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fteval JOURNAL for Research and Technology Policy Evaluation

ISSUE 51 | NOVEMBER 2020

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EDITORIAL

DEAR READERS!

We proudly announce that our Editorial Board gained a new member this year: Falk Reckling, Head of the Strategy Department 'Policy, Evaluation, Analysis' at the Austrian Science Fund joined the Board. A warm welcome from the Editorial Team!

The present issue of the fteval Journal on Research and Technology Policy Evaluation is a thematic one: The theme of this issue is Europe. The topic is a perennial one, but of particular importance in times of Brexit and travel restrictions due to the COVID-19 pandemic. In this issue we want to highlight the European dimension of RTI policy evaluation and share findings and lessons learned.

Contributions range from exercises conducted in single European countries, via evaluations on European programmes, to general reflections on concepts and standards, which are widely applied across the EU or have an intrinsic European dimension.

The first two articles inform about specific evaluation experiences. The first paper is an evaluation exercise analysing ERDF and Horizon 2020 project data. The second presents a collective approach in the design, implementation, and validation of a study on research assessment processes of research funding and research performing organisations commissioned by Science Europe.

The following two contributions provide reflections on a conceptual level. Firstly, major conceptual and practical problems of evaluating internationally oriented R&I strategies and policies of several European Member States are discussed. The fourth paper reflects on key elements of evaluation frameworks for transformative R&I programmes in Europe, which aspire to contribute to solve socio-economic challenges and spur transformation.

Followed by two specific thematic contributions, the next article deals with gender aspects by developing an evaluation framework to design and evaluate gender equality interventions in research and innovation. Article six discusses the impact of innovative capacity on innovation related outcomes, illustrated by the example of the German aerospace sector.

The final article discusses the role of standards and standardisation for research and innovation policy and presents an outline to policy developments and support mechanisms in place at European level, in Germany, and in Austria to improve the usage and development of standards.

Should you be interested in publishing in the fteval Journal for Research and Technology Policy Evaluation, please consult our website or get in direct contact with us. Our upcoming issue #52 will be topically open, but of course we will keep the conversation about Europe on the radar.

We wish you a good read!

Yours,

Klaus Schuch and Isabella Wagner
for the Journal's Editorial Team

November 2020

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EU RESEARCH & INNOVATION FUNDING SCHEMES: USING PROJECT-LEVEL DATA FOR MONITORING & EVALUATION

JULIA BACHTRÖGLER-UNGER AND MATHIEU DOUSSINEAU

DOI: 10.22163/fteval.2020.486

ABSTRACT

This non-technical article promotes the use of project-level data for monitoring and the evaluation of EU research and innovation policy. First, a new dataset of R&I-related projects co-funded by the ERDF during the multi-annual financial framework 2014-2020 is introduced. Second, this data is used, together with Horizon 2020 project information, in order to explore interlinkages between the funding schemes in terms of thematic priorities as well as beneficiaries. On average, 15% of ERDF projects could be identified as being carried out by a beneficiary that also receives funds from the Horizon 2020 programme.

INTRODUCTION

The European Union (EU) provides substantial amounts of funding for research and innovation (R&I) activities in European Member States. Fostering R&I in order to strengthen the EU's global competitiveness has been a key priority of EU policies in the multi-annual financial framework (MFF) 2014-2020. As recently decided in a Special Meeting of the European Council (1720 July 2020), also in the MFF 2021-2027 *"particular priority shall be given to delivering a substantial and progressive enhancement of the EU's research and innovation effort"* (European Council, 2020, p. 17).

In the MFF 2014-2020, Horizon 2020 has been the financially most powerful programme fully dedicated to enhancing R&I. In addition, European Structural and Investment Funds (ESIF) as well as funds specifically targeted at the development of a global satellite navigation system (Galileo) or the improvement of earth observation (Copernicus) provide financing for projects and activities in the R&I sphere (Reillon, 2015). Apart from Horizon 2020 which distributes almost €80bn over the period from 2014 to 2020[1], the largest R&I funding volume is provided by the European Regional Development Fund (ERDF) which is part of ESIF and thus the EU's cohesion and structural policy. The ERDF budget specifically R&I related for the MFF 2014-2020 amounts to €40.9bn[2].

These two major European R&I funding schemes differ considerably in terms of funding principles, regulation and eligibility criteria. On the one hand, the Horizon 2020 programme is based on the excellence of individual R&I projects and does not consider the location of tenderers. Very often, international consortia are awarded contracts in the tendering process. On the other hand, the objective of the ERDF is to foster smart, sustainable and inclusive growth in European regions. Beside other thematic objectives, strengthening research, technological development and innovation represents one (important) vehicle to achieve this goal. The choice of funded projects is mostly non-competitive and depends on strategic considerations considering the development and structural characteristics of the region. Moreover, ERDF allocation is place-based (see e.g. Barca et al. 2012, Foray et al. 2009). The design of regional or national smart specialisation strategies has become a central instrument to support EU Member States in identifying competitive niches and concentrating R&I resources co-financed by the ERDF on a few strategic priority areas.

In order to increase the impact of European R&I policies, Member States are encouraged to develop synergies between the main sources of R&I funding. Thus, the Stairway to Excellence pilot project (S2E) was initiated in 2014, funded by the European Parliament and implemented by the European Commission with the aim to support EU Member States and their regions in developing and exploiting synergies among EU programmes. Synergies can occur through the combined usage of ERDF (ESIF) and Horizon 2020 resources for the same project, consecutive or parallel projects or the co-financing of shortlisted Horizon 2020 proposals which were not funded because of a lack of financial resources through the ERDF (European Commission, 2014). In addition, to foster the achievement of synergies, improvements in coordination and communication between planning and implementing bodies, i.e. managing authorities of operational programmes and national contact points for

1 According to European Council (2020), p.18, the budget of the follow-up programme Horizon Europe for the MFF 2021-2027 will decrease to €75.9 bn.

2 Among ESIF, also the European Agricultural Fund for Rural Development commits €2.2 bn for funding R&I. Retrieved from https://cohesiondata.ec.europa.eu/themes/1# (accessed: 8 October 2020).

Horizon 2020, as well as an alignment of funding principles are required (Perez et al. 2014, Özbolat & Harrap 2018). The conclusions of the Special Meeting of the European Council in July 2020 also highlight the objective of coordinating *"R&I activities funded through Horizon 2020 with those funded under other EU programmes, including through cohesion policy. [...] Important synergies will be needed between Horizon Europe and the structural funds for the purpose of 'sharing excellence', thereby enhancing regional R&I capacity and the ability of all regions to develop clusters of excellence."* (European Council, 2020, p. 18).

To analyse existing interrelationships, synergies or non-intended overlaps between European R&I funding, case studies or interviews with institutional actors or beneficiaries seem to be appropriate research methods. However, these approaches are typically limited to a selection programmes and calls, respectively, or a few regions or Member States given available resources. In order to study interlinkages and synergies between the funding schemes considering the full programmes in all EU Member States, one possibility is to explore and contrast characteristics of (co-)funded projects and beneficiaries.

First, in terms of thematic classification, a synergy between funding schemes may arise by aligning Horizon 2020 and ERDF among a set of technological or policy areas. In order to build on a common analytical framework, we consider as specialisation areas the Horizon 2020 key enabling technologies (KET) and societal grand challenges (SGC). While the relevant KET and SGC assignments are reported for Horizon 2020 projects in the CORDIS database[3], detailed ERDF project-level information is required in order to be able to assign KET and SGC to ERDF projects. For the thematic classification, keywords associated to different KET and SGC provided by the ontological approach of the KNOWMAK project[4] are used.[5]

Second, synergies of funding may occur if the same beneficiary, e.g. the research and development department of a company, an innovative SME or a university, successfully applied for funding from both funding schemes. In order to find out whether there are private or public entities which receive funding for R&I activities from both ERDF and Horizon 2020, it is necessary to investigate the micro-level distribution of both funding schemes.

Next to analysing linkages between funding schemes, project-level data enables further analyses of interest for policy evaluators, policy makers and the public. By linking the beneficiaries' data with business information, such as balance sheet or patent data, policy impacts can be estimated at the individual or small-scale geographical level (see e.g. Fattorini et al. 2019, Bachtrögler et al. 2020b). Using data on INTERREG projects in MFF 2014-2020, Darvas et al. (2019) find that different types of projects contribute differently to successful policy implementation.

The aim of this practice-oriented article is to introduce a new dataset of R&I-related projects co-funded by the ERDF during the MFF 2014-2020 and to present possibilities to analyse interlinkages between R&I funding through the ERDF and Horizon 2020 using project-level data. As the dataset includes project- and beneficiary-level information for all EU Member States and the United Kingdom, this approach does not only serve for national or case studies but allows a contribution to R&I policy monitoring and evaluation at the EU level. The dataset of ERDF projects as well as the link with Horizon 2020 data has been developed in the course of the S2E project.[6]

DATA ON PROJECTS CO-FUNDED BY ERDF AND HORIZON 2020

The Horizon 2020 programme is centrally implemented and managed by the European Commission which develops work programmes and issues calls for proposals, evaluates them and monitors the progress of funded projects (Perez et al. 2014). Thus, project data is also collected by the European Commission and published in the CORDIS database.

Conversely to Horizon 2020 and due to the principle of shared management which implies policy implementation at the level of Member States, a complete structured database of ERDF projects does not exist. In the current programming period, the distribution of ERDF funds in European Member States is based on smart specialisation strategies that are designed and implemented under shared management between the Commission and regional or national authorities. Accordingly, monitoring and evaluation also happens at different levels. At the European Commission level, monitoring of cohesion policy is carried out at operational programme (OP) level with limited accuracy in terms of geographical information (depending on the member state, there are not only regional but also national as well as multiregional OPs), or at the regional level. For the latter, allocations by fund and thematic categories are added up for each NUTS-2 region. Project-level data is provided only for a selection of representative projects on the ESIF open data platform.[7]

Reporting of EU cohesion and structural policy at the level of project and beneficiaries is carried out in national or regional databases. According to Article 115(2) of Regulation (EU) No 1303/2013 (common provisions regulation), managing authorities of OPs are required to provide a list of operations with certain minimum information such as project title, description, location, start and end date, total eligible expenditure and a category of intervention (see Annex XII of the Common Provisions Regulation (EU) No 1303/2013).

In the course of S2E, a project was initiated to design and set up a structured and comprehensive database of operations funded by the ERDF and corresponding beneficiaries for the MFF 2014-2020 (comprising projects initiated by June 2019), based on the systematic collection of all information available at national and regional levels. The resulting ERDF database contains more than 238,000 projects in 27 EU Member States and the United Kingdom, covering around half of ERDF commit-

3 CORDIS (EU research results): https://cordis.europa.eu/en.

4 The aim of the KNOWMAK project is to develop a web-based tool, which provides interactive visualisations and indicators on knowledge co-creation in the European research area. The tool is developed by the European Research Infrastructure for Science, technology and Innovation policy Studies (RISIS) (see https://project.knowmak.eu/about/project-overview/ and https://www.knowmak.eu/).

5 Note that the KET taxonomy of the KNOWMAK project does not completely mirror the one by the Horizon 2020 programme. First, the KET related to space is not considered and, second, the one related to ICT only considers hardware technologies (micro- and nanoelectronics and optics and photonics).

6 See Bachtrögler et al. (2020a) for the technical documentation of the dataset of R&I projects co-funded by the ERDF during the multi-annual financial framework 2014-2020. The data is available in the R&I Regional Viewer: https://s3platform.jrc.ec.europa.eu/synergies-tool.

7 For more information see https://cohesiondata.ec.europa.eu/projects.

ments for the complete MFF 2014-2020 (see Bachtrögler et al. 2020a). Based on the categories of intervention, it is defined whether a project is attributed to the R&I sphere.[8]

While the 86 categories of intervention allow a granular thematic classification of projects co-financed by the ERDF, the Horizon 2020 database provides a thematic categorisation of funded activities based on key enabling technologies (KET) and societal grand challenges (SGC). In order to link the datasets, KET and SGC are assigned to ERDF projects according to project names and descriptions based on the KNOWMAK[9] ontology, which enables comparing the thematic priorities of R&I funding by ERDF and Horizon 2020 in European Member States and regions. Furthermore, beneficiaries profiting from both schemes are identified by name matching and additional manual checks.

R&I-RELATED ERDF FUNDING AND ITS INTERLINKAGES WITH HORIZON 2020

Among all projects co-funded by the ERDF, more than 84,500 projects are classified as R&I-related according to the definition stated above. This is around a third of all projects in the dataset based on lists of operations as reported by June 2019. Those R&I related projects correspond to around €35bn of ERDF funds, which is approximately a quarter of the total ERDF co-financing amount reported in the dataset. Thus, the dataset covers a considerable share of the ERDF budget for the thematical objective "Research & Innovation" (€40.9bn[10]).

However, the share of R&I projects among all funded ERDF projects varies significantly across Member States and regions. While more than half of ERDF funds reported in the dataset are dedicated to R&I activities in Denmark, Finland, Luxembourg, Latvia, the Netherlands and Sweden, more than a third of project expenditure is related to R&I in Austria, Germany, Estonia, Spain, Slovenia and the United Kingdom. The lowest shares of R&I-related projects lie below 10% and occur in Bulgaria, Greece, Croatia and Romania (Bachtrögler et al. 2020a, p. 6).

In large part, this pattern mirrors the level of economic development relative to the EU average which implies different funding priorities in less and more developed regions in order to increase GDP growth. In Bulgaria and Romania, the largest amounts of ERDF funding are invested in transport infrastructure projects (among others, railways, clean urban transport infrastructure and TEN-T motorways and roads). Likewise, the most important category of intervention in terms of the absolute sum of project amounts in Greece is "Clean urban transport infrastructure", for Croatia the second most important one is "TEN-T motorways and roads".

