OECD publishing

POLICY INITIATIVES TO ENHANCE THE IMPACT OF PUBLIC RESEARCH

PROMOTING EXCELLENCE, TRANSFER AND CO-CREATION

OECD SCIENCE, TECHNOLOGY AND INDUSTRY
POLICY PAPERS
October 2019 **No. 81**

OECD
BETTER POLICIES FOR BETTER LIVES

The paper was approved and declassified by written procedure by the Committee on Science and Technology Policy (CSTP) on 15 September 2019 and prepared for publication by the OECD Secretariat.

Note to Delegations:

An earlier version of the document is available on ONE M&P under the reference code:

DSTI/STP/TIP(2019)9/REV1

Policy initiatives to enhance the impact of public research: Promoting excellence, transfer and co-creation

José Guimón*

ABSTRACT

Policies to boost the impact of public research can be classified into three broad categories. Firstly, policy initiatives promoting research ***excellence*** *encourage frontier research by providing large-scale, long-term competitive funding to selected research centres. Secondly, policies supporting knowledge* ***transfer*** *aim at commercialising the results of public research through patent licensing, spin-off companies, and other channels. Thirdly, policies promoting science-industry* ***co-creation*** *focus on fostering more intense modes of research collaboration through joint funding, shared facilities and mixed teams; often involving other civil society stakeholders besides public research institutions and firms. This paper illustrates the variety of options available within each of these three types of policies, based on a review of twelve case studies across nine different countries. The analysis draws attention to the design options, budgets, implementation challenges, international scope, evaluation practices and lessons learnt from these policy initiatives.*

Acknowledgements: This work is part of a policy benchmark analysis which has been financed and commissioned upon request of the French Surveillance committee of investments for the future (Comité de surveillance des investissements d'avenir), in the context of the evaluation of the first phase of the Programme d'investissements d'avenir (PIA). The benchmark study is presented as a series of six monographs. Each monograph provides examples of research, development, and innovation policies, organised by topic of relevance to the PIA. This document presents the third monograph, focused on the theme of public research. It provides the main messages from the cross-country benchmark analysis of 12 case studies of public policy initiatives. The detailed case studies can be found at https://community.oecd.org/community/cstp.

Several national policy officers provided valuable information to develop the case studies (OECD, 2019a). Special thanks to Gesa Baelz and Bülent Genç from the German Ministry of Education and Research; Prakash G. Balan from the National Science Foundation, United States; Sheila Honey from the Department for Business, Energy and Industrial Strategy, United Kingdom; Richard Lamb and David Legg from Innovate UK; and Lucien Vijverberg from the Dutch Ministry of Economic Affairs and Climate. Overall guidance by Alan Paic and Dominique Guellec from the Directorate for Science, Technology and Innovation of the OECD is also gratefully acknowledged.

* Universidad Autónoma de Madrid (UAM)

Table of contents

Executive summary

OECD countries are placing more emphasis on strengthening the impact of public investments in research. This paper illustrates the variety of policy options available for this purpose, based on a review of twelve case studies across nine different countries. The analysis draws attention to the design options, budgets, implementation challenges, international scope, evaluation practices and lessons learnt. The case studies fall into the following three types of policy approaches, which have gained popularity in recent years:

Policies promoting research excellence

These programmes provide large-scale, long-term competitive funding to selected research centres with the aim to build their countries' research capacity, bolstering efforts to achieve stronger critical mass to compete internationally. The target groups or beneficiaries of such initiatives can be set at the university, department or research-group level. Besides generating scientific outputs, they also aim to generate a qualified human resource base, in particular by training young researchers.

The success of research excellence initiatives lies in their capacity to concentrate funding in the best-performing research centres in order to improve the efficiency of public investments in research. Another driver of success is the possibility of stable funding over a relatively long period. However, a notable trade-off is that a focus on excellence may compromise other important values, such as equity or diversity.

To reach their objectives, centres of excellence receive substantial funding over a relatively long period (compared to other policy instruments, such as project grants). Selection processes, monitoring and mid-term "continuity" evaluations are critical elements of excellence initiatives, given these programmes' high selectivity, long-term scope and high budgets.

Policies supporting knowledge transfer

The general objective of these policies is to transfer the results of publicly funded research to industry, thereby enhancing its socio-economic impact. Successful policy programmes designed to support technology transfer entail a combination of different financial instruments (e.g. grants, loans, equity) and "soft" instruments (e.g. training, networking, mentoring). These policy initiatives have a clear focus on driving market interactions, including testing product viability and conducting interviews with potential customers and investors. Beyond the commercialisation of individual research results, such policy programmes can also further cultural change in research organisations.

The case studies analysed illustrate the advantages of an implementation approach centred on creating intermediary organisations (e.g. TTOs) as primary programme partners, which then help researchers and students commercialise their research. It also becomes apparent how technology transfer initiatives can benefit from a regional approach that facilitates implementation and allows focusing on each region's stated priorities.

Some recent trends observed include a growing focus on student entrepreneurship and the provision of equity funding in addition to financial grants. In general, a key challenge is that only a small proportion of technology transfer projects leads to substantial economic impact in terms of income and jobs. Therefore, a key concern for policy makers is to scale-up the most promising projects, including to international markets, rather than just increasing the total number of spin-offs and patents generated.

Policies promoting science-industry co-creation

The case studies suggest that public-private partnerships to create joint research centres are gaining ground as a powerful approach to promote long-term science-industry collaboration. Compared to a simple process of knowledge transfer, these policy initiatives aim to foster the "co-creation" of knowledge through joint funding, shared facilities and mixed teams. They aim to establish more intense science-industry relations over the medium to long term, focusing on applied research linked to industry needs and societal challenges. They also contribute to training young researchers, who may benefit from joint academic-industry supervisors and sometimes end up working in industry.

These initiatives tend to focus on strategic areas that address national or global challenges, where collaboration between multiple stakeholders from the public and private sectors is critical. Mixed groups from universities, public research institutes, firms, and other public agencies and organisations develop joint proposals in order to receive funding as a consortium. This allows moving away from traditional models of bilateral knowledge transfer to new modes of knowledge-sharing between multiple stakeholders, opening up new opportunities to "democratise" the generation and diffusion of knowledge.

Like research excellence initiatives, these public-private partnerships need to be supported by substantial funding over a relatively long period of time, given their ambition to deliver breakthrough innovation addressing grand societal challenges. Their success depends on the capacity of scientists and companies to work closely together, creating a mutual benefit. As with any kind of strategic partnership, avoiding conflicts between the parties means establishing clear contracts or binding agreements governing the co-operation agreements from the outset, particularly to minimise potential disputes around IP.

