was combined with production capacities from automotive, technology and other industrial companies to produce masks.

Table 7. Private sector partners in the initiatives in the sample

No.	Initiative name	Country	Large companies	SMEs	Entrepreneurs/Startups	(Industry) Associations
1	Innovation Clusters COVID-19 Response	Canada	☑	☑		
2	Pandemic Response Challenge Program (PRCP)	Canada		☑	☑	
3	Fondo de Investigación Científica (Scientific Research Fund) COVID-19	Chile				
4	MEXT/RIKEN programme for COVID-19-related research	Japan				
5	COVID-19 Türkiye Platform	Türkiye		☑		
6	High Performance Computer (HPC) Consortium	USA	☑			
7	ART-ER COVID-19 Project	Italy				
8	Task Force Vlaanderen Helemaal Digitaal ('Flanders All-Digital') initiative	Belgium				☑
9	EUvsVirus	EC	☑	☑	☑	
10	Fast Expert Teams vs COVID-19	Finland		☑		
11	COVID-19 portfolio of the Knowledge Share Platform	Italy				☑
12	Covid Pop-up Hub	Austria		☑	☑	
13	Tech4COVID19	Portugal	☑		☑	
14	Fab Helmet	Costa Rica	☑			
15	Respira	Costa Rica	☑			☑
16	Exscalate4COV	Transnational		☑		
17	Oxford-AstraZeneca Vaccine	UK	☑			
18	Ventilator Challenge Programme	UK	☑	☑		
19	Protective Mask Consortium CIIRC RP95-3D	Czech Republic	☑	☑	☑	
20	PRONAII	Mexico		☑		
21	COVID-19 Moonshot	Transnational		☑	☑	
22	MASC: Digital platform for managing stock and supply of personal protective equipment (PPE)	Estonia				
23	Base de Datos COVID-19 (Database)	Chile				
24	Apturi COVID-19	Latvia	☑	☑	☑	
25	Rapid-App	Spain				☑
26	GRAPH Network	Switzerland				
27	CORD-19	USA	☑			
28	Wastewater Surveillance for COVID-19	Australia				
29	Dutch ICU Data Warehouse	Netherlands		☑		
30	CoronaWarnApp	Germany	☑			
		TOTAL	**12**	**12**	**7**	**4**

Figure 5. Disciplines involved in co-creation initiatives



Note: Numbers denote the number of initiatives in which at least one partner from the respective discipline was involved and collaborated with at least one other partner from another discipline; the category "Other" include sector-specific expertise in the textile/fashion, aerospace and automotive industries as well as expertise in logistics, supply chain design, public procurement and from social sciences.

Unsurprisingly, given the nature of the COVID-19 crisis, epidemiology, medical science and public health expertise was most important across the 30 initiatives. Computer/data science experts were among important partners in the initiatives. Other disciplines, such as legal and regulatory expertise (for initiative's outputs to be allowed to be used, e.g. the Tech4COVID19 initiative in Portugal (Case 13) and MASC in Estonia (Case 22)), public relations/marketing (e.g. to increase the uptake of contact-tracing apps by the public, e.g. MASC (Case 22) or Apturi in Latvia (Case 24)), or social science and policy expertise (where findings of the initiative was aimed to inform policy, e.g. the GRAPH Network in Switzerland (Case 26)).

4. Findings

This section discusses the specificities of the co-creation initiatives for and during COVID-19. It then explores how initiatives were organised and managed, motives of core partners to co-create and engage in new partnerships, the role of the government as well as the transferability of outcomes beyond the pandemic.

4.1. What was special about the co-creation initiatives due to the COVID-19 context?

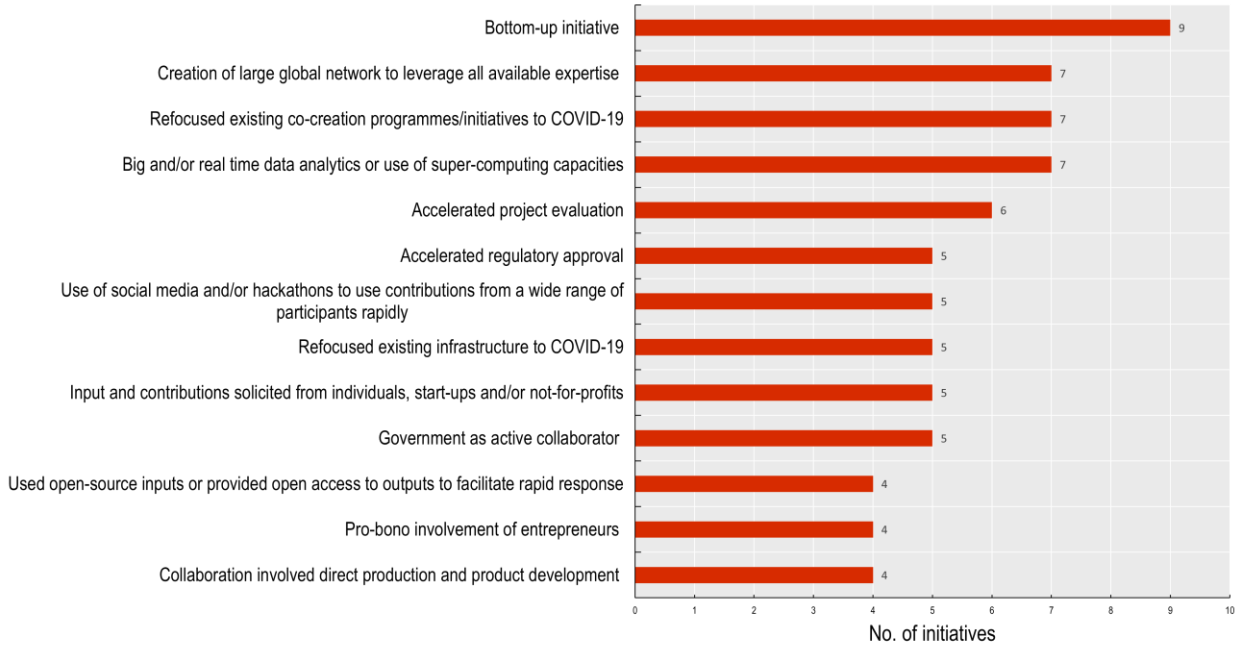
Figure 6 outlines distinctive aspects of these co-creation initiatives, the different approaches to building co-creation partnerships and to operating them. Table 8 also offers and overview of selected dimensions of COVID-19 exceptionality across the co-creation initiatives. Regarding building the initiatives, the following distinctive features stand out:

- Partners collaborating and **growing the initiative from the bottom up,** without a pre-determined plan by an authority, developed several initiatives (9 initiatives); these resulted from the **widespread shared interest in addressing the COVID-19** challenge and **entrepreneurs engaging pro-bono** with new ideas for co-creation (4). For instance, in the Fab Helmet initiative in Costa Rica (Case 14), two designers developed a draft design of a ventilator helmet for patients with COVID-19. They then contacted Fabrication Laboratory (Fab Lab Kä Träre) of Costa Rica's UNED University to develop the prototype, which in turn leveraged its networks to bring together relevant expertise to work on the project and provide resources such as production capacities and capabilities, and exchanging with different groups to work on the design across the country.
- **Active involvement by governments** (5) included tapping into their own **network**, providing access to infrastructures and helping developing implementation plans. For instance, the Flanders Information Agency served as a co-developer and operator of a digital platform that connected software solutions to pandemic-imposed software-related challenges. The agency collaborated with the Interuniversity Microelectronics Centre (IMEC) under the 'Flanders All-Digital' Task Force (Case 8), which was set up by the Flemish government, with support from the Flemish Information and ICT Policy Steering Board at the start of the COVID-19 pandemic.
- **Large global and national networks** (7) and **existing programmes** (7) and **infrastructures** (5) were deployed to tap into the available capacities and expertise to address the global crisis quickly. Leveraging the existing bases of collaboration proved a useful step to quickly advance on collaboration plans, such as the previously established Innovation Clusters in Canada (Case 1), which bring together private companies of all sizes, academic institutions, government and not-for-profit organisations, contributing to COVID-19 co-creation initiatives. Another is the Knowledge Share platform in Italy (Case 11), an online co-creation patent platform, which connects Italian research with companies. In the latter case, showcasing COVID-19-relevant patents on the already-existing infrastructure facilitated a much quicker response.

The characteristics listed below shaped co-creation relationships in terms of their operations. These come on top of the growing use of remote collaboration tools due to social distance requirements that have an impact on all spheres of life and business.

- Despite the social distancing restrictions, **social media** (such as a global Twitter challenge in the transnational COVID Moonshot initiative (Case 21)) and **hackathons** (e.g. in the EUvsVirus (Case 9) initiatives were used as key tools to solicit **contributions from a variety of participants** (5 initiatives), engaging inputs from **professionals** (5), the **open-source** community (4) as well the **public**.
- **Data analysis and advanced digital tools** (7) were used to investigate the virus and develop new ways to combat it, as well as monitor the spread of the pandemic and its associated public health challenges and social developments.
- **Regulatory** (5) and **project evaluation** (6) processes were **streamlined**, often accelerating **product development** (4), given the urgency with which products as solutions to pandemic-specific issues were needed.

Figure 6. Distinctive aspects of COVID-19 co-creation initiatives in the sample



Note: Initiatives can contribute multiple outputs. Consequently, the total adds up to more than 30.

Table 8. Selected elements of COVID-19 exceptionality in the co-creation initiatives

No.	Initiative name	Use of social media and/or hackathons	Accelerated project evaluation and/or approval	Big and/or real time data analytics or use of super-computing capacities	Creation of large global network to leverage all available expertise	Input and contributions from individuals, start-ups, extensive public engagement and/or bottom-up initiatives
1	Innovation Clusters COVID-19 Response		☑			
2	Pandemic Response Challenge Program (PRCP)		☑			
3	Fondo de Investigación Científica (Scientific Research Fund) COVID-19		☑			
4	MEXT/RIKEN programme for COVID-19-related research		☑	☑	☑	
5	COVID-19 Türkiye Platform	☑	☑			
6	High Performance Computer (HPC) Consortium			☑	☑	
7	ART-ER COVID-19 Project		☑			
8	Task Force Vlaanderen Helemaal Digitaal ('Flanders All-Digital')					☑
9	EUvsVirus	☑				☑
10	Fast Expert Teams vs COVID-19					☑
11	COVID-19 portfolio of the Knowledge Share Platform					
12	COVID Pop-up Hub	☑				☑
13	Tech4COVID19				☑	☑
14	Fab Helmet					☑
15	Respira		☑			☑
16	Exscalate4COV				☑	☑
17	Oxford-AstraZeneca Vaccine		☑			
18	Ventilator Challenge Programme		☑			
19	Protective Mask Consortium CIIRC RP95-3D		☑			
20	PRONAII		☑			
21	COVID-19 Moonshot	☑			☑	☑
22	MASC: Digital platform for managing stock and supply of personal protective equipment					☑
23	Base de Datos COVID-19 (Database)			☑		
24	Apturi COVID-19					☑
25	Rapid-App					
26	GRAPH Network			☑	☑	
27	CORD-19	☑			☑	
28	Wastewater Surveillance for COVID-19			☑	☑	
29	Dutch ICU Data Warehouse			☑		☑
30	Corona-Warn-App					☑

4.2. What factors enabled the quick set-up of new co-creation initiatives?

Strong incentives stimulated quick mobilisation in co-creation projects

COVID-19 co-creation initiatives benefited from strong engagement from co-creation partners who contributed resources including funding, time, staff, expertise, capacities, infrastructure and technology. This urgent purpose led to a common prioritisation of COVID-19 activities among all collaborators (even if other activities were slowed due to having lower priority). Providing social value was an important driver for many initiatives. In many cases, people volunteered time that was available due to the precautionary distancing measures and restrictions on many activities beyond traditional working hours. This is not to say that other strategic objectives did not also play important roles for actors to engage. Aside from financial returns, co-creation partners benefited in substantive peer learnings from leading expertise, especially in the initiatives with widespread engagement of researchers all over the worlds, for instance the Exscalate4CoV (Case 16) or COVID Moonshot (Case 21) initiatives.