Figure 1 presents the share of R&I-related ERDF funding per NUTS-2 region and reveals significant within-country variation. Note that detailed information for Hungary is only available for R&I projects and Irish data is provided for only one of two operational programmes.

Furthermore, project- and beneficiary-level data, respectively, allows to link funding data with business information such as the AMADEUS database. By applying name matching it was possible to enrich beneficiaries' data for around 60% of R&I-related projects, and after further manual checks, a NACE main category could be assigned to more than three quarters of projects. However, it is essential to take into account that the coverage of AMADEUS data varies strongly between countries, i.e. from below 2% of R&I projects in Cyprus to 83% in Hungary (the average and median coverage per country amounts to approximately one third of projects).

Considering eleven Member States for which the coverage with AMADEUS data lies above 25%, almost 80% (more than 25,000) of individual beneficiaries can be assigned a NACE industry (main category). While the majority of those, i.e. more than a third, are manufacturing firms, almost a fifth of beneficiaries are carrying out professional, scientific and technical activities or operate in the education sector. Therefore, there appears to be a considerable number of ERDF beneficiaries such as research institutes, universities or innovation-oriented manufacturing firms that could potentially also profit from Horizon 2020 funds.

Linking ERDF beneficiaries with the CORDIS database allows to investigate this in more detail. A comparison of ERDF and Horizon 2020 beneficiaries reveals that there is indeed a significant number of firms, universities and research institutions involved in and profiting from both programmes. Around 15% of R&I projects co-funded by the ERDF are carried out by beneficiaries that also receive Horizon 2020 funds. Considering individual beneficiaries, this corresponds to 5% of ERDF beneficiaries.

Interestingly, Table 1 shows that the number of beneficiaries of both programmes differs strongly across countries. Countries with a relatively small share of R&I-related ERDF projects such as Bulgaria, Greece and Croatia correspondingly appear at the bottom of the ranking in terms of the share of beneficiary overlap. By contrast, e.g. also in Estonia, which dedicates more than a third of ERDF amounts to R&I projects, only 3% of ERDF beneficiaries also receive Horizon 2020 funds.

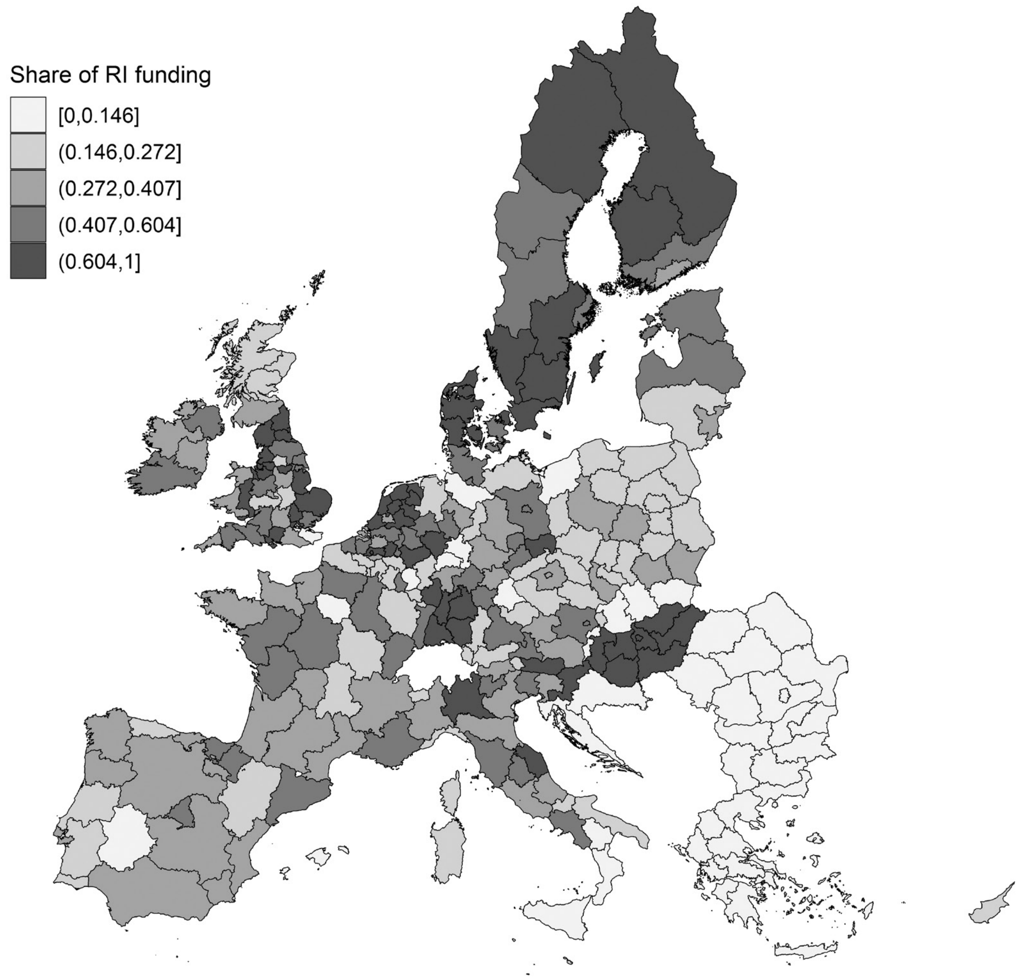
8 R&I related categories of intervention include R & I processes in large enterprises and SMEs, Investment in infrastructure, capacities and equipment in SMEs and large enterprises directly linked to R&I activities, Public and private R&I infrastructure, R&I activities in research centres, Technology transfer and university-enterprise cooperation as well as cluster support and business networks primarily benefiting SMEs, Cluster support and business networks (Bachtrögler et al. 2020a, pp. 7 f.).

9 www.knowmak.eu

10 Retrieved from https://cohesiondata.ec.europa.eu/themes/1# (accessed: 8 October 2020).

Figure 1: Share of ERDF co-funding amounts for R&I-related projects per NUTS2 region

Interval of shares in percentage points/100



Source: ERDF beneficiaries' database (https://s3platform.jrc.ec.europa.eu/synergies-tool) as described in Bachtrögler et al. (2020a), own analysis. Note that in Hungary detailed project data is only available for R&I-related projects. Five bins correspond to quantiles. Projects that could not be assigned to a (single) NUTS2 region are not considered.

Table 1: Share of ERDF beneficiaries carrying out R&I-related projects that also receive Horizon 2020 funds

Country	ERDF+H2020	Country	ERDF+H2020	Country	ERDF+H2020
IE	27%	LU	9%	HR	3%
AT	26%	ES	8%	CZ	3%
UK	23%	SI	7%	EE	3%
BE	19%	CY	7%	PL	2%
MT	17%	DE	7%	BG	2%
DK	15%	FI	7%	HU	2%
RO	12%	SK	6%	EL	2%
NL	11%	LV	6%	LT	1%
FR	11%	IT	6%		
SE	11%	PT	4%	**Average:**	**5%**

Source: ERDF beneficiaries' database (https://s3platform.jrc.ec.europa.eu/synergies-tool) as described in Bachtrögler et al. (2020a), own analysis.

The interlinkage between ERDF and Horizon 2020 funding data in terms of (the same) beneficiaries is one way to explore potential synergies among the funding schemes. Digging deeper into details on funded projects will allow to draw further conclusions on whether the funds are used for different types of projects, e.g. whether the ERDF supports investments in R&I infrastructure used for preparing Horizon 2020 projects. The latter is one way of exploiting synergies recommended by the S2E project (see Perez et al. 2014).

Another way to analyse the interaction between ERDF and Horizon 2020 beneficiaries is according to thematic priorities. For this kind of analysis, KET were assigned to more than 42,000 and SGC to almost 70,000 R&I-related ERDF projects based on project descriptions and the KNOWMAK taxonomy (multiple KET and SGC, respectively, can be assigned to one single project).

As Table 2 shows, the most frequent KET assigned to ERDF projects is biotechnology, followed by advanced materials, and nanoscience and technology. Regarding societal grand challenges, "inclusive, innovative and reflective societies" is the one that was assigned most often to ERDF projects. In addition, challenges corresponding to climate change and sustainability appear to be important issues for programmers of EU structural and cohesion policies. In comparison with other societal grand challenges, and in line with the priorities set in operational programmes, "Health, demographic change and wellbeing" is attributed to a relatively low number of ERDF projects, which – in the context of the current COVID-19 crisis – may gain importance in the future.

Table 2: Number of projects being assigned a specific KET or SGC

Key enabling technologies (KET)	Number
Biotechnology	28,800
Advanced materials	13,900
Nanoscience and technology	12,300
Micro- and nanoelectronics	9,000
Optics and photonics	7,900
Advanced manufacturing technology	6,400
Total number KETs assigned to 42,700 R&I projects	**78,300**
Societal grand challenges (SGC)[11]	**Number**
Europe in a changing world - inclusive, innovative and reflective societies	46,700
Smart, green and integrated transport	27,400
Secure, clean and efficient energy	24,500
Climate action, environment, resource efficiency and raw materials	24,100
Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy	21,400
Health, demographic change and wellbeing	18,500
Secure societies – protecting freedom and security of Europe and its citizens	16,100
Total number SGCs assigned to 69,800 R&I projects	**178,700**

Source: ERDF beneficiaries' database described in Bachtrögler et al. (2020a), own analysis.

CONCLUSION

This article promotes the use of project-level data for the monitoring and evaluation of EU (R&I) policies. In particular, it points to the analysis of the characteristics of R&I projects co-funded by different EU funding schemes (ERDF as part of ESIF and Horizon 2020) for exploring potential synergies or overlaps between those schemes. One limitation of analysing data at a high level of granularity is that more general intra- or interregional or nation-wide developments might be shaded. Therefore, combining data at different aggregation levels will be fruitful in many analyses.

While Horizon 2020 and R&I funding under the ERDF target different objectives and operate under different funding principles, this analysis has shown that 15% of R&I-related ERDF projects are carried out by beneficiaries that also receive funding from Horizon 2020. Furthermore, based on Horizon 2020 funding principles, several key enabling technologies, such as biotechnology, and societal grand challenges, such as inclusive, innovative and reflective societies or sustainable transport, also appear to be priorities in the distribution of ERDF funding within European regions.

In line with the plans of the European Council for the next MFF 2021-2027, the detailed analysis of project- and beneficiary-level data could help to improve the alignment of funding procedures and strategies in order to generate synergies. Thereby, patterns of concentration of funding in different EU regions can be investigated as well as the research question whether these patterns matter for the overall effectiveness of EU R&I policies.

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KEYWORDS
ERDF, Horizon 2020, EU Research and Innovation Policy, Evaluation, Funding Interlinkages

RESEARCH ASSESSMENT PROCESSES: GATHERING EVIDENCE FOR A SCIENCE EUROPE INITIATIVE FOR MUTUAL LEARNING

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DOI: 10.22163/fteval.2020.487

ABSTRACT

This paper discusses a collective approach in the design, implementation and validation of a study commissioned by Science Europe on research assessment processes of research funding and research performing organisations. The collective approach is based on the involvement of its member organisations and Science Europe itself at different stages of the study for the mutual learning of all stakeholders and the community in general.

This paper describes the study, including the purpose, methodology and findings, and discusses the importance of its findings and recommendations for research funding and performing institutions, as well as the singularity of its approach from the perspective of evaluation practices.

INTRODUCTION

Assessment of research is conducted in a wide variety of situations, such as the review of research output, decisions on future research, the appraisal of researchers and also of entire research units and organisations. This is reflected by a wide range of approaches and criteria, often dependent on the academic discipline, institution profile, etc. The challenges, however, are often similar, such as a high number of applications, limited resources, difficulties to differentiate among applications, the trade-off between excellence and relevance, etc.

In 2019, our institution conducted a study on behalf of Science Europe (SE) to explore practices used for the selection of research proposals in competitive research funding programmes and the selection of researchers for promotion within research organisations. The study deliberately puts the focus on generic programmes, "to establish a thorough and comparable knowledge base of the current and developing assessment processes." (SE 2020a, p. 9). The study was part of a broader exercise leading to a set of recommendations on research assessment processes published by SE in July 2020.

Although the entire process must not be taken as an evaluation, it has interesting aspects in common, most importantly, the establishment of a sound and comparable evidence base with the objective of institutional (and policy) learning. The exercise was partly motivated by the broad discussion on new approaches to research assessment – it was then somewhat surprising that the evidence gathered in our study showed that generic programs are widely based on standard processes. This article presents our approach to capture dynamics in a slowly moving context. Before that, we provide an introduction to the broader framework of our study, as we are convinced that this is a promising setting to feed empirical results into design processes, and thereby reinforce the above-mentioned dynamics.

SCIENCE EUROPE DIGGING INTO RESEARCH ASSESSMENT PROCESSES

Science Europe (SE) represents the major public research organizations in Europe. It has 36 members from 27 European countries, of which 31 are research funding organizations and five are major research performing organizations. Founded in 2011 in Brussels, it provides a collective voice for its member organisations (MOs) to advocate and shape science policy and funding. "Ensuring the quality of science" is one of the long-term objectives of SE, and the improvement of research assessment practices is one of the derived priorities, next to cross-border collaboration, EU framework programs, open access, research data, research infrastructure, and recently also COVID-19. Based on consultations, events, and studies, SE produces a variety of publications, like responses/reactions to (European) policies, briefing papers, brochures, factsheets, joint or position statements, as well as survey reports to give examples.