1. Introduction

Research conducted by universities and public research institutes plays a critical role in national innovation systems (Larédo and Mustar, 2004; Larrue et al., 2018). Such public research is shaped by a variety of policy instruments, from funding systems for higher education and research projects, to regulations affecting the relations of universities, public research institutes, and researchers with industry and society.

With large public investment in research and strong budgetary pressures, the governments of OECD countries are placing more emphasis on deepening the impact of their investments in research. Beyond providing institutional core funding, governments are now relying more on competitive project funding and performance-based institutional funding with a focus on rewarding excellence (Jonkers and Zacharewicz, 2016; Larrue et al., 2018; OECD, 2014). Moreover, public investments in research have increasingly concentrated on a set of designated social challenges, missions, or strategic technologies and sectors (European Commission, 2018; Kuhlmann and Rip, 2018). They have also further emphasised enhancing science-industry collaboration and technology commercialisation (OECD, 2019b). Despite these general trends, there exist substantial differences across countries in the organisation of public research (Borowiecki and Paunov, 2018; Lepori et al., 2007).

This report provides an overview of recent policy approaches to boost the scientific quality and socio-economic impact of public research, based on a review of 12 policy initiatives undertaken across 9 different countries at the forefront of research performance (Table 1).

Table 1. Selected case studies, by country and type of policy initiative

	Research excellence	Knowledge transfer	Knowledge co-creation
Austria			Christian Doppler Research Association (CDG)
Canada		Technology Access Centres (TACs)	
Germany	Excellence Strategy	Fraunhofer Venture	Research Campus
Israel	Israel: Centres of Research Excellence (I-CORE)		
Netherlands		Valorisation Programme	
Norway		FORNY	
Sweden			Strategic Innovation Programmes (SIP)
United Kingdom	Research Excellence Framework (REF)	Knowledge Transfer Partnerships (KTP)	
United States			Industry-University Cooperative Research Centres programme
Austria			Christian Doppler Research Association (CDG)
Canada		Technology Access Centres (TACs)	

Source: OECD.

The case studies are divided into three types of policy initiatives: i) research excellence initiatives, which provide earmarked funding to the best-performing research centres; ii) knowledge transfer policies, aimed at commercialising the results of public research

(e.g. through patent licensing or spin-off companies); and iii) policies aiming to support knowledge co-creation by science and industry partners, which go beyond the traditional linear model of arms-length knowledge transfer from science to industry. These three groups of policies are closely related. In fact, their boundaries are sometimes blurred, as they all share the common objective of boosting the returns from public investment in research. For example, research excellence centres are generally selected and evaluated based not only on the quality of their scientific outputs, but also on their socio-economic impact. Similarly, joint public-private research centres aspire not only to solve industry challenges, but also to produce excellent research outputs. Moreover, both types of research centres normally aim to transfer the results of their research to industry through patent licensing, publications, spin-offs, technological contracts and other informal channels.

This report reviews the selected policy initiatives. It summarises their main objectives and achievements, and describes their target groups, budget and time horizon, international scope, selection and evaluation methods, and other critical dimensions. A more detailed case study of each of the 12 policy initiatives is available online (OECD, 2019a). The information was collected through the programmes' official websites and other secondary sources, such as academic publications and evaluation reports. Telephone interviews or email consultations with policy officers in charge of running some of these programmes were also conducted in June 2019.

2. Policies promoting research excellence

Research excellence initiatives encourage frontier research by providing large-scale, long-term competitive funding to selected research centres. Previous work by the OECD (2014) has examined the different policy options available through a survey of OECD countries and a set of case studies. The survey indicated that over two-thirds of OECD countries were operating research excellence schemes in 2014, mostly established within the past decade.

This report presents three additional case studies of policy initiatives promoting research excellence in Germany, Israel and the United Kingdom (Table 2). The UK case is different in that it does not aim to develop new research centres of excellence, but rather to reward existing institutions' excellence through a performance-based funding system.

Table 2. Promoting research excellence: overview of case studies

Policy initiative	Country	Period	Annual budget (EUR million)	Brief description
Excellence Strategy	Germany	2017-present	> 500	Includes two funding lines: i) **Excellence Clusters**, for project-based funding in internationally competitive research fields at universities; and ii) **Universities of Excellence**, to strengthen universities in the long term.
I-CORE	Israel	2010-present	20-50	Funds Centres of Research Excellence to intensify the country's relative advantages in **strategic research fields** while encouraging **collaboration** between groups from different universities and **shared scientific infrastructure**.
REF	United Kingdom	2014-present	45.7	The REF is used to determine the **allocation of public research funding** to universities, based on criteria of scientific **excellence and impact**.

Note: Annual budget range corresponds to most recent estimations available from STIP Compass database or other official sources.

2.1. Objectives and achievements

These policy initiatives aim to build their countries' research capacity, bolstering efforts to achieve stronger critical mass to compete internationally. Besides generating scientific outputs, they also aim to generate a qualified human resource base, in particular by training young researchers.

In Israel, a total of 16 centres have been established since 2011 under I-CORE; in Germany, 57 centres were selected in 2018 under the Excellence Strategy. Both programmes have led to enhanced long-term funding for selected research groups, which may be affiliated to a single university or various institutions. These groups normally operate as virtual networks, without the need for physical proximity – although that may be the case in some centres. Besides the Excellence Clusters programme under the German Excellence Strategy, a second funding window called Universities of Excellence, to be awarded in late 2019, provides additional funding for universities to develop long-term strategic plans that strengthen their international position in research.

Finally, the REF is an assessment exercise conducted every five or six years in the United Kingdom to assess the quality of university research. The scores obtained by each institution are then used as a reference to allocate around GBP 2 billion per year (British pounds) in public

research funding. This performance-based research funding system has led to a more competitive landscape, creating new incentives for excellence in research. Compared to its predecessor, the Research Assessment Exercise, which focused solely on the quality of research outputs, the REF has included since 2004 a system that measures the socio-economic impact of research, representing 20% of the final score. This methodology has created new incentives for universities and individual researchers to undertake more relevant research activities, transfer the results of their research to industry and interact more with non-academic actors (Manville, 2015). However, it has also been criticised for its qualitative and subjective scope, and high operational costs. In fact, while many other countries have adopted performance-based research-funding systems in recent years, most have decided to exclude socio-economic impact as a criterion for assessing such schemes, given the difficulties in measuring it objectively (Sivertsen, 2017).

2.2. Critical dimensions

The success of research excellence initiatives lies in their capacity to concentrate funding in the best-performing research centres in order to improve the efficiency of public investments in research. This requires high-quality selection processes, based on clear guidelines and expert scientific reviewers.