The incentive to collaborate was particularly strong across several initiatives because of the need to combine medical product development and production capabilities and infrastructures to reach objectives. This includes the need for medical product development and production competencies. For instance, the capacities of the Fabrication Laboratory was essential to develop a ventilator prototype in the Fab Helmet initiative in Costa Rica (case 14). The expertise in clinical research procedure design of a large pharmaceutical company in Costa Rica's Respira initiative (Case 15) is another example. The COVID-19 context required those direct connections with capabilities and infrastructure to move quickly from idea to product, as products for immediate use were needed.

Another factor motivating strong collaboration across several initiatives was the need for domain experts to access software applications and supercomputing technologies, infrastructures and capacities. For instance, the transnational Exscalate4CoV (Case 16) initiative relied on access to a proprietary machine-learning solution from a private company to analyse molecules with potential to be used in COVID-19 treatment. Collaboration between health staff and software developers was also needed to create and integrate patient data mechanism in the Dutch ICU Data Warehouse initiative (Case 29). High-powered supercomputing technologies and infrastructure were pivotal in the Japanese MEXT/RIKEN (Case 4) and US HPC Consortium (Case 6) initiatives as both leveraged those technologies to accelerate research into COVID-19 solutions.

Co-creation projects benefited from existing networks, infrastructures and other STI assets

Leveraging existing networks, knowledge, technologies, infrastructure, and policy programmes/structures was a widely adopted approach to quickly capitalise on diverse innovation capacities. Co-creation teams used innovative ways to leverage existing strengths, offering key insights into the possibilities to engage in co-creation for rapid responses even during non-crisis circumstances. Using such existing assets to respond to unforeseen challenges highlights the importance of building resilience for future shocks.

Co-creation initiatives relied on a range of STI networks, consisting of such diverse actors as government ministries and agencies, universities and research institutions, private sector companies, not-for-profit organisations as well as a range of individuals (industry professionals, academics/experts and the general public/users). Partner selection often relied on previous engagement or existing relationships. Such reliance on existing networks varied in scale and scope, from connections between large companies in the same industry

and transnational academic or institutionalised networks to contacts on an individual level. Co-creation of medical innovation has relied on substantially larger existing networks due to the complexity of medical discovery and manufacturing processes involved in developing these innovations, such as in the COVID-19 Türkiye Platform (Case 5), the transnational Exscalate4CoV (Case 16) and the UK's Oxford-AstraZeneca (Case 17) initiatives. Government programmes tended to rely on previously formed clusters or ecosystems.

Other initiatives, though not as complex as medical innovation, also relied on existing institutional (e.g. Canada's Global Innovation Clusters (Case 1) and MEXT/RIKEN programme in Japan (Case 4)) or personal networks extended connections typically centred on the core team. Most of the bottom-up initiatives, often formed by individuals, relied strongly on the personal networks of the core team and leader, (e.g. that of Professor Blomqvist to leading experts for the Fast Expert Teams (Case 10) initiative in Finland, or the existing relationships between researchers across Africa and the University of Geneva as well as between the WHO Regional Office for Africa and government officials in Africa in the GRAPH Network, Switzerland (Case 26), or the personal relations of the founders of the MASC (Case 22) initiative to the Estonian government). Since the contacts of many institutions/individuals were combined, the initiatives developed new networks, combining their respective expertise to produce outputs.

Most government programmes provided funding to support co-creation projects under existing collaboration models, accelerating the development of research outcomes to address current challenges. In such instances, resources and infrastructure of the existing programmes and their networks were urgently leveraged to respond to the pandemic, resulting in quick responses, particularly relying on strong interactions with research institutions and industry, such as in Canada's Global Innovation Clusters (Case 1), the COVID-19 Türkiye Platform (Case 5) or ART-ER (Case 7) programmes. Some initiatives have used existing collaboration models – such as hackathons and platforms – to create task-oriented, temporary teams, connecting a wide range of experts to resolve specific challenges.

The rapid response to co-developing solutions was enabled to a large extent by the existing technologies/infrastructure, much of which was developed prior to the pandemic and was often funded by the respective governments or the private sector. This was mainly evident in medical discoveries and digital platforms. Existing technologies were integrated (e.g. in the Exscalate4CoV (Case 16) or CORD-19 (Case 27) initiatives), and/or adapted to a different use (e.g. automotive and aerospace design and production facilities in the Ventilator Challenge Programme (Case 17) or the patent-sharing database and matching system of the Knowledge Share Platform (Case 11)).

COVID-19 co-creation initiatives also engaged new partners and created new partnerships

Emphasis was set on expanding co-creation networks and building networks to widen cross-disciplinary contributions. This included combining data science and medical science expertise as was the case of the transnational Exscalate4Cov (Case 16).

Digital platforms, virtual collaboration and global calls for participation in collaborative projects taking place entirely online allowed expanding the participation and added to this – hackathons such as the 'Coronathon Türkiye' as part of the COVID-19 Türkiye Platform (Case 5) in particularly drew many new participants; the EUvsVirus (Case 9) brought together 2 235 individuals in 120 teams in a three-day hackathon event, while the COVID-19 Moonshot (Case 21) started via a Twitter-based hackathon inviting

researchers/virologists to submit molecules, donations and assays (testing), resulting in over 4 000 submissions from fore than 150 participants, spanning a range of expertise.