In July 2020, SE published a position paper with recommendations on research assessment processes, based on a study launched by SE and conducted by our institution in 2019 and a broad consultation among Science Europe MOs and stakeholders from the research community in 2020. These recommendations shall provide a framework for further development and optimization of processes and aim to promote knowledge sharing and mutual learning between research organizations.[1] They are linked to previous and ongoing work of other international initiatives, like

1 See Science Europe (2020a), p9.

the San Francisco Declaration on Research Assessment (DORA), the Leiden Manifesto for Research Metrics (Hicks et al, 2018), Global Research Council (2018) Statement of Principles on Peer/Merit Review, the Joint Statement on Research Assessment, jointly released by Science Europe and the European University Association (EUA) and various publications of Science Europe. The recommendations address the following dimensions and themes:

- Approaches used to assess and select proposals and researchers: (i) transparency of research assessment processes, (ii) evaluation and monitoring the robustness of research assessment processes;
- Challenges faced during assessment processes: (i) discrimination, bias, and unfair treatment in research assessment practices, (ii) cost and efficiency of research assessment processes, and applicant investment of time and effort;
- Current developments in the assessment of proposals and researchers.

These recommendations are primarily about assessment processes and methods, and not so much about criteria.[2]

In this article, we focus on the process of this undertaking, to share the experience of contributing as external consultants to a collective evidence gathering and analytical exercise, in the following four sections: First, we present our role as external consultants in the broader context, which is different to our "classical" role as external evaluators (section 3). Section 4 provides a summary of the key findings of our study, on research assessment practices. In section 5, we present our methodology to grasp change, section 6 provides some conclusion on the relevance of this undertaking for the research policy evaluation community.

GATHERING EVIDENCE FOR SCIENCE EUROPE: THE EMBEDDEDNESS OF THIS STUDY IN A BROAD PARTICIPATORY PROCESS

In July 2019, following a competitive call for tenders, our institution was commissioned a study on research assessment processes. The objective of the study was "to investigate ways to find out how SE member organisations (MOs) processes for research assessment lead to selecting the best projects for funding and researchers for their career progression."[3] The findings are based on the analysis of policy documents and documentation specific to the participating RFOs and RPOs[4], an online survey covering their 'generic competitive funding' or 'generic researcher promotion' scheme[5], followed by 20 semi-structured in-depth interviews with a subset of these organisations, and a validation workshop with the Task Force on Research Assessment (TF) set up by SE, as well as representatives of the Science Europe Office.

The following questions have guided the study:

1. What approaches are used to assess and select proposals and researchers in a robust, fair and transparent manner?
2. What are the challenges that research organisations face during the assessment processes?
3. What are the current developments in the assessment of research proposals and researchers?

It is important to note that our study is one piece in a broad participatory and collective exercise, involving member organisations of SE as well as other invited organisations at several points in time as shown in Figure 1.

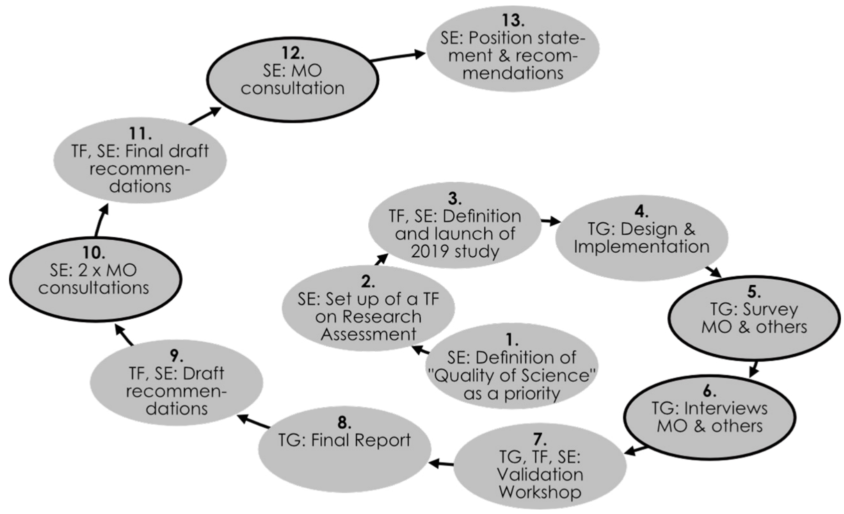

Figure 1: The Science Europe activity on research assessment processes, 2019 – 2020
Source: own graph

2 Ibid.
3 See Science Europe (2020b), p2.
4 These include annual and final reports of funding actions, publications of calls for applications, regulations of the processes in research assessment exercises, and guidelines for applicants and reviewers participating in the assessments.
5 The survey provides a broad overview with particularly good coverage of funding organisations that are members of Science Europe, and additional information of some non-members as well as non-European RPOs and RFOs. It was completed by 38 organisations (33 RFOs, 4 RPOs and 1 organisation that functions both as RFO and RPO), with an overall response rate of 86%.

In the evidence-gathering phase, participants responded to the questionnaire survey (step 5) and some of them were also interviewed (step 6). In the concluding phase, member organisations were involved in broad consultations (steps 10 and 12)[6], based on a first draft and then revised draft of recommendations and a first draft of conclusions in form of the Position Paper prepared by the TF and SE.

In addition, the TF which is composed of representatives from seven member organisations, played a crucial role in the design and launch of the study (step 3), in the discussion and validation of study results (step 7), and drafting and finalising conclusions (steps 8, 10, and 12). Therefore, the study was designed as a truly collective exercise in which external consultants engaged with all other types of stakeholders for the different phases of the study in different roles: with MOs as participants (step 5 and 6), MOs representatives as members of TF, TF and SE as validation partners (step 7-10).

Our institution mainly had the role of a service provider for the professional collection of evidence and data analysis. Following the terms of reference of the study, we developed and used an appropriate methodology and tools to carry out the study, including suggesting the necessary amendments to the proposed questionnaire to ensure that the online survey is robust, and then collected and analysed the data gathered through the online survey and subsequent targeted interviews.

KEY FINDINGS ON ASSESSMENT PRACTICES

The key findings of the study can be summarised as follows:[7]

DIVERSITY OF ORGANISATIONS WITH WIDELY SHARED BASIC PRINCIPLES ON RESEARCH ASSESSMENT

Although the organisations participating in this study are of diverse nature, have a different focus and implement a variety of programs, they have common well-established practices for the assessment of research and researchers, primarily the use multi-stage research assessment processes, external single-blind peer reviews and panel reviews. Other approaches such as rankings, external open reviews, and internal single-blind reviews are also used but to a lesser extent. The least common approach is double-blind reviews, although it is used by one participating RFO with satisfactory results to make the research assessment more objective.

Transparency has received considerable attention in the design of the research assessment processes of the participating organisations not only after the assessment process has been concluded (i.e. by providing feedback from reviewers) but also prior to it (i.e. the publication of the assessment criteria, description of the process and actors) and during its implementation (i.e. through the introduction of rebuttal phases).

CHALLENGES DURING THE ASSESSMENT PROCESS

The mandate to ensure that the assessment process successfully selects the best projects for funding and researchers for promotion was discussed with the participating organisations. Reliance on competitive systems, peer review, multi-stage evaluation processes, written assessment guidelines and qualitative evaluations were discussed by most participating organisations as the key elements for ensuring robust assessments in this regard. Additionally, measures to prevent and detect discrimination and bias are in place in most organisations. The most scrutinised potential biases are gender and discipline, followed by affiliation in the case of RFOs and seniority in RPOs. Generally, the regulations or guidelines for assessment established by the organisations raise awareness on this topic and 68% of the surveyed organisations form reviewer panels with diverse profiles to minimise potential discrimination or bias.

Limited research funds and academic positions set more pressure on research and promotion assessment processes. Particularly challenging is distinguishing and ranking proposals and candidates for promotion when they are of similar quality and worth funding/promoting.

The cost and efficiency of the research assessment are also discussed, particularly in evaluations that do not rely on quantitative indicators. Moreover, the balance between the quality and cost of the research assessment is of critical importance not only for the organisations but also for the scientific community whose members are involved as reviewers and for the applicants. Approaches for improved efficiency for these three stakeholders were discussed by the participants. Some of these approaches aim to optimise the assessment and application efforts, for instance, through the introduction of a scoring system that translates the qualitative assessment to a quantitative scale that facilitates the ranking of candidates, or the introduction of multi-stage evaluation processes to reduce the effort invested by both reviewers and applicants, or the streamlining of funding schemes and standardisation and the standardisation of application processes.

CURRENT DEVELOPMENTS IN RESEARCH ASSESSMENT AND ALTERNATIVE METHODS

Most organisations rely on a qualitative assessment of research, some of them in combination with quantitative approaches (i.e. the number of publications in high-ranking journals) but most of them give higher importance to the qualitative assessment than to any other quantitative approach. Some interview participants elaborated on recent updates on guidelines for assessment to inform reviewers of the importance of the qualitative assessment and to discourage the use of metrics.

Experimentation with alternative assessments systems and tools takes place at a rather incremental basis and in selected small programs. Drawing lots, sandpits, double-blind assessments are being piloted by some organisations, while in others these are already in place mostly for specific programs and purposes. Several organisations are considering

6 In step 10, the first consultation was in written format, the second was organised in way of two virtual meetings: "A first draft of policy recommendations, based on the knowledge gathered from the 2019 Study, was formulated by the SE Office and the TF in January 2020. An online consultation survey was run between 4 February and 11 March for all SE MOs, wheter they had participated in the first phase or not. A remote video-conference workshop was held on 24 March for nominated expers from SE MOs to further discuss the recommendations and topics." At that point, commonalities and divergences in SE MO strategies were identified, these diversities "were the subject of a second virtual discussion during an SE MO consultation event on research assessment processes on 24 March." (SE 2020b, p3). Based on that, the SE Office and TF developed a first draft of the Position Statement (step 11) which was sent to SE MOs for a third and final written consultation (step 12.)

7 This section quotes parts of the executive summary of the study (Technopolis Group 2019).

the use of altmetrics, while some others do not use it but recognise a broad format of research outputs.

Although non-academic impact and significance are often not considered in large generic research funding programs and promotion schemes, evidence was gathered on several RFOs creating mission-oriented funding schemes to prioritise such kind of research. These programs are adapting their research assessments with different or extended criteria and reviewers to better assess this kind of research.

OUR APPROACH TO GRASP DYNAMICS

According to the terms of reference, the study should identify trends, gaps and new directions with regard to testing robustness of selection processes, assessment tools and pilots and experiments. However, related to their generic programs – which are the focus of the study –, most organisations regularly revise and refine small aspects of their research assessment methods on a more-or-less incremental basis. Despite a broad discussion of challenges and resource limitations, major changes could hardly be observed in practice. In order to grasp these dynamics, we opted for two ways of questioning:

The first option was to ask respondents to indicate whether their organisation has implemented changes in the way research proposals or candidates for promotion are assessed, or whether they plan to do so.[8] This allows a differentiated understanding of tools and practices. As shown in Table 1, for most organisations the assessment of the research content of scholarly publications is either a long-standing practice, a recent change or a planned change. The broadening of the range of quantitative tools used to assess research is considered by a significantly lower proportion of organisations. In fact, most organisations have reduced or are planning to reduce the use of journal-based metrics. However, it is difficult for RFOs and RPOs to verify whether reviewers do not use quantitative tools or criteria in their assessment.

As a second option, along with the information about current or past use of an element and considerations to use it in the future (or not), respondents with the experience of using it (currently or in the past) were asked to assess its importance. This approach was for instance used to identify aspects of research that reviewers are required to assess in research assessments (Table 2).

	Long-standing practice	**Made this change**	**Planning to make this change**	**Not made this change and not planning to do so in the future**	**Do not know**	**Not applicable**
Reducing the use of journal-based metrics	8 (21%)	13 (33%)	3 (8%)	7 (18%)	4 (10%)	4 (10%)
Eliminating the use of journal-based metrics	6 (15%)	9 (23%)	4 (10%)	9 (23%)	6 (15%)	5 (13%)
Broadening the range of non-publication research outputs required to assess	4 (10%)	14 (36%)	5 (13%)	8 (21%)	5 (13%)	3 (8%)
Broadening the range of quantitative tools that are used to assess research impact	1 (3%)	6 (15%)	6 (15%)	14 (36%)	7 (18%)	5 (13%)
Considering qualitative indicators of research impact, such as influence on policy and practice	6 (15%)	10 (26%)	5 (13%)	11 (28%)	5 (13%)	2 (5%)
Considering the research content of the scholarly publications[9]	17 (44%)	7 (18%)	6 (15%)	3 (8%)	3 (8%)	3 (8%)
Being explicit about the criteria used in the assessment	29 (74%)	2 (5%)	4 (10%)	1 (3%)	2 (5%)	1 (3%)

Table 1: Long-standing practices, changes and plans for changes in research assessments Source: own data based on the survey answers of the organisations participating in this study (n=39).

8 See Technopolis Group (2019), p. 18f.

9 The assessment of the content of the scholarly publications was often conducted on a selection of publications provided by the applicant as relevant previous work.

	Currently using	Used in the past	Never used but considering using in the future	Never used and not considering using in the future	For organisations (RFOs and RPOs) that are using or have used the respective aspects: Very important	Moderately important	Less important
Soundness of the proposed methodology	32 (100%)	0 (0%)	0 (0%)	0 (0%)	29 (91%)	1 (3%)	0 (0%)
Feasibility of the proposed research	33 (100%)	0 (0%)	0 (0%)	0 (0%)	29 (88%)	2 (6%)	0 (0%)
Resource allocation in line with objectives	31 (97%)	0 (0%)	0 (0%)	1 (3%)	17 (55%)	11 (35%)	1 (3%)
Feasibility of research in relation to applicants' expertise	33 (100%)	0 (0%)	0 (0%)	0 (0%)	27 (82%)	4 (12%)	0 (0%)
Complementary expertise of researchers	28 (97%)	0 (0%)	1 (3%)	0 (0%)	16 (57%)	11 (39%)	0 (0%)
Dissemination plan	28 (88%)	1 (3%)	1 (3%)	2 (6%)	11 (38%)	13 (45%)	3 (10%)
Novelty of the research question	33 (100%)	0 (0%)	0 (0%)	0 (0%)	24 (73%)	7 (21%)	0 (0%)
Potential econ. and soc. Impact	22 (69%)	1 (3%)	2 (6%)	7 (22%)	6 (26%)	14 (61%)	1 (4%)
Potential transfer/ commerc.	19 (59%)	2 (6%)	2 (6%)	9 (28%)	2 (10%)	13 (62%)	3 (14%)
Potential contribution to public policies	17 (55%)	2 (6%)	2 (6%)	10 (32%)	4 (21%)	10 (53%)	2 (11%)
Ethical considerations	32 (100%)	0 (0%)	0 (0%)	0 (0%)	25 (78%)	5 (16%)	1 (3%)

Table 2: Aspects of research that reviewers are required to assess in research assessments.
Source: own data based on the survey answers of the organisations participating in this study (n=39).