Another driver of success is the possibility of stable funding over a relatively long period. This allows carrying out ambitious and complex research agendas, building up the necessary infrastructure, and hiring talent from the national and international job markets. Long-term stable funding is particularly important for novel lines of research that can lead to significant breakthrough innovation, but that are risky and potentially difficult to develop with short-term project funding. Such stable funding needs to be accompanied by regular monitoring and evaluation to ensure expected outcomes are met and take corrective actions when necessary, including terminating public funding. Besides regular monitoring, research centres are often subject to more in-depth evaluations after the expiration of the initial funding period to determine whether they are eligible for a new round of public funding.

Unlike other traditional research-funding schemes, excellence initiatives can achieve higher administrative and funding flexibility, enhancing their ability to attract talented researchers from abroad and build high-quality interdisciplinary research teams (OECD, 2014). Other studies have also emphasised the important contribution of such policy initiatives to professionalising the academic workforce, and enabling universities and research groups to set their own priorities and engage in professional research governance (Hellström, 2017).

However, a notable trade-off is that a focus on excellence may compromise other important values, such as equity or diversity. The concentration of research funding on a restricted number of actors will lead to a more unequal distribution of funding – and possibly reduced funding for less advanced academic institutions – which might trigger negative reactions and political tensions. A frequent challenge in large decentralised countries is balancing the political need to satisfy all regions' expectations to participate in such programmes with the technical need to select the best institutions and networks according to the agreed standards.

2.3. Target groups

The target groups or beneficiaries of such initiatives can be set at the university, department or research-group level. When set at the level of the research group, the programme normally leads to the creation of new research groups (e.g. Israel's I-CORE and Germany's Excellence Clusters) combining researchers from various institutions. By contrast, the REF in the United Kingdom does not develop new centres of excellence, but rather distributes funding to existing

university departments or research centres. Meanwhile, Germany's Universities of Excellence sub-programme sets its targets at the institutional level.

2.4. Priority industries and technologies

Centres of excellence programmes sometimes target specific strategic industries or technologies as a means of concentrating funds in those areas that are expected to produce the highest socio-economic impact (OECD, 2014). In the case of the Israel's I-CORE programme, research topics for the centres were selected through a broad bottom-up process of consultation with the Israeli academic community in order to reflect the genuine priorities and scientific interests of researchers in Israel. Designated committees then selected specific topics from among the large number of suggestions received. Once the topics were announced, an open call asked groups of researchers to submit proposals for I-COREs on these topics. By contrast, the German Excellence Strategy and the British REF do not set sectoral or thematic priorities.

2.5. Budget and time horizon

Excellence programmes normally provide public funding in the form of non-refundable grants. These initiatives generally involve a large budget, given the ambitious objective of building critical mass to perform frontier research. Funding can be used to cover direct project costs for research and training activities, often including improvement or extension of physical infrastructure, recruitment of researchers, graduate training and scholarships, scientific conferences and international travel expenses.

To reach their objectives, centres of excellence receive substantial funding over a relatively long period (compared to other policy instruments, such as project grants): around EUR 2 million annually over six years in the case of Israel's I-CORE centres and EUR 3-10 million annually over seven years in the case of Germany's Excellence Clusters programme, with the possibility of a second funding period. Meanwhile, the United Kingdom conducts its REF assessment exercise every five or six years. Thus, these four policy instruments converge in their duration – approximately six years, which is also the standard for other research excellence initiatives (OECD, 2014).

2.6. Selection criteria and procedures

The selection process for research excellence initiatives is very competitive, as the objective is to concentrate funding in a limited number of centres in order to reach critical mass. The selection processes for both Israel's I-CORE and the German Excellence Strategy were carried out in two stages: preliminary proposals and full proposals. Selection was based on an academic peer-review system with expert evaluation committees, sometimes featuring international members. In the case of I-CORE, two calls have been conducted so far, leading to the selection of 4 centres in 2011 and 12 centres in 2013. In the case of the Excellence Strategy, the first call for proposals was issued in 2018, resulting in the selection of 57 excellence clusters.

Although different from the others, the assessment process of REF in the United Kingdom is also based on rigorous peer review by 36 expert panels covering all academic disciplines. The expert panels comprise senior academics, international members and "research users" (including business managers), who assess university departments and research centres based on their research outputs and socio-economic impact. A new method to evaluate impact, consisting of "impact case studies" submitted by research centres or departments, was introduced in 2004. The expert panels play a key role in assessing the wider impact of research beyond academia.

2.7. International scope

Research excellence initiatives can normally use the funding received to conduct international activities (e.g. organising or attending international conferences) and recruit foreign researchers. For example, I-CORE in Israel states as one of its objectives "bringing excellent researchers back to Israel, as a central means of fortifying the research capabilities and the academic faculty of the institutions of higher education".

2.8. Monitoring and evaluation

Established centres of excellence are normally monitored at least annually by the programme's management office and are also subjected to a mid-term and final evaluation. Evaluations of the entire programme are useful to reform subsequent stages. For example, the design of Germany's Excellence Strategy feeds on the final evaluation of the previous Excellence Initiative, active until 2017. The Excellence Strategy was launched in 2018 and has obviously not been evaluated yet. However, an evaluation survey was sent to reviewers of the first call for projects with the goal of assessing the programme's selection process, which demonstrates a strong commitment to evaluation from the outset.

Evaluations are based on a variety of methods and performance indicators, typically including scientific publications, patents and training of doctoral students. The United Kingdom's REF illustrates how new models are emerging to better capture socio-economic impact based on qualitative case studies. Although the REF is an evaluation system in itself, it has also been subject to external evaluation. A commissioned review by RAND Europe concluded the REF was successful overall, but also identified a number of challenges, such as the difficulty of assessing the impact templates, the large variations in the process and the difficulty of involving users in evaluations (Manville et al., 2015).

2.9. Conclusion

The efficiency of public investments in research can increase by focusing on a smaller number of research centres, based on a combination of scientific excellence and socio-economic impact criteria. Selection processes, monitoring and mid-term "continuity" evaluations are critical elements of excellence initiatives, given these programmes' high selectivity, long-term scope and high budgets.

3. Policies supporting knowledge transfer

Recent work conducted under the auspices of the OECD Working Party on Innovation and Technology Policy has examined the many financial, regulatory and soft policy instruments available to promote knowledge transfer (Guimón and Paunov, 2019). Typical policy instruments include financial grants, support services and other incentives provided to academic entrepreneurs and spin-off companies aiming to transfer the results obtained from publicly funded research, either by commercialising new products themselves or licensing the technology. The mobility of skilled human capital is also an important channel for knowledge transfer, which can be supported by different types of policies, e.g. grants for student internships, industrial PhD programmes or new regulatory frameworks that facilitate industry secondments of university professors. To discuss the policy options available, this report studies five policy initiatives from different countries (Table 3).