4.3. How did co-creation practices adapt to the context of crisis in order to speed up solutions?

Agile management practices enabled the smooth operation of co-creation projects

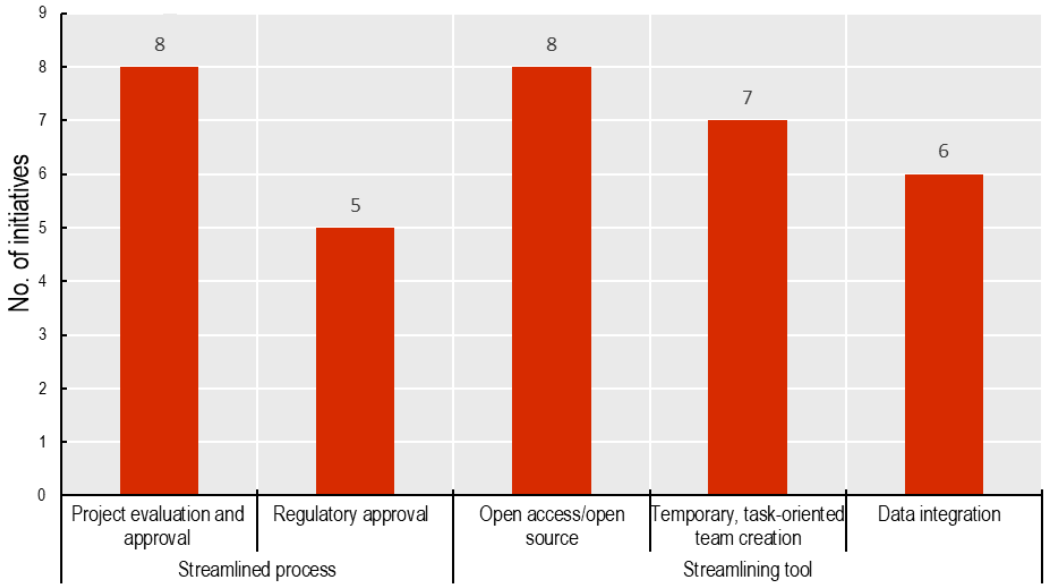
The COVID-19 context required agile management practices to produce fast results, including:

- **Pursuing various pathways simultaneously:** The numerous attempts targeted at creating COVID-19 vaccinations serves as an example of the benefits from pursuing different approaches across initiatives. The experimentation with multiple approaches also contributed to the quick development of effective vaccines.
- **Using interim evaluations of progress and adjusting adopted pathways quickly.** The latter was crucial for redirecting resources to additional options, if necessary. Being able to adjust activities also required making quick decisions to scale-up production of essential medical supplies and equipment, wind-down operations with declining demand, swiftly stop projects that were not delivering, and quickly find alternative sources of funding in cases where government funding was not available.
- **Effective communication**. Effective digital communication to coordinate contributions from different partners was important to ensure initiatives' agility. This was in many cases a very time-consuming part of the initiative with possible options for more efficiency in organising this communication.

Co-creation initiatives adopted processes and tools to optimise their efficiency and effectiveness

Much emphasis was set on optimising efficiency and effectiveness to produce urgently needed results. This included streamlining evaluation and regulatory approval processes as well as adopting tools to support streamlining. Data integration, open access/open source and intellectual property arrangements were all important in optimising efficiency (see Figure 7).

Figure 7. Types of streamlined processes and streamlining tools in the sample



Note: Initiatives can have relied on several streamlined processes and streamlining tools.

In order to find quick solutions to the COVID-19 pandemic, regulatory approval processes—which are crucial to medical innovation—were given a lot of attention (Figure 7). Regarding the UK initiative leading to the COVID-19 Oxford-AstraZeneca vaccine (Case 17), a vaccine taskforce, which consisted of scientific, regulatory and government personnel was created. The objective of the group was to identify how regulatory processes could be adjusted for the quicker delivery of vaccines without compromising essential security checks. In the Respira initiative in Costa Rica (Case 15), a university, a pharmaceutical company, an industry association and a hospital collaborated to locally produce medical ventilators. Since prior to the pandemic Costa Rica imported ventilators, efficient regulatory conditions to approve the new ventilators had to be established.

Project evaluation and approval processes for funding support were also accelerated with the introduction of fast-track application processes. This included expedited funding disbursement and lower administrative requirements. An example is the *Fondo de Investigación Científica* (Case 3), in which a large number of external evaluators was mobilised to review the high volume of project proposals. Staff were reallocated within the Chilean National Agency for Research and Development to process the fast-tracking and evaluation of COVID-19 projects. Funding calls focused on the goal of the respective proposals, but relaxed some requirements such as having co-sponsoring or restrictions on how public funding could be spent. The Technology Agency of the Czech Republic, for instance, gave co-creation partners permission to re-purpose funding they had received for other projects to support applied research and innovation for the Protective Mask Consortium (Case 19) initiative.

Figure 7 outlines the several tools that were adopted to streamline processes. These include providing open access to input and outputs (8 cases), data integration (6 cases), and the creation of temporary task-oriented teams (7 cases, discussed in the section on quick collaborations below).

Open access to the inputs and outputs of initiatives served to enhance the participation of a wide array of experts, and to facilitate rapid progress and diffusion. For example, in the Fab Helmet (Case 14) initiative from Costa Rica, the open-source community from various 'fab labs' (fabrication laboratories, i.e. small-scale workshop offering (personal) digital fabrication) across the globe supported the initiative. In the Apturi (Case 24) initiative in Latvia as well as the CoronaWarnApp (Case 30) in Germany, the code of the respective app developed was made open-source to facilitate updates and improvements to the software in the future. In the CORD-19 (Case 27) initiative from the United States, open access to research data and publications in journals, provided by publishers, was key for the initiative to reach its objective of providing to the research community with information on the latest findings relevant to COVID-19.

Moreover, data integration was essential for developing initiatives that had an important digital component, such as the contact-tracing apps (Apturi (Case 24) and Rapid-App (Case 25)), digital supply-tracking platforms (MASC (Case 22)) and other data platforms to gather, store and disseminate relevant COVID-19 statistics (*Base de Datos* COVID-19 (Case 23)) and GRAPH Network (Case 26), the latest research literature (CORD-19 (Case 27), epidemiological data on the COVID-19 incidence (Wastewater Surveillance (Case 28)) and COVID-19 patient data (Dutch ICU Data Warehouse (Case 29)).