This allows the analysis of trends both in terms of use and relevance of aspects reviewed in research assessments. For example, the study provides evidence that the majority of the programs already ask reviewers to consider the potential economic or societal impact in their assessment. However, only a minority ranks this as highly important. This might be surprising as research policy is increasingly considering the need to stimulate research in directions that provide knowledge relevant to tackle societal challenges. In fact, the 'generic programmes' organisations participating in this survey indicated they mainly focus on scientific criteria and have a high level of stability of assessment criteria, as not many changes have taken place in the past, nor are considered for the future.

CONCLUSION

Science Europe's (SE) engagement to analyse research assessment processes and formulate related recommendations provides several learning opportunities for the evaluation community, even if it is undoubtedly not an evaluation itself.

First, it brings more light into research assessment processes and SE's member organizations' approaches to evaluate these processes. This was not the focus of this article, but in the position paper, SE recommends that "All organisations should conduct evaluations of the robustness of their assessment processes.", and "Organisations should

10 fteval symposium "commitment in internal evaluations", 30.11.2020 in Vienna.

re-evaluate their processes at fixed intervals, whenever broad reforms to assessments are implemented, or when problems are identified." (SE 2020a, p. 13). As a matter of fact, this kind of evaluations gain importance, and fteval will also devote an event on this topic.[10]

Second, the approach clearly aligns with some of the defining principles of evaluations, namely "a transparent and systematic procedure, based on empirically obtained data; distinct from everyday assessment procedures" (fteval 2019, p6). However, here, in contrast to evaluations, the entire process of the study constituted a collective exercise, in the sense that a community of actors engaged in the formulation of recommendations for themselves. They are organized in an association, with administrative support, a task force and the support of an external service provider for the collection of evidence. This collective approach naturally complies with the 3rd principle of RTI Evaluations (fteval 2019, p. 11), addressing participation, and seems particularly promising concerning the 4th principle, namely utilization and benefits: "The benefits of an evaluation are generally enhanced if relevant interest groups are involved in the evaluation process, if specific evaluation questions are formulated and responded professionally, and if coherent recommendations are communicated as a result of the evaluation" (p.12).

In return, the 7th principle of independence needs to be looked at more closely, it states "the evaluation is not materially influenced or manipulated by political interests, the client, programme managers or those affected, nor by any possible bias of the evaluators themselves." In this kind of study, we would argue that the inclusion of all member organisations in the analytical phase (not only for providing data and information), provided transparency and re-iteration and ensured that the result has no bias. We would, however, argue that the involvement of external consultants with sound experience in (independent) evaluation procedures helped to ensure that the evidence base has clear priority over any individual interest.

As a matter of fact, evidence on research assessment processes in generic programs shows that they are more stable than we would have expected, given the challenges, growing constraints, but also new technical opportunities. Sound questioning approaches allowed to get a differentiated view on past and present experience, intentions and the importance of a broad range of aspects. Many of these were taken up in the SE's recommendations published in July 2020. Of course, their implementation can only be assessed after a while, but the active involvement of the member organisations in their formulation is both promising and exemplary.

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KEYWORDS
Research assessment; collective evidence validation; assessment dynamics; Science Europe; research funding organisations; research performing organisations.

CONCEPTUAL AND PRACTICAL PROBLEMS OF EVALUATION OF INTERNATIONAL R&I POLICIES

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DOI: 10.22163/fteval.2020.488

INTRODUCTION AND SCOPE

This article discusses major conceptual and practical problems of evaluating internationally oriented R&I strategies and policies of a number of European Member States. The article, however, is not based on an originally exercised evaluation study but systematises and summarises results from a so-called Mutual Learning Exercise, which has been implemented under the Horizon 2020 Policy Support Facility. The findings deal with the complexity of R&I internationalisation strategies and their specific policies and support schemes, and in particular the difficulty in conceptually approaching them in evaluative ways due to various factors. These include shortcomings in the logic and design of the R&I internationalisation strategies, the identified gap between the high-level internationalisation objectives and the specific policies as well as practical issues concerning data and indicators.

In section 2, we provide information about the Horizon 2020 Policy Support Facility and the Mutual Learning Exercise on National Strategies and Roadmaps for International Cooperation in R&I, which constituted the operational and methodological framework as well as the empirical basis of the findings presented in this article.

In section 3, we discuss how some of the conceptual deficits of R&I internationalisation strategies impede evaluations that are more complex and in section 4 we focus on fundamental practical challenges of evaluating R&I internationalisation policies.

Both in section 3 and section 4, we also aim to explain the background and reasoning for the two main recommendations regarding evaluative issues, which were elaborated during this Mutual Learning Exercise on National Strategies and Roadmaps for International Cooperation in R&I.

THE HORIZON 2020 POLICY SUPPORT FACILITY AND THE MUTUAL LEARNING EXERCISE ON INTERNATIONAL COOPERATION IN R&I

The Horizon 2020 Policy Support Facility (PSF) is a specific instrument of the European Commission funded under Horizon 2020. It gives Member States and countries associated to Horizon 2020 practical support to design, implement and evaluate reforms that enhance the quality of their research and innovation investments, policies and systems.

The Policy Support Facility aims to provide best practice, independent high-level expertise and guidance at the request of Member States and countries associated to Horizon 2020 (i.e. Associated Countries) to support evidence-based policy making through a number of services: Peer Reviews, Mutual Learning Exercises and Specific Support to Countries. An evaluation of the PSF has shown that the instrument is of high quality, appreciated by the clients and effective to induce policy reflection, however, with one major weakness. This major weakness is the follow-up on the established recommendations and the lack of or difficult access to follow-up support to turn recommendations into practice (Meyer-Krahmer et al., 2019). At operational level, the European Commission has been supported in the implementation of the PSF by a consortium consisting of Technopolis Belgium (lead), the Manchester Institute of Innovation Research and the Centre of Social Innovation (ZSI).

In contrast to the ‘Peer Review scheme’ and the ‘Specific Support to Countries scheme’ offered by the PSF, which usually target and support single countries, Mutual Learning Exercises (MLE) focus on specific R&I challenges of interest to several Member States and Associated Countries. MLEs aim to identify good practices, lessons learned and success factors based on robust evidence. Exchange of experiences and policy learning constitute the scope of MLEs.

The MLE on ‘National Strategies and Roadmaps for International Cooperation in Research and Innovation’ (R&I) (abbreviated by INCO MLE) has been implemented between March 2019 and February 2020. Its task was to organise an intense policy exchange about various national approaches towards international cooperation in R&I. Particular attention was paid to sustained challenges of R&I internationalisation and new or upcoming developments. The following countries participated in the INCO MLE: Austria, Belgium/Flanders, Denmark, Finland, France, Greece, Hungary, Ireland, Moldova, Norway, Portugal, Romania, Slovenia, Sweden and Turkey. It goes without saying that these countries differ a lot as regards their R&I internationalisation strategies and activities. Generalizations are therefore difficult.

Evaluation of international R&I policies was just one among several other topics. This article highlights the main findings regarding the corresponding issues of monitoring and evaluation. Other important topics of the INCO MLE included, among other issues, diverse aspects of strategy development, consideration of SDGs in policy designs, multi-stakeholder funding activities, STI agreements and good cooperation principles. The reports of this MLE, which cover all these topics and more, can be accessed via the website of the Research and Innovation Observatory of DG R&I[1]. They provide a complete picture of the various aspects discussed during the MLE on 'National Strategies and Roadmaps for International Cooperation in Research and Innovation'.

Different methods were applied to gain country-related information and to organise the engagement and exchange of the participating countries. These included country visits (to France, Romania and Sweden), input provided by external experts in form of challenge papers, which were then elaborated into Thematic Reports, input presentations from various country delegates from ministries and agencies in charge for R&I internationalisation, and several targeted discussion rounds. In addition, a considerable amount of input in terms of taking stock of the current practices of the MLE participants were gathered through three surveys that were carried out prior to the country visits (Schuch et al., 2020).

Survey 1 dealt with important aspects related to the design and development of national strategies for international R&I cooperation. Survey 2 investigated the substance, structure and use of Science and Technology Agreements (STA), differentiating between successful and less successful approaches and examples. Survey 3 finally scrutinised the attitudes, practices and uptake of challenge-driven approaches, as well as existing and novel 'good principles' in international R&I cooperation.

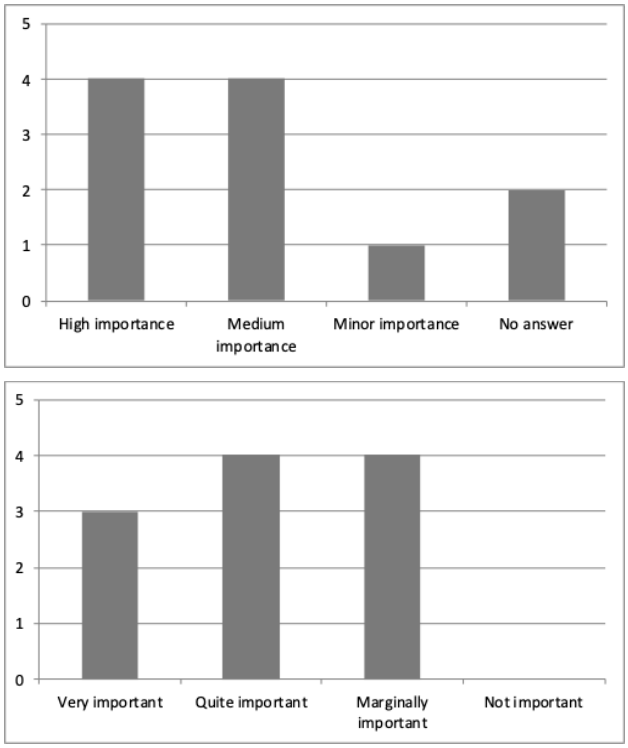
The findings from these surveys and the subsequent discussions and findings are systematised and summarised in three Thematic Reports (Schuch, 2019; Boekholt, 2019; Könnölä, 2019), which can be accessed from the PSF website[2].

CONCEPTUAL CHALLENGES OF R&I INTERNATIONALISATION STRATEGIES AND POLICIES

Although a considerable body of literature provides evidence on R&I internationalisation in general (Dachs 2017; Schuch, 2017; OECD, 2016; Deuten, 2015; Alkemade et al., 2015; Laurens et al., 2015;OECD 2010; Hall 2010; Shapira et al. 2009; Hatzichronoglou 2008; OECD 2008a; OECD 2008b; OECD 2008c; OECD 2005; UNCTAD 2005,), mostly focussing on internationalisation of multi-national enterprises, a much lower volume of literature is available on international comparisons of R&I internationalisation policies (SFIC 2019; SFIC 2018; SFIC 2015; Schwaag-Serger and Remoe 2012; Schwaag-Serger and Wise 2010; TAFTIE 2009; Boekholt et al., 2009; CREST Working Group 2007).

Our findings have shown that most of the participants of the INCO MLE have developed R&I internationalisation strategies, which are either single-standing documents or integrated parts in overall national strategies. Most R&I internationalisation strategies usually include both cooperation within and outside Europe with emerging and developing countries[3]. In many – but not all - cases, the knowledge triangle research-innovation-education is covered. Some countries focus explicitly on innovation, while others are more hesitant in this direction. In addition to goals deemed to strengthening the specific country's own position in terms of scientific excellence or global competitiveness, many countries also consider the mutual tackling of global challenges as an important task of research cooperation or define goals in the field of science diplomacy.

Figure 1: Importance of R&I internationalisation within the national R&I strategy (top) and within the national strategic policy discussions (bottom)



Source: First survey sent to MLE participants, n=11; Schuch et al. (2020).

1 https://rio.jrc.ec.europa.eu/policy-support-facility/mle-national-strategies-and-roadmaps-international-cooperation-research-and; accessed on 30 September 2020.

2 https://rio.jrc.ec.europa.eu/policy-support-facility/mle-national-strategies-and-roadmaps-international-cooperation-research-and; accessed on 3 October 2020.

3 For instance, the Austrian 'Beyond Europe'-R&I internationalisation strategy is an exception, because it focuses only on non-EU countries.

Eight of eleven country delegates, who participated in a first survey launched under this MLE mentioned that the aspect of internationalisation within their overall national R&I strategy is very important or at least of medium importance (see Figure 1, top hand side). The 'no answer' responses were given by MLE participants who did not have an overall national R&I strategy. If asked, however, how important the aspect of internationalisation is within the strategic policy discourses in their countries, then the picture becomes more blurred (see Fig. 1, bottom hand side). This blurred picture might indicate that R&I internationalisation is sometimes considered rather as an appendix or a 'nice to have' than integrally positioned within core elements of national R&I strategies.