Table 3. Supporting knowledge transfer

Policy initiative	Country	Period	Annual budget (EUR million)	Brief description
TAC	Canada	2010-present	5-20	TACs are established by colleges or polytechnics across Canada's **regions** to support innovation by **SMEs**.
Fraunhofer Venture	Germany	2001-present	n/a	A dedicated department of Fraunhofer Institute focuses on supporting the development of spin-offs by its researchers, including through **financial support, training, networking and mentoring.**
Valorisation Programme	Netherlands	2010-18	7	Creation of 12 regional consortia providing **entrepreneurship education, advice and funding** to technology-based start-ups.
FORNY	Norway	1995-present	20-50	Development of **technology transfer offices (TTOs)** and specific **funding for spin-offs and patent applications** by researchers from publicly funded research institutions.
KTP	United Kingdom	1975-present	60.5	Trilateral partnerships between a university, a firm and a graduate student, whereby the **graduate works at the firm** on a project for one to three years.

Note: Annual budget range corresponds to the most recent estimations available from the STIP Compass database or other official sources.

3.1. Objectives and achievements

The general objective of these policies is to transfer the results of publicly funded research to industry, thereby enhancing its socio-economic impact. The policy instruments used by these programmes generally combine advisory services and financial support (including grants, loans and equity). Most initiatives outlined in Table 3 focus explicitly on developing spin-off companies, a policy objective that has gained traction across OECD countries in recent years as a means to translate new scientific knowledge into commercial use (OECD, 2019b).

Norway's FORNY programme provides funding to TTOs at universities to support spin-offs and patent applications, including proof of concept and commercialisation activities. The programme was established in 1995 and has experienced a strong expansion over the years in terms of budget and the number of grants provided. Besides grants for researchers, the programme also grants targeted funding to improve the competence level and foster a national network of TTOs.

The Dutch and Canadian programmes also relied on developing intermediary organisations with a marked regional focus. In the Netherlands, the Valorisation Programme has created "regional consortia" promoting academic entrepreneurship and knowledge commercialisation. Researchers, entrepreneurs and start-ups can approach these consortia for advice and funding, which they can then use for entrepreneurship education, screening and scouting, intellectual property (IP) development, pre-seed funding or proof of concept, experiments and networking events. In Canada, 30 Technology Access Centres (TAC) have been established throughout the country's regions. TACs are small specialised applied research and development (R&D) centres affiliated with a Canadian polytechnic institute that support innovation in SMEs. While the TACs themselves do not extend any financing to SMEs, they offer flexible services – e.g. business and technical services, applied research projects and customised training – for free or at a price to help solve their innovation challenges. Each TAC has the flexibility to focus on its region's specific challenges (e.g. the realities of rural and remote areas, different-size companies and different industrial sectors).

In addition to policy initiatives at the national level, this report includes a case study on spin-off support at Fraunhofer, Europe's largest research institute. With the growing autonomy granted to universities and research organisations, support for technology transfer is often provided at the institutional – rather than national – level. Fraunhofer is frequently cited as an international best-practice example of successful technology transfer, and has dedicated increasing resources to supporting spin-offs in recent years. Around 25 new spin-offs are created each year based on Fraunhofer's research results. In 2001, Fraunhofer Venture was created as a dedicated department to promote spin-offs by connecting IP and technologies, entrepreneurs, investors and industry partners. Fraunhofer Venture provides both financial grants and specialised services to research teams interested in launching a spin-off to commercialise their research results. In addition to offering financial subsidies, Fraunhofer Venture also invests in the equity of some of the spin-offs; in 2017, for example, it invested EUR 1 million in eight new start-ups. To further support such equity investments, Fraunhofer Tech Transfer Fund was created in 2019 as a dedicated fund for spin-offs, with an initial volume of EUR 60 million.

Finally, the United Kingdom's Knowledge Transfer Partnerships (KTP) programme is one of the most remarkable international examples of policy programmes promoting knowledge transfer through the mobility of skilled human capital. The KTP programme is based on a three-way partnership between a firm, a university and a suitably qualified graduate who will undertake a project within the firm for a period of one to three years, under the joint supervision of the university and the firm. The university employs the graduate, but the firm co-finances its salary, together with the grant received with the programme. As of March 2019, around 800 live partnerships were active, 80% of which involved SMEs. Besides contributing to science-industry knowledge transfer, the programme is a useful tool to enhance the employability of highly skilled graduates and the propensity of early-career researchers to engage with industry.

3.2. Critical dimensions

Successful policy schemes supporting spin-offs combine financial support with targeted training, networking and support services, offering specific lines of support for entrepreneurial researchers and spin-offs at different stages of their life cycle. These policy initiatives have a clear focus on driving market interactions, including testing product viability and conducting interviews with potential customers and investors. Beyond the commercialisation of individual research results, such policy programmes can also further cultural change in research organisations.

The case studies from Canada, the Netherlands and Norway illustrate the advantages of an implementation approach centred on creating intermediary organisations (e.g. TTOs) as primary

programme partners, which then help researchers and students commercialise their research. In addition, the experiences of the Canadian TAC and the Dutch Valorisation Programme suggest that the adoption of a regional approach facilitates implementation and allows focusing on each region's specific priorities.

Policy initiatives based on this approach also promote collaboration and dialogue between the different intermediary organisations responsible for programme delivery. Such dialogue can take place through regular meetings between their representatives, to share good practices and co-ordinate programme activities, as well as build strategic support and a sense of ownership.

In the United Kingdom, the KTP programme owes its long-standing success to the fact that it provides a simple yet effective platform for facilitating collaborations between universities and firms, whereby highly skilled university graduates engage in innovative projects inside firms.

3.3. Target groups

Unlike policies aiming to create centres of excellence or joint labs, which are more selective and concentrate resources on a small number of beneficiaries, these policy initiatives often target a large number of beneficiaries. Their ultimate beneficiaries are individual researchers or research groups aiming to commercialise the results of their research.

A recent trend consists in targeting not only spin-offs initiated by well-established professors and scientists, but also those initiated by students and early-career researchers (see also OECD, 2019b). Norway illustrated this trend nicely with the launch in 2016 of the STUD-ENT scheme, focusing on student entrepreneurship, as part of the FORNY programme. While the KTP programme in the United Kingdom does not belong to the group of spin-off support schemes, it has focused on graduate students from the outset, illustrating the strong potential of this channel of knowledge transfer.