Finally, the COVID-19 experience also illustrated that quick uptake of innovations requires user engagement. This was the case for vaccine adoption. Raising awareness among the population was also essential for the Latvian initiative Apturi (Case 24) and the German CoronaWarnApp (Case 30). These initiatives developed mobile contact tracing applications to identify people who may have come into contact with an infected person and to manage the population's exposure to COVID-19. Raising user uptake also applied to the platforms that were developed. The Swiss GRAPH Network (Case 26), for example, developed training modules to build capabilities of data users and leverage the data provided by the network to inform policy.

Multi-disciplinary teams were best prepared to generate impactful solutions

The complexity of the pandemic-imposed challenges meant that solutions depended on combining a diverse range of expertise, technologies, and infrastructure from different disciplines in order to generate solutions. Given the nature of the pandemic, combining expertise from a diverse team of collaborators or pooling technologies from different disciplines often involved collaboration between medical sciences (understanding COVID-19 or the epidemiological needs of potential solutions) and diverse other fields, as illustrated in Figure 5 above.

Using their production/manufacturing, logistics and design facilities, the initiatives focussing on manufacturing end products built connections between those with the conceptual idea and the material and component suppliers from different sectors. Finding collaborators for multidisciplinary cooperation was often done by tapping into government networks, but also through social media or by monitoring the supply chain, as was the case in the MASC initiative from Estonia (Case 22), which developed a digital platform for managing stock and supply of personal protective equipment (PPE). The Protective Mask Consortium (Case 19) initiative in the Czech Republic is one example of a new supply chain created by linking previously decentralized production facilities. Another example is the Ventilator Challenge Programme (Case 18) in the United Kingdom, which involved partners from the automotive and aviation industries supporting the production of medical ventilators.

Quick collaborations were experimented by leveraging digital opportunities

Several initiatives relied on quick collaborations to produce results. Seven initiatives were based on building temporary, task-oriented teams, such as the EUvsVirus (Case 9), which brought together 2 235 individuals in 120 teams in a three-day hackathon event. In the Finnish Fast Expert Teams (Case 10), expert teams worked together through virtual collaboration platforms producing solutions for COVID-19 challenges in a matter of six weeks. While the Portuguese Tech4COVID19 (Case 13) initiative supported 5 360 volunteers developing 72 projects in five months.

Many collaborations operated fully digitally as social distancing and travelling restrictions only offered this mode of operation. An example is the Austrian COVID Pop-up Hub (Case 12), which functioned as a temporary think tank through a virtual discussion platform. The COVID Pop-up Hub engaged the general public in policy development processes and facilitated exchanges with experts on COVID-19-related topics (Digital Health, Distancing, Economic Buffers and State Intervention). The Fast Expert Teams vs COVID-19 initiative from Finland also formed a temporary digital community and temporary expert teams.

Digital tools were also used in other ways, in the COVID Moonshot project, which aimed to develop antiviral drugs against COVID-19 by identifying new molecules that could block SARS-CoV-2, three scientists organised a hackathon inviting researchers/virologists to submit molecules, donations and assays (testing) via the social media platform Twitter, resulting in over 4 000 submissions. The CORD-19 initiative in the United States solicited contributions and expertise through a challenge that was posted on Google's Kaggle AI, an online machine-learning platform where innovation competitions are posted, and teams can win prizes for developing and submitting innovative solutions.

Hackathons proved particularly effective to draw attention and participation from a wider community, and to build new networks. They were used by the COVID-19 Türkiye Platform (Case 5), EUvsVirus (Case 9) and COVID Moonshot (Case 21) initiatives. The EUvsVirus initiative (Case 9), for example, brought together collaborators from across the EU, from both the private and public sector, civil society, and academia to solicit ideas and quickly identify solutions to address overarching COVID-19 challenges. The 120 teams of winners of the hackathon event (selected from 2 164 projects) then went on to attend a matchathon online event aimed at scaling up co-creation solutions by matching winning project teams with industry partners and investors to progress the innovative solutions into production.

4.4. What role did governments play in co-creation during the COVID-19 crisis?

Governments engaged in twenty-eight of the thirty co-creation initiatives reviewed in a variety of ways. This strong engagement – which also involved creating the initiative in 17 cases - is unsurprising, since governments led national responses to the COVID-19 pandemic. Governments' key roles involved building networks and negotiating terms among partners (18 initiatives), providing funding (20 initiatives), collaborating directly in the co-creation activity (16 initiatives) and legitimising products or co-creation activities (Figure 8). In most of these initiatives the government fulfilled more than one of these roles and often engaged beyond providing financial support.

Active involvement as network builder and negotiator consisted in governments tapping into their networks to link different actors. As a negotiator and network builder, the government used its unique position to leverage its connections with both research and industry and to connect potential co-creation partners with expertise in different science and technology fields and sectors. In two initiatives in the United States (HPC Consortium

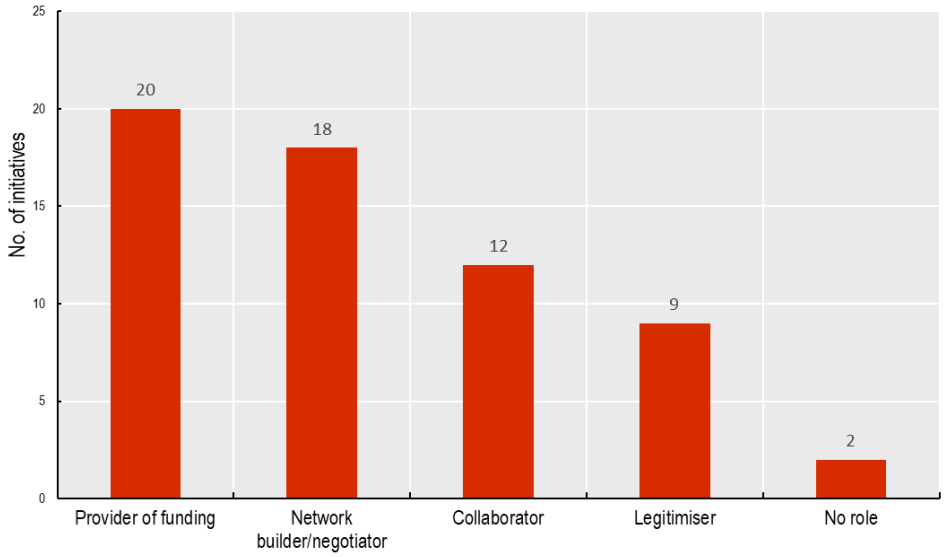
(Case 6) and CORD-19 (Case 27), the White House Office of Science and Technology Policy connected public research institutions and universities with private companies to participate on COVID-19research-driven projects. In the CORD-19 initiative, the government negotiated with publishers to provide open access to the scientific literature on COVID-19. In the GRAPH Network project, which was initiated by the University of Geneva in Switzerland, the World Health Organisation's Regional Office for Africa connected researchers of the network with governmental officials in order to obtain access to relevant national data.