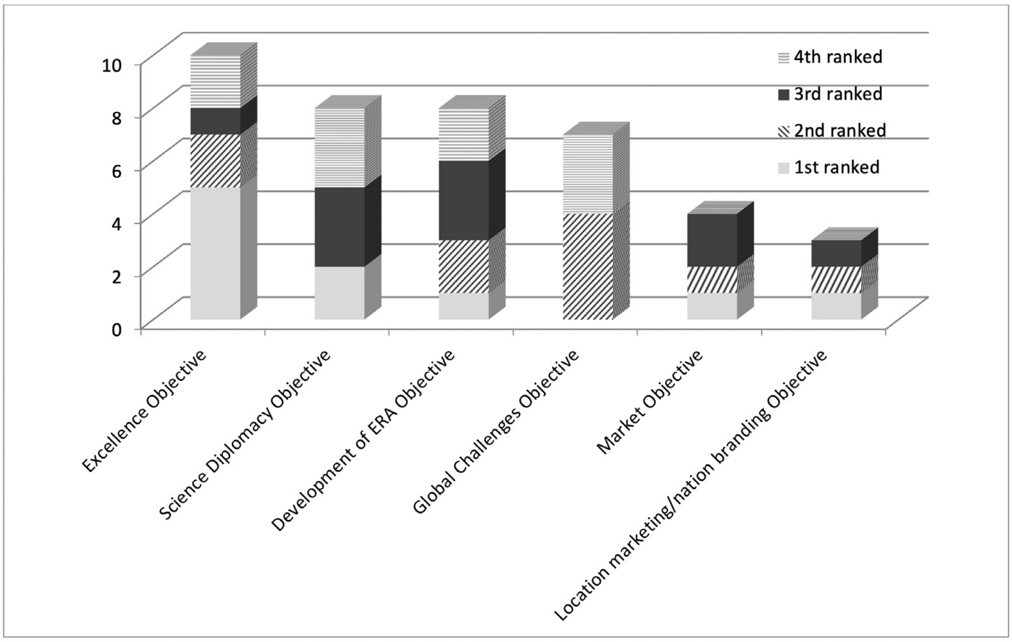
The INCO MLE participants confirmed more or less the findings from literature (Boekholt et al., 2009; CREST, 2007) that most of the R&I internationalisation strategies of EU Member States focus on the 'Excellence Objective', 'Market (or innovation) Objective', 'Global (or Grand) Challenges Objective' and 'Science Diplomacy Objective', but they added the 'Development of the ERA Objective' as further main objective (see Fig. 2). The latter is not at least caused by the inclusion of Associated Countries in the INCO MLE, for whom ERA integration is of particular importance.

According to Boekholt et al. (2009), the objectives can be differentiated by a narrow and a broader STI cooperation paradigm. In the narrow STI cooperation paradigm, the drivers for international research collaboration policies aim to improve the quality, scope and critical mass in science and research by linking national resources and knowledge with resources and knowledge in other countries. Here, the drivers originate from within the science community and are translated into science and research policy instruments. The 'Excellence Objective' represents the 'purest' narrow STI cooperation objective. In the broad STI cooperation paradigm other non-science policy objectives also interact with the 'intrinsic' science-oriented paradigm and STI cooperation becomes a means to reach other policy ends. According to Boekholt et al. (2009) these other policy ends relate to (i) improving national competitiveness, (ii) supporting less developed countries by developing STI capabilities, (iii) tackling global societal challenges and (iv) creating good and stable diplomatic relationships.[4]

During the INCO MLE discussions, it also became clear that the emphasis in current R&I internationalisation policy is changing. While R&I internationalisation policy had almost only positive connotations in the past, it is now much more geared towards concrete outcomes and a growing sensitivity towards cooperation with certain countries. This is mainly caused by competitiveness concerns as well as concerns regarding ethical conduct of R&I activities. The concern about competitiveness issues is amplified by the fact that innovation-related rationales are becoming more prominent in current R&I internationalisation thinking. This is grounded in a more economic understanding and rationale of Science and Technology (S&T) policy-making in general. It is, however, also propelled by the challenge-driven approach, which basically bridges research to innovation-related activities in different social spheres.

Although recognised as a strong driver of economic growth and structural change, innovation is perceived as disruptive to the field of

Figure 2: Ranking of R&I internationalisation objectives



Source: First survey sent to MLE participants; own calculations; n=11; Schuch et al. (2020).

4 A detailed description on the relevant objectives for international cooperation can be found in Schuch (2019).

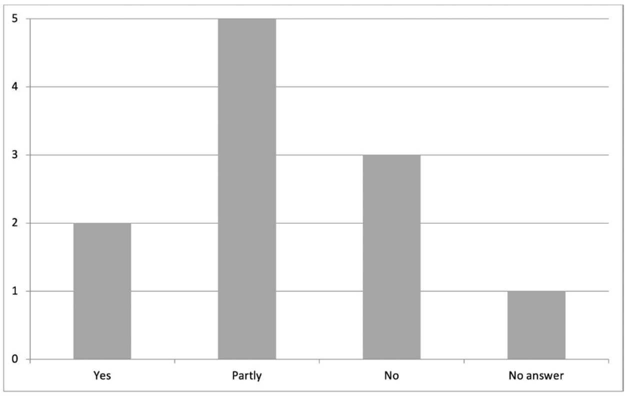
international S&T cooperation (Schuch, 2019), because it creates winners and losers. Traditional international S&T policy strategies, however, typically aimed to support pre-competitive mutual benefit through cooperation in fundamental sciences. Accordingly, the specific interventions to foster international R&D cooperation were – and still to a large extent are – focusing mainly on areas of basic research and international mobility of researchers and students, with quite some conscious distance from immediate commercial interests. All INCO MLE participants agreed that it is a challenge to bring the different spheres of 'academic knowledge production' and 'business-driven innovation practices' together and to develop R&I internationalisation approaches that combine these spheres (possibly including also public sector innovation, social innovation and common public good aspects). Two of the eleven participants responding to the first survey mentioned that 'innovation' and 'science' are 'worlds apart' in their internationalisation practices and four more countries confirmed that this is at least partly the case (Schuch et al., 2020).

The ongoing shift in rebalancing and valuing the at least partly competing R&I internationalisation objectives and the perceived quest for adequate and meaningful implementation policies are challenging the existing R&I internationalisation strategies.

There was consensus among the INCO MLE participants, that international R&I cooperation should be designed as strategically as possible in order to achieve the best possible impact. The basic feature of a strategy is that it defines clear goals and provides orientation on how and which R&I internationalisation policies are developed and implemented (i.e. a policy-mix oriented intervention logic). A clear intervention logic (e.g. based on a Theory of Change) would help to lay out the sequence of outcomes that are expected to occur as result of a set of interventions by applying clear policies. In other words, a logical deduction for an intervention pathway would, firstly, take the new and upcoming framework conditions for international R&I cooperation into account. It would, secondly, start with high-level objectives and rationales about the expected changes that policy interventions should trigger or enforce. These would then be broken down into specific activities, measures and outputs that are supposed to drive the change. Such a logic seems desirable but is hardly available in practice. Moreover, to track the results of policy interventions, clear intervention logics would certainly facilitate the work of evaluators.

The first survey among the INCO MLE participants, however, showed that only a few of the responding countries fully apply a Theory of Change for their international R&I cooperation strategy (Schuch, 2019). Only some R&I internationalisation strategies list a series of policy interventions to the identified objectives. The Austrian 'Beyond Europe' strategy is a good example for this, without, however, making a clear logical connection or pathway between the overall objectives and the policy interventions (which are mostly either programmes, or instruments or other measures or initiatives) explicit. Such a logical deduction of an intervention pathway could be qualified as an explicit Theory of Change that asks about what will have changed or what changes will have occurred due to policy interventions. Thus, the ToC approach focuses much on the tangible (sequence of) outcomes/results of an intervention or a portfolio of interventions, and not just on the overall objectives. The quality of a ToC can be approximated by plausibility (i.e. the logic of the outcomes pathways), the feasibility (i.e. can the proposed interventions realistically achieve the expected long-term outcomes and impact) and testability (which refers broadly to the indicators). In a further step, an evaluation could track whether these expected outcomes could have been actually produced (or not). R&I internationalisation strategies that are using intervention logics enable easier tracking of whether the expected outcomes have been actually achieved (or not) and can be better evaluated.

Fig 3: Availability of a Theory of Change for R&I Internationalisation Strategy



Source: Survey sent to MLE participants; n=11; Schuch et al. (2020).

As shown in Fig. 3, however, traceable Theories of Change or intervention logics were hardly formulated in R&I internationalisation strategies, although many countries include some elements of it. Although R&I internationalisation strategies propose (rather broad) objectives, clear and logically integrated connections as to concrete outcomes, approaches, operational measures and proposed or available resources are often lacking (see for instance the Austrian R&I internationalisation strategy 'Beyond Europe'). We repeatedly identified gaps between boldly formulated high-level objectives and specific interventions, which should be directly derived from them or responding to them. In reality, some of the practised internationalisation interventions, especially those that are not coupled with domestic R&I programmes and instruments, seem rather under-critical and hardly able to make substantial contributions to the overall goals. Sometimes these are legitimised by science diplomacy considerations.

Not surprisingly, one main recommendation of the MLE was to include a logic-based approach in the process of developing future R&I internationalisation strategies or roadmaps.

Box 1: Apply a clear intervention logic to substantiate international R&I cooperation strategies

The recommendation is to take a clear intervention logic based approach in the process of developing R&I internationalisation strategies or roadmaps. How to make use of a broad understanding of innovation and operationalise it for the purpose of an inclusive and effective international R&I cooperation should be scrutinised in particular.

Addressee: The national R&I policy-making level responsible for establishing a strategy or roadmap for international R&I cooperation and the designers of specific policies (e.g. R&I cooperation programmes, instruments or initiatives).

PRACTICAL PROBLEMS OF MONITORING AND EVALUATING R&I INTERNATIONALISATION POLICIES

As for any other public intervention, it is important to check the progress of the implementation of R&I internationalisation and to identify and assess the results, which can be attributed to it. Of primary interest is to understand how and to what extent the internationalisation interventions, which should normally be derived from the existing internationalisation strategy or directly respond to it, contributed to the objectives stipulated by the strategy. As shown in the previous section, however, the gap between high-level objectives and the derivation and design of concrete support schemes is quite large and unclear, which impedes more efficacy and outcome-oriented evaluative approaches. Moreover, continuous collection of R&I internationalisation data for monitoring purposes, especially beyond Europe, is very rare and evaluations in the field are just occasionally implemented (Boekholt, 2019; Schuch, 2019).

From a strategic point of view, Edler and Flanagan (2009) identified needs for evaluations of R&I policies and corresponding indicators at four stages:

- Evaluations with corresponding indicators to describe and assess the status quo of the internationalisation of the R&I system under investigation. This is in particular important before an R&I internationalisation strategy or roadmap is developed and adopted.
- Indicators to set targets and to make choices. The definition of a desirable scale and scope of activities is a key challenge, because, per se, more internationalisation is not always necessarily better.
- Indicators to understand the international 'opportunity environment'. Good intelligence regarding potential international R&I cooperation countries is vital.
- Evaluations with adequate indicators to verify if important initiatives, programmes and instruments work in the way as they were designed. Evaluations of individual programmes and instruments or portfolios of programmes and instruments scrutinise their relevance, effects (outputs and results) and – if possible – impacts.

In the following paragraphs some examples of R&I internationalisation indicators are shown which are repeatedly mentioned and used in studies and assessments. Our research revealed that there is no shortage of input or output related indicators, but of outcome and impact related indicators and corresponding data. Extensive lists of indicators for example have been compiled by Brandenburg and Federkeil (2007) for measuring internationality and internationalisation of higher education institutions and by Schuch (2011) for measuring the internationalisation of science and research (see the examples provided in Box 2). Such internationalisation indicators can be grouped in different categories depending on the respective purpose. As follows, a possible distinction is made between R&I internationalisation indicators at the level of:

- embedding of an R&I internationalisation strategy in a broader domestic R&I strategy
- at systems level
- at the level of research organisations
- at individual researchers level.

Box 2: Examples of R&I internationalisation indicators

R&I INTERNATIONALISATION INDICATORS

Indicators related to embedding of the R&I internationalisation strategy in broader domestic R&I strategies

Examples:

- How many of the national programmes/instruments/tools have an R&I internationalisation component (or are fit and open for it in general) (mainstreaming)?
- How much budget is allocated for R&I internationalisation in these domestic programmes/instruments/tools?
- What is the scope and size of targeted (uni-, bi- and multi-lateral) R&I internationalisation measures?
- Extent of participation, volume and share in European or international R&I schemes (JPIs, int. ERA-NETs, international research infrastructures etc.)

Indicators at system's level

Examples:

- Financial indicators (R&D budget inflow/outflow; share of high-tech exports)
- International representation related indicators (R&D offices abroad; staff in international R&I organisations; participation in regulatory or standards setting)
- Scientometrics (publications and co-publications differentiated by themes, countries, regions; EPO and USTPO patents)
- Mobility patterns (share of foreign academic staff at public research organisations and universities; share of international students/graduates)
- Project related indicators (e.g. juste retour from FPs)

Indicators at the level of organisations[5]

Examples:

- Financial indicators (e.g. export quota of the R&I organisation; international licensing income)
- Scientometrics (co-publications & impacts; patents)
- International rankings
- PR and altmetrics related indicators (google and social media metrics)
- Personnel related indicators (international appointments; share of foreign personnel)
- Mobility indicators (guest professors; international students/graduates)
- Offshoring (e.g. foreign campuses or branch offices) and int. joint ventures
- Project related indicators (participations and coordinations in EU or other international programmes; raised international third party funding)

Indicators at individual level

Examples:

- Publication related indicators (quantity and quality)
- Patent related indicators
- Scientific and non-scientific speeches (conference participation)
- Participation in international bodies (e.g. advisory groups of the EC; editorial boards …)
- Mobility related indicators (e.g. international research stays; international appointments)
- Degrees obtained abroad
- Number of supervised international students including cotutelle de thèse
- Project related indicators (e.g. participation in FPs; coordination of FP projects; international funding raised)

Embedding indicators and indicators at the systems level are the most relevant indicators for the assessment of the status quo of internationalisation of a specific country's or region's R&I system (Schuch, 2019). While these indicators usually target a higher level of aggregation to describe and assess a certain situation or status quo, they hardly measure the impact or R&I internationalisation in terms of, e.g. lasting networks, knowledge and innovation-related results and outcomes, dissemination of knowledge or contributions to environmental and societal challenges (Fikkers and Horvat, 2014; Gnamus, 2009).