3.4. Priority industries and technologies

The policy initiatives described in this section do not set thematic priorities. The only exception is Canada's TAC programme, which gives regions the flexibility to focus the activity of their TACs on their specific industrial specialisation.

3.5. Budget

As shown in Table 3, the budgets of these policy initiatives vary widely. The United Kingdom's KTP has the most expensive annual budget, at around EUR 60.5 million. The Netherland's Valorisation Programme has the least expensive budget, at EUR 7 million. In addition to the information in Table 3, some additional indicators of the programmes' budgets are as follows:

- Through the Dutch Valorisation Programme (2010-18), a total of EUR 62.7 million in subsidies has been granted to the 12 selected consortia, which are required to provide co-funding of at least 50%. This implies an annual subsidy of around EUR 7 million per year for the whole programme and EUR 580 000 per centre.
- Until 2018, annual funding awarded to the 30 existing Canadian TACs totalled EUR 4.8 million. The programme's annual budget increased to EUR 8.9 million in 2019, and the number of TACs is expected to grow to 58 by 2020-21.
- The United Kingdom's KTP programme had an annual budget of around EUR 60.4 million in 2018-19 and provided an average annual grant of EUR 78 200 per project.
- Fraunhofer Venture provides sequential financial support to research teams engaged in developing a spin-off company. Teams selected to participate in the 12-week "FDays"

acceleration programme receive EUR 25 000 each. Those that move to the next phase (business-plan development and coaching) receive an additional EUR 150 000. Teams that also participate in the final stage (management development) receive up to EUR 100 000. In addition to these grants, Fraunhofer Venture invests in the equity of some of the spin-offs (EUR 1 million invested in eight new start-ups in 2017). Fraunhofer Tech Transfer Fund was created in 2019 as a dedicated fund for spin-offs, with an initial endowment of EUR 60 million.

3.6. Selection criteria and procedures

Policy initiatives that operate through intermediary organisations (e.g. TACs, the Valorisation Programme, FORNY) normally operate in two stages. In the first stage, they launch a competitive call for proposals to select the institutions that will deliver the programme and provide guidelines on the eligibility requirements. Norway's FORNY selects these institutions from among universities' TTOs. The condition for participating in the Dutch Valorisation Programme is the creation of regional consortia consisting of universities, firms, municipalities, provinces and other societal actors. Meanwhile, the Canadian TAC programme offers support to polytechnics or colleges through a two-stage application process, i.e. letters of intent followed by applications from invited applicants; applications are reviewed against the TAC grant selection criteria by a panel comprising representatives from industry and academia.

For the second stage, the programme provides guidelines for selecting individual projects, although intermediary organisations maintain a certain degree of flexibility (depending on the programme) to reach their own decisions regarding selection criteria and procedures. Across these programmes, the elements typically considered when selecting individual research projects include the project's novelty; the researchers' experience; the business plan; and the project's implementation capacity, market potential and TRL.

3.7. International scope

Programmes aiming to support spin-offs (such as those discussed in this monograph) also aim to improve connections with international capital markets that may help finance spin-offs. In particular, they facilitate connections with international venture capital funds, business angels or multinational companies that could contribute equity funding.

In Canada, the international dimension of the TACs works both ways. On the one hand, the TACs help Canadian SMEs take products and processes to market, and gain exposure to business opportunities around the world. On the other hand, TACs provide "soft-landing" services for international firms wishing to enter the Canadian market with their own innovation.

3.8. Monitoring and evaluation

These policy programmes are monitored regularly through a variety of measures to assess progress in implementation and performance. Some of these initiatives have undergone wider evaluations, such as the Canadian TAC programme in 2018. Likewise, the Dutch Valorisation Programme underwent a mid-term evaluation in 2014 and a final evaluation in 2018, both commissioned to an external consulting firm. The Norwegian FORNY programme and its results have been evaluated several times, resulting in some criticism that it has led to very few success stories, despite the large amount of money invested.

Similarly, the British KTP programme has been evaluated various times throughout its history, typically every five to seven years. The latest evaluation (Siora et al., 2015) included a model to estimate the programme's economic impact; it concluded that every GBP 1 of KTP grant

invested resulted in up to GBP 8 of net extra gross value added to the UK economy. The evaluation was based on both qualitative and quantitative methods, including interviews with stakeholders, a review of the information held in Innovate UK's KTP databases and ad hoc surveys. The next major review is scheduled for 2020/21.

Evaluations are used to inform policy decisions regarding the programmes' expansion or reform. A thorough assessment of the Fraunhofer Venture was conducted in 2018. As a result, the approach used to support spin-offs was transformed in 2019, leading to a new programme called AHEAD, with some changes made to address weaknesses in the previous model. In particular, the new model aims to streamline and simplify the spin-off support programme, creating a single brand merging the previous four sequential sub-programmes. This enables more effective marketing and outreach. More importantly, it removes artificial barriers that existed in the past (i.e. dealing with new applications, programme managers, rules, structures and expectations) when transitioning from one sub-programme to the other.

3.9. Conclusion

These policy initiatives share a focus on transferring the results of research to industry, with the aim of enhancing the socio-economic impact of public research. Successful policy programmes designed to support technology transfer entail a combination of different financial instruments (e.g. grants, loans, equity) and soft instruments (e.g. training, networking, mentoring). They also require a regulatory framework that enables researchers to engage in such activities and provides them with incentives (Guimón and Paunov, 2019). A major challenge is that only a small proportion of technology transfer projects leads to substantial economic impact in terms of income and jobs. Therefore, a key concern for policy makers is to scale-up the most promising projects, including to international markets, rather than just increasing the total number of spin-offs and patents generated.

The case studies illustrate how technology transfer initiatives can benefit from a regional approach that facilitates implementation and allows focusing on each region's stated priorities. These programmes need to respond to the specific challenges of different countries/regions and are often subject to change over time, stemming from evaluation and learning. Some recent trends observed in these case studies include a growing focus on student entrepreneurship and the provision of equity funding in addition to financial grants.

4. Policies promoting science-industry co-creation

The knowledge transfer policies discussed in the previous section reflect a linear model of innovation, whereby knowledge generated at universities and research institutes is transferred to industry (i.e. academia acts as the knowledge producer, and industry as the knowledge receiver and user). In addition to supporting this type of unidirectional "transfer" process, policies also aim to support more bidirectional knowledge exchange and "co-creation" through science-industry collaboration, whereby both parties jointly generate new knowledge. The traditional approach to promoting science-industry collaboration has been to offer financial grants to research projects, conditional on the establishment of consortia between academic researchers and industry. Over the years, these kinds of collaborative grants have been widely adopted, and now rank among the most relevant innovation policy instruments across OECD countries in terms of relative budget (Veugelers, 2015). As shown in Table 4, the most common approach is to offer a maximum grant amount per project of more than EUR 1 million (40% of cases) over 25-36 months (75% of cases), although some programmes offer lower grants over a shorter period.