Regarding the funding of co-creation projects, the traditional function of the government was reorganised, leading to greater involvement. In order to respond quickly to the COVID-19 crises' changing circumstances, agility was crucial. For this reason, after funding decisions were approved, government institutions became considerably more involved in programmes to consult with recipients on progress and adapt in line with needs. An example of an evolving programme was the *Fondo de Investigación Científica* in Chile (Case 3) which initially funded 63 projects in July 2020 through the "Quick Access COVID fund", but subsequently disbursed funding to additional 12 projects in December 2020. While the initial projects related to the COVID-19 disease, subsequent projects also addressed the social effects of the pandemic-imposed restrictions, such as developing teaching modules at distance.

Governments also collaborated by co-steering in order to better meet requirements in continuously changing environments. This was the case in Japan's MEXT/RIKEN programme (Case 3) to use supercomputing power for research on COVID-19, in which the Ministry selected themes under which researchers could apply with their projects to use the supercomputer. In the Austrian COVID-19 Pop-up Hub initiative (Case 12), the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology co-developed the themes (Digital Health, Distancing, Economic Buffers and State Intervention) for the public virtual discussion and participatory policy idea development taking place via the Hub.

The government also provided legitimacy to several projects by using the data or outputs of the initiatives. For example, the MASC tracking platform (Case 22), a real-time digital inventory and demand monitoring platform with a distribution tool to manage personal protective equipment (PPE) logistics, was endorsed by the Estonian government and consequently used by the Health Board, the Ministry of Social Affairs, the Ministry of Finance, and about 300 other public sector agencies in Estonia. In Costa Rica, the government issued certification for ventilators in the Fab Helmets (Case 14) initiative. In Latvia and Germany, the government actively campaigned for the use of respective contract-tracing apps (Apturi, Case 24; CoronaWarnApp, Case 30).

Figure 8. Different roles played by governments in the sample



Note: Several government roles can apply to any one initiative. Consequently, the sum of the different roles is larger than the number of initiatives. The provider of funding category includes funding provided by government ministries (7 cases), government agencies (8 cases), regional governments (2 cases) and an international governmental institution, namely the EU, the WHO and embassies (3 cases).

In conclusion, in many initiatives, the government fulfilled other roles to providing funding, a change in the government's usual more passive roles in co-creation. This is unsurprising as governments led the COVID-19 crisis responses. Yet, it provides for an interesting demonstration of the diverse roles government can play. This may in particular be of importance when it comes to addressing the climate crisis.

4.5. What were the key outcomes of the COVID-19 initiatives for the future?

The thirty co-creation initiatives explored in this study contributed solutions to deal with the pandemic and its socioeconomic consequences. These included insights to support research or policy on COVID-19; products related to COVID-19 such as ventilators, drug therapies and vaccines; digital platforms or tools to address COVID-19 challenges; and new databases. Several initiatives also built experts teams (see Figure 6 above for details).

In addition to those critical direct contributions, co-creation during the pandemic also strengthened capacities and generated knowledge that will be highly valuable for the future:

- **Better knowledge and capacities to deal with SARS-CoV-2 and possibly related viruses.** This comprises new knowledge on drugs and vaccines to deal with the SARS-CoV-2 virus and on the technologies used to develop drugs and vaccines, as well as to investigate the nature of the virus SARS-CoV-2. An example is the use of machine learning for molecule analysis (Exscalate4CoV (Case 16)). It also includes capacities to quickly develop products that proved critical in dealing with the virus but were not available in sufficient quantities. For example, the Czech Protective Mask Consortium (Case 19) initiative produced masks that were quickly prototyped and then produced using 3D printing.
- **Transferable skills and know-how for future innovation**. The experience of engaging in diverse multi-disciplinary activities resulted in participating partners

acquiring skills and know-how. This includes, for instance, skills acquired by domain experts in medical sciences and data scientists from applying machine learning techniques and supercomputing capacities to COVID-19 medical challenges. Other relevant skills for future innovations were gained by the researchers, entrepreneurs and manufacturers from working together on manufacturing products as was the case of ventilators and medical masks (e.g. Fab Helmet in Costa Rica (Case 14)). Moreover, important transferable skills and know-how were gained by researchers, public officials and citizens from the experiences that involved gathering and exploiting real-time data of different types (e.g. infection and mobility data). In addition, lessons from operating co-creation initiatives during the crisis may benefit the public sector by improving agility of processes (e.g. fast-track application processes, streamlined regulatory processes). Experiences in operating new instruments that were less common in the past (e.g. hackathons, prizes) can also help enhance policy making.