Another problem is the adequacy (i.e. relevance, reliability and validity) of the indicators used. Indicators should be capable to capture and measure the basic properties and objectives of the R&I internationalisation strategy and its underlying Theory of Change. There are no 'one-size-fits-all' indicators and no 'one-size-fits-all' methodological recipes. Different indicators are needed for different considerations and purposes. Thus, specific indicators need to be constructed, using metrics that are universal, precise, unambiguous and relevant. Unfortunately, the number of evaluations of international R&I cooperation interventions is still so limited that, for the time being, a robust stock of knowledge about the adequacy of the indicators used is lacking.

Another problem is that R&I internationalisation data are often uneven and have limited comparability. Thus, a good monitoring system, internationally co-ordinated and organised by the agencies responsible to support R&I internationalisation or based e.g. on the availability of well-maintained and comparable current research information systems (CRIS) is advantageous. For comparative bibliometric-based analysis, a certain dependency on commercial data providers can be ascertained. Since often monitoring data as well as secondary data on R&I internationalisation are not sufficient or available, case-based evaluative surveys are still common practice. They are costly and often only one-off activities. However, for assessing the progress of R&I internationalisation they should be repeatedly implemented for monitoring purposes. Thus, several studies already recommended launching pilot surveys on European level or at least co-ordinated by a couple of European countries on variable geometry (Vullings et al., 2013). It is assumed that the use of jointly agreed indicators and methodologies to assess the impact of national and European R&I internationalisation policies would increase comparability between countries and contribute to standardisation of indicators, methods and practices. Due to their 'beyond academic impact' orientation, challenge-driven international R&I cooperation activities could be taken as a starting point.

Attribution problems, e.g. the logical and de facto connection between inputs (e.g. resources assigned to certain interventions), outputs, results (or outcomes) and impacts remain an issue. While outputs can relatively easily be attributed to certain activities that are triggered (and usually also funded) through policy interventions, outcomes (e.g. the direct effects on the intended target groups) and especially impacts (e.g. the longer-term effects on the final beneficiary groups or systems not directly targeted by the intervention) are very difficult to grasp and assess.

Also the lack of widely acknowledged benchmarks in the field of R&I internationalisation makes it difficult to set targets. To give an example: Should a country, in which 15% of all professors employed in universities are coming from abroad, invest in attracting even more foreign professors or not? It is recommended to answer such a question, however, in connection with the expected outcomes attributed to the specific intervention, e.g. have the 15% increased the quality of research output or did they probably even crowd-out national human resources? There are no universal and definitely no optimum benchmarks available, because

5 These are to some extent an aggregation of individual employee data (see next paragraph).

the context factors are varying. Thus, comparisons with other countries should be cautiously made. Relative benchmarks (e.g. by using control points over a couple of years or by comparing only with comparable countries) are thus recommended in connection with impact evaluations.

The monitoring and evaluation of international R&I cooperation are further impeded by a lack of sufficiently good practices and standards. This starts with a shortage of guidelines as to how to formulate clear intervention logics for specific purposes (complemented by practical examples) (see section 2 of this article) in order to understand what success means so that the progress and effectiveness of international R&I cooperation interventions can be better monitored and evaluated. Such an exercise should obviously start with the most common policy interventions in international R&I cooperation, including collaborative activities as part of STI agreements.

Based on this, guidelines for a systematic monitoring of international R&I cooperation in order to follow up progress and enable comparison of the results over time should be developed and existing national monitoring systems accordingly adjusted.

Ideally, national R&D surveys, which are carried out every year or every two years by the national statistics offices in each EU country, could be expanded to capture international cooperation in R&I. The focus here should be on suggesting a limited number of meaningful indicators to assess the relevance, effectiveness and impact of R&I internationalisation.

The INCO MLE finally recommended that the suggested work on establishing guidelines, jointly co-created indicators and co-designed monitoring and evaluation standards as well as the testing of results-oriented indicators through a jointly launched pilot survey should be considered by SFIC (the EU's Strategic Forum for International S&T Cooperation) and commissioned to experts, maybe with support from the European Commission.

Box 3: Monitor and evaluate international R&I cooperation policies

The recommendation is to jointly develop monitoring and evaluation standards in order to facilitate the assessment and comparability of international R&I cooperation activities.

The joint monitoring and evaluation standards should focus on:

- Drafting meaningful guidelines as to how to formulate a clear intervention logic and objectives for specific purposes to understand what success means.
- The development of guidelines for systematically monitoring international R&D cooperation to follow up progress and to enable comparison of results over time
- The elaboration of a proposal for supplementing the national R&D surveys with a few meaningful indicators to assess the relevance, effectiveness and impact of R&I internationalisation
- The preparation of a pilot survey at the European level or at least by a couple of EU Member States and Associated Countries (variable geometry) to assess the impact of national and European R&I internationalisation activities

Addressee: SFIC or a group of European countries on the basis of variable geometry.

CONCLUSIONS

R&I internationalisation policies are facing a radical change. This applies to both the strategic direction and the operational policy-delivery. Aspects such as innovation support and international competition, consideration of the SDGs, the attempt to overcome global challenges through international cooperation, as well as tactical and ethical considerations as to who one actually wants to cooperate with and under what framework conditions are increasing significantly. This also has an impact on evaluation theory and practice. Since the focus in the past used to be on pre-competitive collaborations that were deeply rooted in basic research, it was probably sufficient to measure the scientific output and outcome of such forms of collaboration. Today's evaluations also concern questions of innovation and competition-related outputs and outcomes as well as scientific and technical contributions and their effects on solving global challenges. These are not specific challenges that only the evaluation of R&I internationalisation interventions has to face, but general challenges for R&I policy evaluation.

Particularly problematic, however, with regard to R&I internationalisation policies is the extensive lack of logical impact chains as a basis for internationalisation interventions. The gap between broadly formulated overall objectives and the upstream logical elements of an intervention (outcomes, outputs, activities and inputs) is evident in many cases and system boundaries not defined. The attribution gap is exacerbated by the fact that many R&I internationalisation measures are fragmented and subcritical, especially if they are stand-alone and are not embedded in other national R&I interventions or at least clearly linked to them.

To make matters even more complicated, international R&I measures are not always of a unilateral nature, but are set up bilaterally and multilaterally. This means that efforts by one country also require corresponding and coordinated efforts by the partner country or countries. Evaluations should therefore take into account the different sides of the shared intervention efforts and should therefore also be carried out in cooperation. At the level of the INCO MLE participants and their international partner countries, this hardly happened at all.

The INCO MLE has therefore rightly suggested that joint evaluation efforts to measure international R&I cooperation, its relevance and its effects should take place under the supervision of SFIC and with the support of the European Commission. So that this does not remain a one-off matter, preliminary work would be necessary, which the interested member states would have to carry out in a coordinated action. This preliminary work concerns, for example, the definition of common indicators and the collection of suitable data on the basis of coordinated and harmonised metrics.

Such aligned efforts would increase comparability between countries, help in identifying inspiring practices and in setting target values and benchmarks.

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Acknowledgements
The author sincerely acknowledges the feedback from the two peer reviewers.
The author acknowledges the support provided by the European Commission to this Mutual Learning Exercise and especially the intellectual contributions of all delegates from the participating countries and in particular, of my expert colleagues, Gunnel Gustafsson, who was the chair of the Mutual Learning Exercise, Patries Boekholt and Totti Könnölä. The findings of this Mutual Learning Exercise, which are presented in this article, are published in Schuch, K., Gustaffson, G., Boeholt, P. and Könnölä, T. (2020).

KEYWORDS
Internationalisation; techno-globalisation; European R&I internationalisation; INCO, international cooperation in science, research and innovation

KEY ELEMENTS OF EVALUATION FRAMEWORKS FOR TRANSFORMATIVE R&I PROGRAMMES IN EUROPE

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DOI: 10.22163/fteval.2020.489

INTRODUCTION

Challenges in climate, urbanisation and demography call for a transformation of societies and way of life. The von der Leyen's Political Guidelines assign Europe as leader of the transition "to a healthy planet and a new digital world. But it can only do so by bringing people together and upgrading our unique social market economy to fit today's new ambitions" (von der Leyen 2019).

Many governments, as well as the European Union (EU), have already responded by making changes to their research and innovation (R&I) policies shifting from merely stimulating technology development for the sake of economic growth to a system-oriented public R&I policy that should bring about transformative change with the goal of adressing grand societal challenges (e.g. Missions and planned partnerships of Horizon Europe, Swedish Viable Cities Programme, JPI Urban Europe, EIT Climate KIC, etc.). It is acknowledged that R&I policies contribute in coordination with sector, market or implementation policies to effective transformation.

The aspirations of the emerging R&I programmes are high, and demand exists that these new programmes help to mobilise R&I to address transformation challenges more effectively. However, past experience shows that it is not sufficient to support and finance "innovations" in order to achieve necessary structural change that the afore mentioned challenges demand. To accelerate system transformations hindering structures need to be dismantled. Transformation processes need to be politically designed and coordinated, in order to allow for a balance of conflicting societal interests (SRU 2016) and in parallel also a change of economic structures and associated societal implications has to be tackled, such as in the case of the transition towards electric-mobility or the phase out of a fossil fueld based energy system (SRU 2015).

Transformative R&I programmes also require experimentation with a mix of instruments. For example, challenge oriented R&I funding, new types of research and innovation actions with new types of stakeholders involved or even in the lead, change in regulation regimes, career incentives, living laboratories or public-private funding models, just to name a few. Challenges in the implementation of transformative R&I programmes are manifold and the demand for learning and studying the effectiveness of such measures is high. Yet, it is unclear how such evaluation frameworks should be structured or what elements they should entail. Against this background, we discuss the implications for the evaluation of this type of emerging transformative R&I programmes. Our key research question is:

What are key elements of evaluation frameworks for transformative R&I programmes in Europe, which aspire to contribute to solve socio-economic challenges and spur transformation?

The focal point is on the relevance of Strategic Research and Innovation Agendas (SRIAs) and the Monitoring and Evaluation (M&E) systems that need to be set up following such an approach.

From an analytical point of view, we base our analysis on the nexus of shifting intervention rationales for public R&I policies and the requirements for conducting theory-based evaluations and contribution analysis (Mayne 2008, Mayne 2011). We do this by analysing the changing nature of European R&I policy making and contextualise these with existing evaluation paradigms. This analysis is based upon a literature review.

Empirically, we base our analysis upon an exemplary review of recent and emerging European R&I policy initiatives, that pursue a transformative approach as they aim at shaping technological and societal change and contain transformative characteristics such as directionality, whole of governance approach, experimentation and multidisciplinarity, and co-creation, learning and societal engagement (see European Commission 2020, Schot and Steinmüller 2018). The analysis is based on the planned European Partnerships in Horizon Europe and the specific Joint Programming Initiative JPI Urban Europe. More specifically, we provide an overview, how Strategic Research and Innovation Agendas (SRIAs) of European Partnerships and evaluation logic models can be utilised as a starting point for the monitoring and evaluation (M&E) of transformative R&I policy. SRIAs encapsulates important elements of a transformative innovation policy approach as they are clearly challenge oriented, recognise the importance of engaging and coordinating a variety of stakeholders and draw on instruments outside the traditional realm of R&I policy.

CHANGES IN EUROPEAN, TRANSNATIONAL AND NATIONAL R&I POLICY MAKING

At the EU level and in many EU Member States, R&I policies are increasingly geared towards contributing to tackling grand societal challenges by means of different programmes and instruments.

At the EU level, the new European Framework Programme for R&I, Horizon Europe, aims at jointly tackling "Global Challenges and European Industrial Competitiveness" in its second pillar[1]. In addition, Horizon Europe incorporates new "R&I Missions" to increase the effectiveness of funding by pursuing clearly defined targets. Among other objectives, the missions shall link activities across different disciplines and different types of research and innovation and drive a systemic change and transform landscapes rather than fix problems in existing ones. Adding to that, a full roll-out of the European Innovation Council in Horizon Europe aims at putting Europe on top of the next wave of breakthrough and disruptive innovation that creates new markets, in particular by combining physical and digital products and services based on new technologies and business models.

Significant changes in Horizon Europe compared to Horizon 2020 are 1) a joint tackling of societal challenges and competitiveness, 2) a mission oriented approach towards R&I policy making, and 3) an emphasis of creating new markets. These elements strengthen an orientation towards societal change and transformation. Although Horizon 2020 worked into this direction already, it turned out that the gap between highly abstract challenges and the reality of specific projects was very wide (Weber et al. 2019). By large, Horizon 2020 continued to pursue a technology centred approach in its second pillar, 'Industrial Leadership', while only the third pillar 'Societal Challenges', promoted integrated projects which were expressively not structured according to technologies but challenges that need to be resolved.

At the level of transnational networks of European countries, the European Partnership programmes will be strengthened in Horizon Europe to coordinate, pool and increase resources from Member States, research and industry to accelerate change across Europe and contribute to the Sustainable Development Goals. The European Partnerships are in the midst of preparing their re-configuration by the development of challenge and mission oriented Strategic Research and Innovation Agendas. Under the framework of the European Institute of Technology (EIT), the EIT Climate Knowledge and Innovation Community is another prominent example aiming to achieve system transformation through innovation (Brodnik et al. 2020), defining its purpose and mandate broad and positioning itself as a cross-sectoral initiative that goes beyond matters of innovation policy in a strictly economic sense (Diercks, 2018).