Table 4. Grant programmes for public research requiring collaboration with industry partners: distribution by grant amount, grant duration and annual budget

Based on 129 policy initiatives from 34 countries in 2017.

Maximum amount of grant awarded, EUR	
Less than 100 000	14%
100 000-500 000	31%
500 000-1 million	15%
More than 1 million	40%
Maximum grant duration	
12 months or less	6%
13-24 months	19%
25-36 months	75%
Annual budget range, EUR[2]	
Less than 1 million	10%
1-5 million	21%
5-20 million	17%
20-50 million	19%
50-100 million	8%
100-500 million	10%
More than 500 million	15%

Note: 1) The 34 countries in the sample are Australia, Austria, Belgium, Bulgaria, Brazil, Canada, Chile, People's Republic of China, Colombia, Costa Rica, Czech Republic, Germany, Finland, France, Greece, Hungary, Ireland, Latvia, Lithuania, Malta, Mexico, Morocco, Netherlands, Norway, Peru, Poland, Portugal, Russia, Slovenia, Sweden, Switzerland, Thailand, Turkey and the United Kingdom. 2) For this question, the sample size is 103, because 26 observations with missing answers have been excluded.
Source: Adapted from Guimón and Paunov (2019), based on the STIP Compass database.

Beyond collaborative research grants, policies can also support longer-term co-creation relationships by developing joint laboratories between academia and industry. Such public-private partnerships targeting the joint generation of knowledge are increasingly being supported by policy makers (Koschatzky and Stahlecker, 2016; OECD, 2019b) and have also become more attractive to firms adopting "open innovation" strategies (De Silva and Rossi, 2018; Frølund et al., 2018). They are sometimes referred to as "collaborative research centres" or "competence

centres". Given their long-term, strategic and open-ended scope, they are closely related to the notion of "centres of excellence". Although the boundaries are blurred, the distinctive feature of co-creation (compared to excellence initiatives) is the partnership formed between academia and industry to fund, manage and implement the centre's research activities. This study analyses four relevant policy initiatives to build a better understanding of policy options that foster co-creation (Table 5).

Table 5. Promoting knowledge co-creation: policy examples

Policy initiative	Country	Period	Annual budget (EUR million)	Brief description
CDG	Austria	1988-present	20-50	Grants for the establishment of **research labs within universities** based on industry-relevant questions in basic research, with **50% of industry co-funding**.
Research Campus	Germany	2011-present	10-20	Public-private partnerships to drive innovation by **merging private and public research competences at a single location**.
SIP	Sweden	2013-present	N/A	Grants for **innovation programmes in strategic areas** conducted by **consortia of universities, companies, civil society organisations and government agencies**.
Industry-University Cooperative Research Centres (IUCRCs)	United States	1973-present	17	**IUCRCs** conduct research of interest to both industry members and the centres researchers.

Note: Annual budget range corresponds to most recent estimation available from the STIP Compass database or other official sources.

4.1. Objectives and achievements

Compared to a simple process of knowledge transfer, the objective of the policy initiatives discussed hereinafter is to foster the co-creation of knowledge through joint funding, shared facilities and mixed teams. They aim to establish more intense science-industry relations over the medium to long term, focusing on applied research linked to industry needs and societal challenges. They also contribute to training young researchers, who may benefit from joint academic-industry supervisors and sometimes end up working in industry.

One of the longest-standing policy initiatives of this kind is the IUCRC programme of the National Science Foundation (NSF) in the United States, which has been operating for over four decades. The programme develops long-term partnerships among industry, academia and government. Many industrial partners continue funding the IUCRC beyond the 15-year funding period offered by the programme: recent evaluations show that one year after the end of the programme's funding, more than 80% of the centres remain active. The programme has initiated more than 170 centres in virtually every state in the country; 77 are still receiving NSF support today. Around 60% of IUCRC partner institutions are large corporations, 20% are smaller enterprises and 20% are other federal/state agencies, as well as NGOs. Industry partners become engaged in different ways with the research centres, but their staff do not necessarily participate in executing the research projects.

The Research Campus initiative in Germany goes a step further in integrating both parties. A research campus must meet three criteria: i) it merges private and public research competences at a single location; ii) it has a medium- to long-term perspective; and iii) it builds on a reliable public-private partnership. Following the selection made in 2012, a total of 9 research campuses are currently being funded, for a period of up to 15 years (until 2027), with the possibility of extending it further through a follow-up programme. The research campuses represent a new

type of research structure in the German system, where researchers from universities, research institutes and companies work "under one roof". While several companies – including SMEs – must participate in a research campus, large multinational companies are mostly the driving force. The research campuses operate under various forms of organisation and contracts, depending on their specific needs.

The approach is slightly different in the case of the Austrian CDG programme, which has been operating since 1995 with the goal of developing public-private partnerships for "application-oriented basic research". The CDG provides grants to establish research laboratories (CD Laboratories) within an Austrian university or research institute, based on an industry challenge (i.e. "industry-relevant questions in basic research"). CD Laboratories must receive 50% in industry co-funding. Public support lasts up to seven years, but collaborations tend to extend beyond that period, even without public grants. CD Laboratories consist of research groups (5-15 people) and are led by a laboratory head. They are directly embedded within a host university or research institution. However, a set (or "module") of scientific activities can be located at a different university or research institute. In 2012, the CDG started managing an additional funding programme for Josef Ressel Centres (JR Centres), which are similar to CD Laboratories but are exclusively established at universities of applied sciences. JR Centres focus more strongly on applied research, have a maximum duration of five years and have a lower budget than CD Laboratories. As of June 2018, 90 active CDG-funded research units (80 CD Laboratories and 10 JR Centres) were being supported.

The Swedish Strategic Innovation Programmes (SIP) initiative is based on a different approach. It features larger consortia of various actors (universities, companies, civil society organisations and government agencies), and a more explicit focus on finding sustainable solutions for national and global challenges. The first step of the programme consisted in a bottom-up process, where key actors of the innovation system worked together to formulate "strategic research agendas" (SIAs) through widespread consultative processes involving large numbers of relevant actors. The second stage consisted in inviting proposals for SIPs within the areas defined by those SIAs. Sixteen SIPs have been selected to date. Once initiated, the SIPs are responsible for launching calls for project proposals (one or two calls every year for each SIP) and overseeing the implementation of the resulting projects. The programmes also conduct a small number of "strategic projects", which are usually larger and organised through a more direct process, without issuing an open call. SIPs organise regular (e.g. annual) consultations with their members and stakeholders in order to continuously assess needs and priorities, as well as industry fairs and workshops on specific topics of interest to the community.