- **Knowledge about how to operate co-creation initiatives in an uncertain and quickly changing context.** Lessons learned from experience with what worked and what did not work so well during the pandemic can help inform future co-creation initiatives. This includes experience on i) how to deal with co-creation across disciplines that use very different "languages"; ii) how to source inputs from diverse actors, including civil society; iii) how to pool existing infrastructures and resources to increase joint capacities; iv) how to coordinate efforts using digital tools; v) how to communicate most efficiently and vi) how to deal with unexpected challenges that come up throughout co-creation processes.
- **New networks and connections are valuable for innovation going forward.** Connections between industry and public researchers, or between data scientists and government institutions, may lead to new ways of thinking about joint collaborations and lead to the creation of new initiatives.
- **Software, platforms and data tools for wider application.** The software developed throughout the period (e.g. apps, data platforms) may also be used for other purposes in the future. For instance, the data processing and integration mechanism of the Dutch ICU Data Warehouse initiative (Case 28) offers the potential to improve quality of care and patient outcomes. CORD-19 initiative / tracing apps are an example of new tool
- **Widespread experience in working with new data- and digital-intensive tools.** Working at distance obliged all to work with digital tools for meetings. In addition, there was collaboration by pooling data and computing capacities, work with large platforms and operating with new players. The large scale databases of real-time data and other digital tools developed to fight the COVID-19 pandemic (e.g. data sharing platforms, matching platforms, apps, etc.) were put in place at an unprecedented speed. The CORD-19 initiative in the United States (Case 27) is a case in point. Researchers and also the public administration and citizens became much more familiar with the use (and challenges of using) real-time data and with digital platforms and apps. The experience by the public administration and citizens offers new opportunities for the wider use of digital tools to enhance policy making.

Several initiatives have explicitly adopted plans beyond COVID-19. Some initiatives set goals beyond the immediate needs of the pandemic from the onset. This included supporting digital patient care or contributing to the economic recovery. Others started to repurpose infrastructure developed to serve the pandemic. In other cases, co-creation

partners have capitalised on the networks and capabilities created during the pandemic to explore new commercial opportunities.

5. Policy lessons

This section discusses the main policy lessons that emerge from the thirty co-creation initiatives.

(1) Purpose is the strongest driver of co-creation; incentives to support co-creation should go beyond facilitating access to funding

Contributing to a common shared goal and a worthy cause (i.e. providing quick solutions to the health and socioeconomic crisis) was the most important driver of engagement in co-creation activities during the COVID-19 pandemic. Participating in projects with long-term strategic significance was another often alluded motive for engagement.

While funding remains an important mechanism to stimulate (and enable) co-creation, policies would benefit from capitalising on these incentives in order to stimulate co-creation to address a wide range of pressing societal challenges, such as climate change, food supply chain disruptions and the energy transition. Co-creation programmes that are purpose-driven and pursue missions that serve societal goals, go in this direction.

In order to design new purpose-driven co-creation programmes, or increase the directionality of existing programmes, it is important to first develop overarching STI plans and strategies that clearly define and prioritise a range of strategic goals or missions. Such strategies can increase the visibility of specific causes and attract a wider pool of contributors. Identifying mechanisms to recognise outstanding contributions towards achieving those strategic objectives would also be critical to increase incentives to engage.

(2) Crisis-specific programmes may not be needed out of the crisis, but networks and infrastructures should be strengthened during "normal" times

The experience of the COVID-19 crisis proved that STI actors are able to quickly mobilise their capacities and resources in order to contribute solutions to unexpected and highly disruptive events. Actors that were already part of diverse networks, however, were much more agile in setting up new co-creation projects to respond to pressing needs. Such pre-existing networks implied that actors already had trust and a good understanding of each other's strengths (and possibly weaknesses), facilitating the task of quickly creating new teams and setting up new projects.

In turn, quick solutions developed to address the COVID-19 challenges often built on existing technologies and infrastructures, developed prior to the pandemic and often partly funded by governments. This was the case of many medical discoveries and digital platforms. Opportunities for open engagement in innovation allowed enhancing the use of existing technologies and expertise at scale.

STI policies can help build more resilient systems for the future by creating incentives to strengthen and expand networks during "normal times", and by continuing to support investments in key infrastructures and technologies. Particular focus should be placed on the creation and expansion of networks that go beyond disciplinary and sectoral boundaries and engage a wide variety of actors from academia, industry, government and civil society. Such networks are especially attractive and enriching for participants; indeed, one of the main incentives for co-creation identified in the COVID-19 case studies was the opportunity to work alongside leading experts in technology areas and research fields that were beyond one's core area of expertise.

Investments in technologies and infrastructures, on the other hand, should be channelled in priority towards those considered more strategic given the existing assets and capacities of the domestic economy, as well as those that can have a diversity of applications across the economy – also known as key enabling technologies, such as robotics, additive manufacturing or high-performance computing.

(3) There is room for building new collaborations between researchers and producers to accelerate innovation during "normal" times

The COVID-19 pandemic exemplified the potential for quickly turning ideas into product innovations. The urgent need for end-product solutions (e.g. ventilators, rapid testing kits, etc.) prompted the spontaneous engagement among diverse actors (academics, manufacturers) with capacities that proved highly complementary and interdependent. Such capacities range from scientific knowledge and technical skills, to manufacturing capacities to prototype, test and manufacture new products, and logistical infrastructures to quickly distribute them at scale. Where previous links already existed, collaborations proved more agile and effective, especially during the set-up phase. Where they did not, problems to scale up solutions were often encountered.

STI policies aimed at creating new and strengthening existing partnerships between researchers and producers would enable more agile responses in the advent of a future crisis, and in turn help accelerate innovation today. Efforts at local and regional level to increase the visibility of the existing knowledge, technological and manufacturing capacities of universities, public research centres and industry, respectively, could facilitate the identification of potential collaboration partners, create new networks and reinforce existing ones. The densification of such collaboration networks would enhance systems' resilience to future shocks.

(4) Policy should support the wider development and use of digital tools for co-creation.

With national lockdowns and other measures heavily restricting the mobility of people, the COVID-19 crisis offered a real-world and large scale experiment on the potential of digital tools for collaborative research and innovation. While in the past the potential for success of fully virtual collaborations was very much put into question, the quick and expanded adoption of virtual modes of collaboration and the outputs they provided during the pandemic confirms that geographic co-location is no longer a *sine qua non* condition to engage in meaningful partnerships. Online platforms for collaboration and data sharing were critical in building solutions – among others, they enabled the organisation of hackathons and open challenges to source solutions from a wide diversity of innovators, including non-traditional ones. Research data sharing enabled the simultaneous exploitation of existing data among different actors using different techniques. Social media (e.g. Twitter, Facebook) and virtual communication tools (e.g. Zoom) became main channels of communication and exchange for research and innovation purposes.