Many national governments have responded by making changes in part of their R&I policies shifting from stimulating technology development and economic growth towards a more system-oriented public R&I policy, at least in its objectives: they are gradually moving in this direction by introducing integrated and co-ordinated mechanisms with ambitious objectives in mind. Among others, examples for this can be found in Germany, in the field of renewable energies, following its decision to abandon nuclear power which is being accompanied with increasing efforts for R&I funding for the transformation of the energy sector; the Netherlands, as seen in its current policy reform regarding top sectors; and of Japan, as reflected in its inter-ministerial research and innovation programmes (Cross-ministerial Strategic Innovation Promotion Program) (Larrue 2019).

NEW LEGITIMATION OF PUBLIC R&I POLICIES AND NEW EVALUATION PARADIGMS

The focus of European R&I policy interventions has been moving from a 'project – instrument driven supply policy' to a more 'challenge driven, mission-oriented policy' approach, that can be characterised as follows:

- on the overall policy level, technological challenges and ambitions are being increasingly complemented (or even replaced) by an orientation towards addressing major societal challenges;
- on the instrumentation level, financial R&I instruments are combined with more demand side instruments, regulatory policy instruments, and sectoral policies, which altogether are sought to be orchestrated and complement each other;
- on a project level R&I actors and problem owners increasingly share responsibilities for shaping and co-creating solutions that go beyond product and service innovations; target oriented R&I portfolios rather than single-project-logics emerge.

These changes in the programming portfolio are triggered by a paradigm change in (European) R&I policy making. Prevailing paradigms of R&I policy intervention are based upon 1) rationales of market failures and funding modes for pre-competitive research, which contributed to the institutionalisation of public R&I support in the post World War II area, and 2) system failures – with the notion of National Innovation Systems and a focus on (missing) links and knowledge transfer between actors, networks and organisational learning. Transformative R&I programmes add legitimation of public interventions in R&I through 3) a transformation failure rationale in society (see Schot and Steinmüller 2018).

From the perspective of the market failure rationale, R&I policy is legitimized only through a requirement to fix under-investment in R&D (which would lead to sub-optimal innovation output) and compensate for externalities (e.g. by e.g. by introducing IP-rights to incentivize private sector R&D), which would ultimately limit the ability to commercialise scientific results and hamper economic growth (Weber & Rohracher, 2012). The EU summits at Lisbon (2000) and Barcelona (2002) emphasized the importance and the public role of R&D for increasing the competitiveness of industries and have thus decided to increase the R&D intensity in the EU from nearly 2% in 2000 to 3% of GDP by 2010. This European target, which is still not reached in 2020, is a prominent example justified by the market failure rationale.

In evaluations, the market failure rationale is closely linked to the concepts of input and output additionality. Input and output additionality analyses study the leverage effects of public funding for R&D in terms of private spending and technological performance. The effectiveness of

1 https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme/missions-horizon-europe_en

the presumed intervention mechanism that public incentives increase R&D engagement in the business sector and that such additional publicly induced R&D activities lead to new products and processes improving Europe's technological performance (Czarnitzky and Hussinger 2018) is at the center of these evaluations. Evaluation studies focussing on input and output additionality are by large summative, ex post evaluations. While these evaluations are capable to analyse the effects of an intervention by means of counterfactual econometric and bibliometric analysis, they tell little about the mechanisms that turn an intervention into a success or failure and are of limited use for learning and adaptation.

From the perspective of the system failure rationale, the actual use of knowledge, rather than just the production of knowledge through science, moves to the fore. This emphasizes the interactions between different types of actors, in particular science and industry (cf. Schartinger et al. 2006). An important focal point for this perspective is how a constellation of different actors and the interactions between them can strengthen the absorption of innovation in everyday practices of businesses or end-users (Diercks et al., 2019).

The system failure rationale was characterised by the emergence of new R&I policy instruments like competence center programmes, which sought to bridge the gap between knowledge production and research outputs of the public research system and the production of market driven and societally valuable solutions in the business community, i.e. - contributing to an increase in the productivity of knowledge investments through spillovers (Arnold et al. 2004, TAFTIE 2016).

In evaluations, the system failure rationale is closely linked to the concept of 'behavioural additionality'. The concept of behavioural additionality tried to enlarge the traditional perspectives in evaluation methods based on 'input' and 'output' additionality and link them with the policy framework of the national innovation system (Clarysse et al. 2009, Larosse 2004). Behavioural additionality is considered as the core of an evolutionary / structuralist view which urges policy action to increase cognitive capacities of agents and/or to resolve exploration, exploitation, selection, system, and knowledge processing failures, rather than simply addressing market failures (Gök and Edler, 2012). The emergence of the concept of behavioural additionality was important – as it in fact expressed a 'catching-up' of policy and evaluation theory on already widely applied practices of policy makers to explicitly target behavioural changes in the design of policy instruments (ibid).

The focus on behavioural additionality emphasizes a resource-based view on the firm (Georghiou and Clarysse 2006) and the interactions with public research organisations and collaborators along the value chain. Evaluations of public R&I policies increasingly focussed on the network structures that emerged through public interventions (for example the inclusion of new actors, their role in the networks etc.) and the capabilities acquired by the organisations.

In the new third frame, the transformation failure rationale, the focus of the intervention moves beyond the sphere of R&I policy because solving grad societal challenges cannot be relegated to this policy field alone. The transformation-failure rationale links R&I policy to contemporary social and environmental challenges such as the Sustainable Development Goals and calls for transformative change. One widely used way of conceptualising transformation is the socio-technical system's perspective. In this body of literature, transformational changes are conceptualised as changes to the supply and demand side in the dimensions Science and Technology, Policy and Governance, Market and Users, Industry Structure and Strategy (see Ghosh & Schot, 2019). As such, transformative innovation policy adds something to the innovation policy space that was thus far crucially missing: a normative purpose and directionality that goes beyond the general focus on competitiveness, economic growth and fixing market and systems failures (Weber & Rohracher, 2012). For becoming effective, transformative innovation policies require a mix of 1) policies for creating support for niche innovation and 2) policies for destabilising existing regimes (ibid.). Within this framework, it is understood that changes in socio-technical systems often emerge at the niche level (small, local), as alternative configurations, and move towards creating change in the regime – which represents highly stable and entrenched configurations of the existing rules, technologies and social elements, which guide the actions of actors within a system and create pathways in which incremental change and evolution takes place (Markard et al., 2012)

While core principles of transformation-oriented innovation policies have already been identified and investigated, academic literature and experiences in conducting evaluations of transformation-oriented R&I policies are rare. Larsen (2019) developed a framework, in which transformational failures are being connected with structural elements of innovation systems. Together, they provide a framework for identifying systemic challenges and also potential instruments for addressing them. The framing could also be used for the purpose of evaluating transformative policy mixes. For evaluations of transformative R&I policies, Molas-Galart et al. (2020) postulate the following six key principles that evaluations of these policies should adhere to: 1) using a formative approach aiming at improving policy definition and implementation, 2) integration within policy design and implementation processes, 3) addressing different levels of policy intervention, from specific projects at niche and local level to complex policy interventions involving different programmes, 4) participation and open debate should be facilitated and conflicts of power, interest and perceptions should not be avoided, 5) methodological diversity, which adapts methods and techniques according to the context, and 6) adoption of a generic Theory of Change (ToC), which should be informed by transformative innovation theory to help distinguish the key dimensions of a policy experiment.

Compared with the other framings of R&I policies and their evaluations, the focus of evaluations needs to move from individual actors (firms, research organisations) to socio-technical systems, and the specific role of the state in driving policy change through a mix of instruments that aim at the creation of niche innovations with transformative potentials and measures destabilizing existing regimes through provision of incentives, deliberate phase-outs or changes to framework conditions.

In terms of monitoring outcomes, not the performance of individual firms or research organisations is in the centre of attention, but for example a change in discourse (new shared vision, new ways of thinking), practical applications of new technologies, changing modes of policy making, and new business practices in an ecosystem come to the fore (cf. Kivima 2020). Focal points are the generation of structural and procedural preconditions for enabling transformative change.

In the following we show, through which transformation-oriented principles and mechanisms European Partnerships attempt to contribute to the realisation of transformative change. Therefore, we focus on the definition of Strategic R&I Agendas (SRIAs), which are based on transformation challenges that are being reflected in joint visions. Based upon the example of the Joint Programming Initiative Urban Europe, we then show, how SRIAs also need to be utilized for the definition of a M&E framework.

EUROPEAN PARTNERSHIPS: TRANSFORMATION ORIENTED INTERMEDIARIES

The development of European R&I partnerships across Europe and across stakeholder groups has been facilitated by the European Commission and the EU Member States following the Lisbon strategy with the aim to develop the European Research Area (ERA): These partnerships were originally designed and have been further developed to overcome the fragmentation in the R&I landscape, to avoid duplication of efforts, to address the economic crisis, competitiveness and innovation[2].

European R&I Partnerships take responsibility for the "orchestration" of a transformative innovation policy agenda, in which orchestration can be understood as a type of normatively directed mutual coordination between different elements (actors, resource flows, activities,) in an innovation system (cf. Brodnik et al. 2020 on the role of R&I partnerships as intermediaries). In contrast to the traditional emphasis on centralised control, orchestration points to the importance of mutual actions and interactions as the basis of pro-active adjustments by a range of different actors or by dedicated intermediaries (Kuhlmann & Rip, 2018).

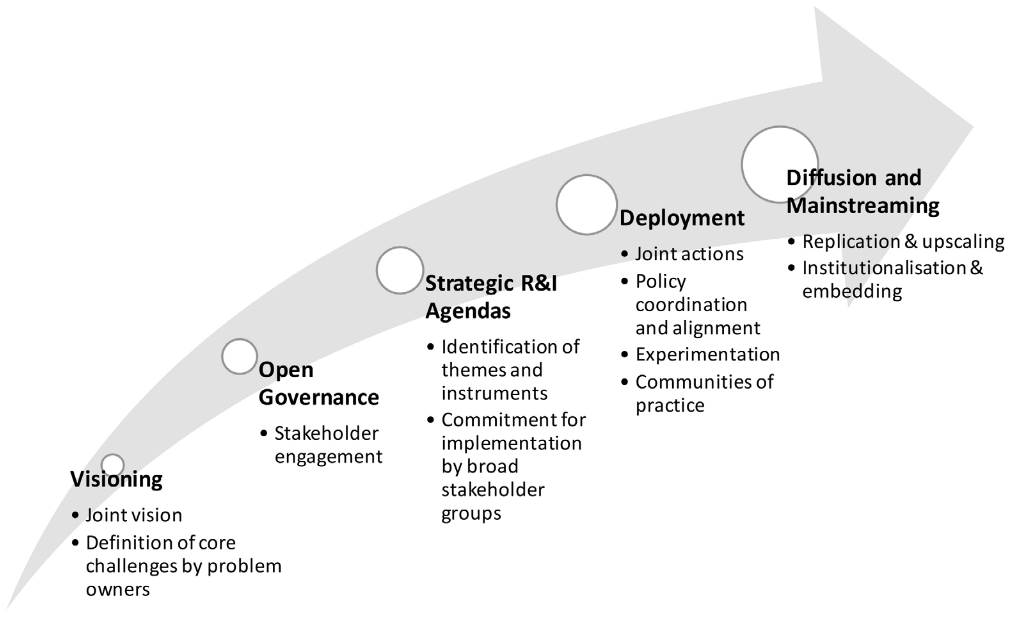
Under Horizon Europe, the new European Framework Programme for R&I (2021-2027), the ambition of European Partnerships - with the Member States and Associated Countries, the private sector, research organisation and civil society organisations as partners - is to deliver on global challenges and modernise industry.

As an R&I programming approach, we characterise European Partnerships transformative, as they aim at enabling the shaping of transformative change for society, economy and environment. They focus R&I efforts not only on the provision of technological innovation and new solutions, but also on the change of production and consumption systems, including mobility, energy production, food and agriculture and other resources throughout society and industry (Schot and Steinmueller, 2018) which differentiates them from other R&I programmes.

Their scope of strategic activities (see Figure 1), renders them transformative, as they represent elements of 1) directionality, 2) a whole of governance approach, 3) experimentation and foresight, 4) co-creation, learning and societal engagement (cf. European Commission 2020) and 5) institutionalisation and embedding. Partnerships perform the following strategic actions:

- **Visioning:** European partnerships seek to enhance directionality of R&I actions through a definition of a joint vision going beyond the sphere of R&I policy making and a definition of core challenges by programme owners. Prominent examples are the 10 Joint Programming Initiatives[2], which aim to pool national research efforts and tackle common European challenges like climate change, healthy ageing of citizens, challenges of urbanisation etc. more effectively. The Joint Programming Process was launched by a communication of the European Commission in 2008[3], which emphasized the need for a new approach to cooperation between Member States in the field of research – for tackling Europe's major societal challenges more effectively.
- **Open Governance:** tailored structures through alignment of national policy measures and stakeholder engagement. The governance structures of European partnerships seek to align EU Member State policies according to the needs of the challenge to be tackled. Different types of partnerships are characterised by different types of key actors in the governance structures of

Figure 1: European Partnerships: transformative intermediaries through agenda setting, policy co-ordination and new instruments



Source: Own illustration

2 See: https://www.era-learn.eu/partnerships-in-a-nutshell/european-partnerships/general-information
3 See: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/joint-programming-initiatives
4 See: http://ec.europa.eu/research/press/2008/pdf/com_2008_468_en.pdf

the partnerships and activities performed (Dinges 2019). In all stages of the joint programming process (from planning to deployment and diffusion), stakeholder engagement plays a key role in the governance of partnerships in order to ensure directionality of activities and enhance policy learning.