4.2. Critical dimensions

Like research excellence initiatives, these public-private partnerships need to be supported by substantial funding over a relatively long period of time, given their ambition to deliver breakthrough innovation addressing grand societal challenges. Their success depends on the capacity of scientists and companies to work closely together, creating a mutual benefit. Previously existing contacts and trust between the different parties are a key condition for pooling different interests and competences in strategic research fields oriented towards the long term (Koschatzky and Stahlecker, 2016). Ultimately, the success of these programmes depends on the ability of the parties to develop a mutual benefit and a good understanding, to enable the centres' continuity after the expiration of the programmes' public funding phase. Over the course of the programme, the research centres develop new research methods, skills and competences, as well as new equipment and infrastructure, which are highly valued by the industrial partners.

As with any kind of strategic partnership, avoiding conflicts between the parties means establishing clear contracts or binding agreements governing the co-operation agreements from

the outset, particularly to minimise potential disputes around IP. For example, the IUCRC programme relies on effective administrative and operational processes that have been improved over the course of its long history, including systematic training for researchers presenting proposals and prospective centre directors, and instructions and facilitating devices (e.g. manuals on how to set up a centre, guidelines and standardised processes). The internal governance mode with which the centres must comply facilitates their initial establishment, avoiding long negotiations between prospective partners.

4.3. Target groups

In these programmes, mixed groups from universities, public research institutes, firms, and other public agencies and organisations develop joint proposals in order to receive funding as a consortium. This allows moving away from traditional models of bilateral knowledge transfer to new modes of knowledge-sharing between multiple stakeholders, opening up new opportunities to "democratise" the generation and diffusion of knowledge. However, these consortia have different characteristics depending on the programmes: the IUCRC, SIP and Research Campus programmes have a large number of partners (often over 20 companies), whereas the standard at the CDG is to have just one university or research institute partnering with one or two companies.

Participants may need to meet specific requirements. For example, only US academic institutions with graduate research programmes may apply to the IUCRC programme (with the aim of integrating research and education), and the principal investigator of the proposal must be a tenured faculty member. In the case of the German Research Campus initiative, SMEs need to be included in the consortia.

4.4. Priority industries and technologies

These initiatives tend to focus on strategic areas that address national or global challenges, where collaboration between multiple stakeholders from the public and private sectors is critical. Sweden's SIP programme provides an interesting model for selecting such priority areas, based on wide consultative processes with different stakeholders that jointly formulate roadmaps and innovation agendas in each field. In Germany and the United States, the selection process considers the project's alignment with national science and technology priorities (which may change over time), as well as its potential to generate significant socio-economic impacts. Conversely, the Austrian CDG programme does not set explicit thematic priorities.

4.5. Budget and time horizon

The budgets of these policy initiatives vary substantially, although they tend to offer a large amount of funding per centre over a relatively long period of time (from 7 to 15 years):

- IUCRCs (currently numbering 77) receive public funding from the programme over 15 years, divided in three 5-year phases. Each university participating in an IUCRC receives up to USD 150 000 (US dollars) annually in Phase I, USD 100 000 in Phase II, and USD 50 000 in Phase III.
- Each German research campus (currently numbering 9) receives up to EUR 2 million in public funding per year for a period of up to 15 years.
- Austria's CD Laboratories (currently numbering 90) are awarded a grant amounting to a maximum of EUR 4.9 million over a 7-year funding period.
- Swedish SIPs (currently numbering 16) are supported over a 12-year period, but information regarding the programme's budget is not available.

In addition, the notion of co-creation implies that public funds are complemented by a substantial contribution to the centres' budget from private partners:

- IUCRCs collect at least USD 400 000 annually through membership fees from at least eight industrial partners.
- Austria's CDG programme requires 50% co-funding by company partners (with the other 50% financed by the public partner and the programme grant).

4.6. International scope

All of these programmes aim to achieve internationally excellent research and may use their budget to attract foreign talent. The centres may also establish partnerships with foreign research institutions or firms. For example, in Germany various foreign multinational firms participate in the programmes as industry partners of the research campuses, including companies such as Cisco, General Electric, Hewlett-Packard, Hitachi and Fuji Electronics. Their participation offers opportunities to use such policy initiatives as platforms to enhance a country's connections with global innovation networks and attract internationally mobile R&D. However, from a more protectionist stance, allowing foreign firms to enter into open innovation partnerships with national research institutes may be interpreted as a risk to national competitiveness, given knowledge leakage, raising the question of whether government-funded research should be offered to foreign firms under equal conditions as for national firms. Under World Trade Organization regulations, such programmes cannot discriminate against foreign-owned subsidiaries. However, more subtle ways exist to impede their participation when the selection process is subject to qualitative evaluations by policy makers, who may face political pressures or have a bias towards national champions.

In the case of the CDG, the industrial partner may be a foreign company, including a firm that is not registered in Austria as a subsidiary. Moreover, a centre can be established in partnership between an Austrian industrial partner and a foreign university or research institute. In both cases, the application must include information on the reasons for this international partnership, and the expected benefits for the Austrian economy and innovation system. Research undertaken at a non-Austrian university/research institution with companies outside Austria cannot be supported.

In the United States, foreign universities or research institutes can join the IUCRC programme as partners of a multi-university centre. In this case, the application must include additional documents, such as a detailed plan to interact with the international research site, and a formal agreement between the foreign and US-based site that replicates the provisions for intellectual property rights. In addition, many foreign-owned firms have joined IUCRCs as members, either through their US subsidiaries, or by providing funding and fees directly from their home countries.

In Sweden, the SIP programme promotes international outreach activities, such as producing roadmaps and commissioning analytical studies (e.g. screening similar initiatives in other parts of the world); organising visits of core members to relevant centres of expertise in other countries; and using the programme as a platform to examine relevant EU activities and initiatives, with a view both to shaping these developments and taking advantage of funding opportunities.

4.7. Selection criteria and procedures

These policy initiatives rely on competitive selection and interim evaluation processes, based on rigorous peer reviews by an independent jury. Typical selection criteria include the track records

of applicants (including research and industry members), and the expected scientific and commercial impact. In the case of the IUCRC programme, proposals can be submitted twice a year; they are evaluated by NSF programme officers, as well as three to ten external experts outside NSF. In Germany, the Research Campus selection process was structured around a single call for proposals, with predefined deadlines set in 2011. In both cases, the application process involves two stages: a "pre-phase" for developing the proposals and a "main phase" for presenting the full proposals.