The more intensive use of digital infrastructures for collaboration purposes has a number of policy implications. First, these technologies reduce the cost of interaction among partners that are not physically co-located, and therefore programmes supporting co-creation can expand their scope – for example to include inter-regional and international collaborations – without incurring in important cost increases. Second, the budget structure of co-creation projects significantly change in this context, with higher allocations to cover costs linked to digital infrastructure. Third, digital security provisions become of

paramount importance when setting up new projects, in particular to prevent data breaches (especially when sensitive data is involved) and cyber security attacks.

Governments should continue to devote efforts to develop regulations and policies to ensure that the benefits of data access and sharing are reaped, while the associated risks are managed and reduced to a socially acceptable level. The OECD Recommendation on Enhancing Access to and Sharing of Data (OECD, 2021[2]), and the OECD Recommendation on Access to Research Data from Public Funding (OECD, 2021[3]) provide guiding principles in this regard.

Mobilising computing resources and expertise quickly to address future crises is also important in this regard. The blueprint for a National Strategic Computing Reserve (NSCR), i.e. a coalition of experts and resource providers that can be mobilised quickly to provide critical computational resources in times of national or international urgent need, emerged from the experience of the High-Performance Computing (HPC) Consortium created during the COVID-19 in the United States (Case 6) to address this issue.

(5) New approaches should be leveraged more to tap into the large pool of diverse and readily available capacities in the economy

The crisis has also demonstrated the wide diversity of actors that are willing to contribute their time, expertise and resources to co-creation projects aimed at tackling a specific societal challenge. These comprise a broader group of individuals than those traditionally targeted by research and innovation programmes. Tapping into this pool of expertise through the use of instruments such as open innovation challenges, prizes and hackathons offers opportunities to increase the diversity in research and innovation teams. Such diversity can enhance creativity and spur more novel and disruptive thinking, which are critical to contribute to transitions towards more sustainable, resilient and inclusive systems.

Engaging those diverse groups in the longer term and for a broader range of purposes is a key challenge ahead for policy makers. Experimentation with new models for sourcing contributions, such as hackathons and prizes, and the active use of social media to communicate the launch and features of new programmes could stimulate the engagement of a broader pool of contributors, including individual innovators and entrepreneurs. It is also essential to revise and modernise the processes related to open call applications in order to address any possible barriers preventing the participation of non-traditional actors.

(6) Governments' involvement in co-creation activities as network builders can help speed up solutions; enhanced agility in their operations should be encouraged

The public sector played a variety of roles in co-creation activities during the COVID-19 crisis, including that of network builder and negotiator, legitimiser/endorser and collaborator. In particular, governments' linkages with both research and industry put them in a unique position for rapidly connecting potential co-creation partners, with expertise in different science and technology fields and sectors.

Governments have also demonstrated their capacity to be very agile in times of emergency. A range of approaches were used to stimulate collaborative innovation and gather inputs from all parts of STI systems during the COVID-19 crisis, including fast-track open competitions, hackathons, matchmaking activities, open access to research infrastructures, and the introduction of regulatory flexibilities to accelerate the process of approval for new products that tackled COVID-19.

Strengthening internal capacities to best perform each of the abovementioned tasks in co-creation – and in particular that of network builder – should be a priority going forward. Governments and funding agencies should also revise their internal processes (in particular that of programme set up and deployment) with a view of increasing agility and flexibility. Small scale experiments can help test different approaches and tools.

(7) User engagement in co-creation can help uptake of new solutions

The COVID-19 crisis also made evident that the active engagement of users in (some phases of) co-creation projects is essential for uptake. This was well illustrated for the uptake of COVID-19 vaccines and other medical products for which assuring citizens and getting their endorsement was essential. Also, deploying the COVID-19 apps to effectively help contain the spread of the virus required engaging with users and their reservations to apply the apps. This including acquiescing prospective users' privacy concerns about sharing health and location information. The use of apps digital platforms to support researchers, experts and policy makers benefited from engaging with these expert users for quicker and better uses of these solutions.

Efficiently engaging the public in co-creation projects is not an easy task even more so where social distancing regulations were applied. Online platforms to gather inputs or through which people can co-develop ideas for policymakers to take up, endorse certain projects and provide donations, and the use of social media channels to increase the visibility of such platforms, could help increase engagement. Beyond COVID-19, pilot programmes could be implemented at local and national levels, equipped with appropriate reporting, monitoring and feedback mechanisms to enable continuous policy learning and improvements

6. Conclusion

This paper provides a review of the diversity of co-creation experiences during the COVID-19 crisis. By using a qualitative case study approach, the analysis highlights the richness of proposals to address the many challenges posed by the crisis. This in turn leads to a better understanding of how co-creation initiatives operated and offers a number of important policy lessons in return.

As is the case with all analyses, there are still unanswered questions that require further research, such as the return to public funding and governmental involvement in these initiatives. Was the public investment on co-creation initiatives well spent? Would more or less have produced better results? Did the benefit outweigh the costs? Would there have been ways to increase the return to public spending without raising public spending? These are important but difficult questions that require comprehensively evaluating the outcomes and public and private costs incurred in co-creation initiatives. By offering an overview on the types of outcomes and costs incurred, this study provides support for such analyses.

References

De Silva, M. et al. (2022), "Co-creation during COVID-19: 30 comparative international case studies", *OECD Science, Technology and Industry Policy Paper Series*, No. 135, OECD, Paris. [1]

OECD (2021), *Recommendation of the Council concerning Access to Research Data from Public Funding*, OECD Legal Instruments, https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0347. [3]

OECD (2021), *Recommendation of the Council on Enhancing Access to and Sharing of Data*, OECD Legal Instruments, https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0463. [2]