The evaluation process also aims to avoid duplications in the different centres' research agendas. Some applicants to Sweden's SIP programme were asked to resubmit rejected proposals after taking into consideration the existence of overlapping proposals. For instance, communities submitting ten separate agendas related to the forestry sector were eventually encouraged to submit a combined proposal.

4.8. Monitoring and evaluation

Besides annual monitoring, the centres are subject to interim evaluations every 3 to 5 years (similarly to the excellence centres discussed previously), as they receive public funding over a relatively long period of time (7-15 years).

- The German research campuses receive funding over a period of up to 15 years, but are subject to interim evaluations every 5 years. Existing research campuses are due for a renewed evaluation by the jury over 2018-21 (depending on the research campus) to consider transitioning into the second main phase. In addition, wider evaluations of the overall programme have been commissioned to external consultants from the outset: a first evaluation covered 2012-16 (when the programme started), and the next evaluation was just launched for 2019-21. These evaluations aim to evaluate impact, provide advice to the centres and share good practices. The 2012-2016 evaluation was in fact undertaken as an accompanying research project and funded as an R&D project, following the same competitive selection project as that of the research campuses.
- In Sweden, each SIP is subject to a review process every 3 years, which will determine whether it will continue to receive funding (up to a maximum of 12 years). While the main purpose of these reviews is to support strategy development within each SIP, they also aim to assess the programme's overall impact.
- In the United States, individual IUCRCs must present annual project reports, as well as a final project report at the expiration of each five-year phase. The annual report is divided into three main parts: i) the director's report; ii) the evaluator's report; and iii) the formal certification of membership funds. All centres must be followed by an independent evaluator from the moment they begin their activities. Thus, the process combines self-evaluation with independent evaluation. Besides the evaluations of individual IUCRCs, the overall programme has also been subjected to several evaluations.
- In Austria, CD Laboratories are established for a maximum of seven years, split into three periods of two, three and two years; they can only enter the subsequent period after passing a scientific evaluation. In addition to regular monitoring and interim evaluation of individual laboratories, the CDG programme as a whole has undergone three independent evaluations, most recently in 2016.

4.9. Conclusion

The case studies illustrate how public-private partnerships to create joint research centres are gaining ground as a powerful approach to promote long-term science-industry collaboration, often focusing on designated priority areas. A key challenge for these policy initiatives is to

build a shared vision among the different participants that is democratic but also operational (Grillitsch et al., 2019). Another typical challenge is related to the lack of governance capabilities of those managing the consortia.

Like centres of excellence initiatives, the programmes tend to operate with large budgets. However, they concentrate resources on a limited number of centres over a relatively long period of time, unlike knowledge transfer schemes, which cater to a larger group of beneficiaries over a shorter time. This highlights the importance of selection, monitoring and evaluation processes in ensuring the programme's objectives are being met.

References

Borowiecki, M. and C. Paunov (2018), "How is research policy across the OECD organized?", *OECD Science, Technology and Industry Policy Papers,* No. 55, OECD Publishing, Paris, https://doi.org/10.1787/235c9806-en.

De Silva, M. and F. Rossi (2018), "The effect of firms' relational capabilities on knowledge acquisition and co-creation with universities", *Technological Forecasting and Social Change*, 133, 72-84.

European Commission (2018), *Mission-oriented research and innovation: Inventory and characterisation of initiatives. Final Report*, European Commission, Directorate General for Research and Innovation, Brussels.

Frølund, L., F. Murray and M. Riedel (2018), "Developing successful strategic partnerships with universities", *MIT Sloan Management Review*, Winter Issue, 71-79.

Grillitsch, M., T. Hansen, L. Coenen, J. Miörner and J. Moodysson (2019), "Innovation policy for system-wide transformation: The case of strategic innovation programmes (SIPs) in Sweden", *Research Policy*, 48(4), 1048-1061.

Guimón, J. and C. Paunov (2019), "Science-industry knowledge exchange: A mapping of policy instruments and their interactions", OECD Science, Technology and Industry Policy Papers, No. 66, OECD Publishing, Paris, https://doi.org/10.1787/66a3bd38-en

Hellström, T. (2017), "Centres of excellence and capacity building: from strategy to impact", *Science and Public Policy*, 45(4), 543-552.

Jonkers, K. and T. Zacharewicz (2016), *Research performance based funding systems: A comparative assessment*, Publications Office of the European Union, Luxembourg.

Koschatzky, K. and T. Stahlecker (2016), *Public-private partnerships in research and innovation: Trends and international perspectives*, Fraunhofer Verlag, Stuttgart.

Kuhlmann, S. and A. Rip (2018), "Next-generation innovation policy and grand challenges", *Science and Public Policy*, 45(4), 448-454.

Larédo, P. and P. Mustar (2004), "Public sector research: a growing role in innovation systems", *Minerva*, 42(1), 11-27.

Larrue, P., D. Guellec, D. and F. Sgard (2018), "New trends in public research funding", *OECD Science, Technology and Innovation Outlook 2018* (Chapter 8, pp. 185-204). OECD Publishing, Paris, https://doi.org/10.1787/sti_in_outlook-2018-en.

Lepori, B., P. Van den Besselaar, M. Dinges, B. Potì, E. Reale, S. Slipersæter, J. Thèves and B. Van der Meulen (2007), "Comparing the evolution of national research policies: what patterns of change?", *Science and Public Policy*, 34(6), 372-388.

Manville, C. et al. (2015), *Assessing impact submissions for REF 2014: An evaluation*, RAND Europe, Cambridge, UK.

OECD (2019a), OECD Committee for Scientific and Technological Policy, https://community.oecd.org/community/cstp.

OECD (2019b), *University-Industry Collaboration: New Evidence and Policy Options*, OECD Publishing, Paris, https://doi.org/10.1787/e9c1e648-en

OECD (2014), *Promoting Research Excellence: New Approaches to Funding*, OECD Publishing, Paris, https://doi.org/10.1787/9789264207462-en.

Siora, G. et al. (2015*), KTP Programme: The Impacts of KTP Associates and Knowledge Base on the UK Economy*, Warwick Economics and Development, Warwick, UK.

Sivertsen, G. (2017), "Unique, but still best practice? The Research Excellence Framework (REF) from an international perspective", *Palgrave Communications*, 3, 17078.

Veugelers, R. (2015), "Mixing and matching research and innovation policies in EU countries", *Bruegel Working Papers,* No. 2015/16.