- **Strategic R&I Agendas:** translating a joint vision into an operational approach. SRIA is a partnership's strategy document, which identifies the partnership's targeted impact, foreseen portfolio of activities and measurable expected outcomes, resources, and milestones within a defined timeframe. As such, SRIAs do not only put emphasis on reaching a greater extent of directionality in R&I actions, they try shaping a joint mindset among policy actors, R&I actors and other stakeholders.
- **Deployment:** experimentation with multiple instruments. Experimentation in deployment instruments is another key feature of European Partnerships. The portfolio of instruments goes beyond Joint Calls for transnational research and innovation projects and includes Pan-European community building measures, creation of joint infrastructures, and actions for strategic alignment of national R&I policies and operational alignment in research planning and implementation, guided by the priorities of the SRIAs are key elements of the partnerships instruments (cf. Meyer and Dinges 2017).
- **Mainstreaming and diffusion:** European Partnerships seek to create new configurations of R&I and user communities and higher impact by deepening activities. Increasing the effectiveness of research and innovation through measures advancing the integration of innovations in existing institutional structures and measures for replication and upscaling are key ambitions of European partnerships.

The development of a SRIA constitutes a core element of all European Partnerships under Horizon Europe in order to ensure that their long-term vision is translated into concrete roadmaps with smart and measurable objectives. In the European Partnership landscape, SRIAs with a transformation orientation have been first developed by the Joint Programming Initiatives. In Horizon Europe SRIAs aim to ensure that European Partnerships pursue a systemic approach, driving transformative change through adherence to the following principles[5]:

1. **Large-scale directionality and impact orientation:** A SRIA should be developed with a main pathway to impact in mind and should allow to develop more practical action plans, in the form of a roadmap or an annual work plan, which are then set out accordingly.
2. **Flexibility in implementation and activities beyond joint calls:** A SRIA should foresee some flexibility in its modes of implementation, i.e. the SRIA is not an action plan. The SRIA should serve to give guidance without pre-determining specific actions in order to be able to take into account changing environments and to adjust to changing policy, societal and/or market needs, or scientific advance.
3. **Synergies and complementarities between related activities at EU, national and regional level:** A key element of a partnership's systemic approach is its contextualization. The contextualization of a partnership is an important element in the SRIA development process, where the analysis of R&I trends and drivers, gaps and opportunities, national and European policy goals, and complementary activities and initiatives typically lay the framework for the partnership's expected R&I contribution.
4. **Mission driven and Challenge-orientated:** A SRIA should include a mission and R&I challenges ahead to reach the mission. The R&I challenges should be elaborated by problem owners to reach a better demand articulation in the SRIA. The SRIA lay out means by which stakeholders have been addressed and engaged in the development process of the SRIA and will be throughout the operation of the partnership.
5. **Anticipating changing needs and enhanced capacity to adapt/steer R&I strategies to those needs:** In order to be able to anticipate changing needs and steer accordingly, a SRIA should include appropriate approaches for monitoring and assessing progress towards its strategic objectives.

In the development process, SRIAs should make use of forward-looking methods (e.g participatory foresight, forecasts, visioning, as part of the agenda setting). They should also be co-designed and committed to by all partners and therefore involve a broad set of stakeholders early on in a participatory and co-creative manner. Views and opinions from relevant stakeholders such as member states, partners, R&I actors and communities must be collected and appropriately fed into the SRIA in a way that it engages and empowers relevant stakeholders that they seriously commit to implement the SRIA with its activities and resources.[6]

In its results, SRIAs should not only define priorities that are being translated into general and specific objectives, and concrete actions, but they aim to provide a logic framework going beyond the development of technological solutions, building a holistic programming approach to support transformational change through, 1) a joint vision that unites the various stakeholders, 2) mobilisation of resources from different (policy) actors at different levels and EU Member States for realising the desired change, and 3) support for the emergence of new socio-technical regimes through creation of new solutions, practices etc. (niche building) and instruments that change existing regimes (e.g. through funding rules and instruments, R&I and sectoral policy coordination related to a challenge, standards for stakeholder involvement). Hence, for European R&I Partnerships SRIAs constitute a promising approach of transformative policy making, as they delineate both ambition and means for a mission-oriented approach aiming to create landscapes rather than purely fixing markets (cf. Mazzucato, 2019).

In the following, we outline how the conceptualisation of monitoring and evaluation for European Partnerships relates to the conceptualisation of a SRIAs, which is in its essence a theory of change of a desired transformation process. For this purpose, we use the example of the monitoring and evaluation concept of the Joint Programming Initiative Urban Europe (Meyer et al. 2017).

5 See: https://www.era-learn.eu/support-for-partnerships/additional-activities/strategic-research-and-innovation-agendas/systemic-approach-form#why-should-sria-pursue-a-systemic-approach----which-principles-should-be-considered-when-establishing-a-sria-

6 For examples of SRIA development processes see: https://www.era-learn.eu/support-for-partnerships/additional-activities/strategic-research-and-innovation-agendas/guide-for-the-sria-development-process

INTERVENTION LOGICS AND MONITORING OF TRANSFORMATION-ORIENTED R&I POLICIES: THE CASE OF THE JOINT PROGRAMMING INITIATIVE URBAN EUROPE (JPI UE)

As a transnational R&I programming initiative of 20 European countries, JPI UE follows a SRIA which provides the basis for devising the main activities and decisions of the initiative. The first SRIA was implemented from 2015 to 2020 and the SRIA 2.0 sets the main objectives from 2020 until 2026 (JPI Urban Europe 2015, JPI Urban Europe 2019).

Against the background of the SRIA, the management authority of JPI UE led the development process of a monitoring and evaluation concept (Meyer et al. 2017), which serves different purposes and actors.

ACTORS AND PURPOSES FOR MONITORING AND EVALUATION (M&E) IN EUROPEAN PARTNERSHIPS

A dedicated and permanent M&E system enables the management to 1) effectively steer and make decisions in the partnership, 2) adjust and fine-tune joint actions and 3) measure progress towards outcomes and impacts. Additionally, it allows for fast-track reactions, analysis and requests from the Steering Body of the partnership, the European Commission (EC) and the High Level Group for Joint Programming (GPC).

In its present form under Horizon 2020, actions related to M&E of European Partnerships are being performed by a number of different entities including in particular the management authorities of partnerships, the European Commission, and in the case of Public-Public-Partnerships the High Level Group for Joint Programming (GPC):

- The managing authorities of European Partnerships are intermediary institutions, which are responsible for the implementation of the partnership SRIA. The managing authorities are responsible for designing and applying a partnership specific monitoring and evaluation system for internal steering and decision making. In the case of the Joint Programming Initiative Urban Europe, the managing authority consists of experts that are delegated by national and regional owners and managers of R&I programmes that participate in JPI Urban Europe. The managing authorities are primarily responsible vis a vis the principal decision-making body. In the case of JPIs the decision making body consists of representatives of member states or associated countries whereas in the case of Public-Private Partnerships such as the Art. 187 JTIs they present the European Commission, European Industrial Associations and EU Member States.
- The GPC has established a working group to provide guidelines and suggestions for performance measurement across all JPIs (GPC Working Group „Measuring JPIs' Progress and Impact" and GPC Implementation Group on "Monitoring & Evaluating JPIs").
- The EC regularly evaluates the process to ensure that that the objectives and impacts of each partnership are in line with the objectives of the overall process and thus contributing to overarching policy goal. In the case of the Joint Programming independent expert reviews (Acheson et al. 2012, Hunter et al. 2016) reported on the successes and failures of the process. As the European Commission is the main co-funder of European Partnerships, the Management Authorities of the Partnerships are also responsible to report to the EC on the effectiveness and impact of the Initiative.
- Furthermore, the European Commission has funded the ERA-LEARN project, which aims to support the JPIs with expert advice and has provided a short "Guide on P2P evaluation / impact assessment" (Amanatidou et al. 2016) and a number of national and field specific impact assessment reports on various partnerships[7].

Compared with other policy initiatives we notice that monitoring and evaluation activities of European Partnershisp are embedded in a multi-level system in which the managing authorities are not only responsible for the process of setting targets, but also take over responsibilities regarding the operational side of monitoring and evaluation.

Striking the balance between "internal learning needs" and provision of "external legitimation" are inherent challenges for the European Partnerships in this regard. Key pre-requisites therefore are: 1) developing an appropriate M&E system in which objectives and pathways for achieving impact are accurately framed upfront and 2) shared responsibilities for M&E, in which the managing authorities of partnerships put a strong emphasis on learning through means of monitoring and self-evaluation while external institutions account responsible for the evaluation of the overall effectivness.

In the follwing we show how the Joint Programming Initative Urban Europe (JPI UE) has operationalised its M&E system based upon the SRIA. JPI UE makes use of a logic framework, which aims at capturing the transformative ambition of the initiative.

A LOGIC MODEL DELINEATING MULTIPLE PATHWAYS TO IMPACT

One of the most useful tools for enabling monitoring and evaluation of a public policy intervention or programme is the development of a logic model, which represents the programme theory (cf. Amanatidou et al., 2016 in the context of European Partnerships). A logic model outlines the connection between ends and means of a programme. It comprises

7 See: https://www.era-learn.eu/support-for-partnerships/governance-administration-legal-base/monitoring-and-assessment

the underlying rationales of a programme (a specific challenge to be addressed), formulates specific objectives that should be achieved by the programme, and provides an overall roadmap on how specific activities of the programme can be expected to produce immediate outputs connected to outcomes/intermediate impacts and eventually the realisation of the objectives (the long-term impacts).

Thereby, a specific challenge of transformation oriented R&I initiatives is to establish causal linkages between challenges going beyond the R&I sphere, its activities, outputs, outcomes and impacts. Although we can establish logical links between them, measuring this is difficult due to attribution problems, particularly in complex research environments as they are addressed in JPIs. For setting up a logic model it is important to first revisit the rationale for the JPI. Generic logic models are made up of the following steps:

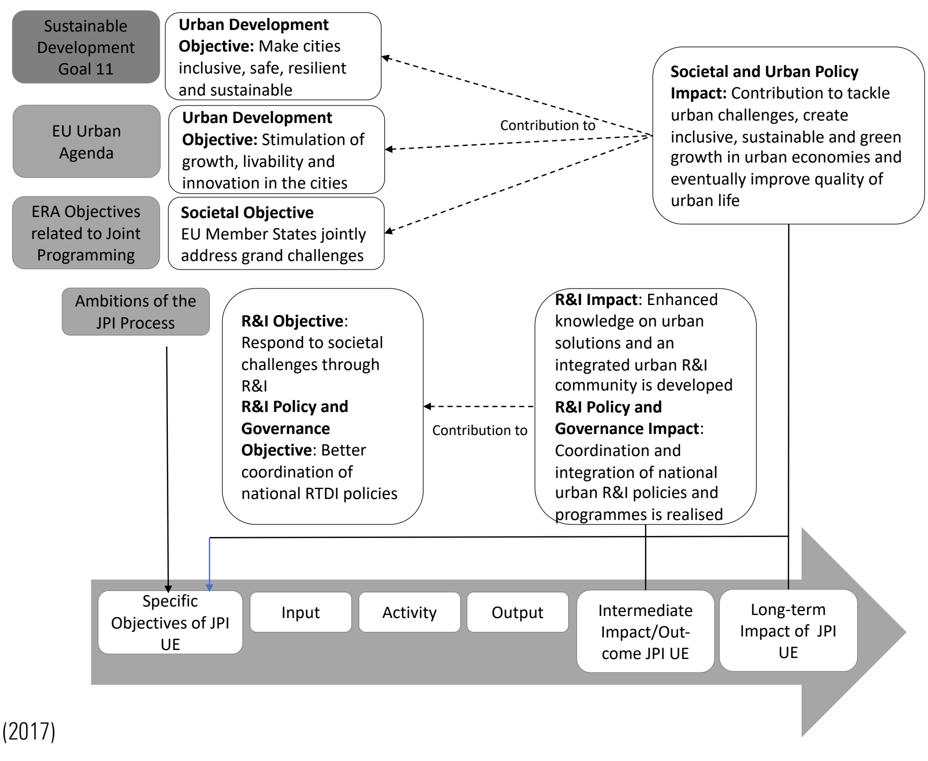
1. An analysis of the challenges, needs or issues that need policy intervention, assuming that markets and other social processes will not lead to sufficient improvements. These challenges are translated into rationales or reasons for policy intervention. For existing JPIs a first step is to revisit the rationale for the JPIs – i.e. to consider all reasons for which the JPI was established, and the problems, situation or challenges it aims to tackle.
2. This analysis of problems and associated policy reasons implies a set of objectives, with the aim to address and ideally solve the defined (societal) problems.
3. In turn, this leads to the main instruments/measures/joint actions that are undertaken to best address these objectives, which need input, typically time and human and financial resources, although political and infrastructural preconditions may also have to be met. The inputs enable activities that are expected to lead to outputs. The use of these outputs by the target group leads to the immediate results of the work enabled by the inputs.
4. The outputs enable wider results or outcomes to be created. It is expected that the outcome of JPIs primarily affect the change of behaviour of the direct beneficiaries of the R&I activity. In this sense, the society as a whole has not yet received a payback on its investments.
5. The results or outcomes enable wider (economic or societal) impacts that also affect society at large or enable system change and contribute to the tackling of a societal challenge.

JPI UE follows three different types of objectives which place the JPI and its existing activities in a policy context of: 1) urban policy and urban society objectives, 2) urban R&I objectives and 3) R&I policy and governance objectives. JPI UE objectives that address urban policy and society relate to the ambitions of the Sustainable Development Goals and the EU Urban Agenda. It also reflects where the JPI UE aims to make an impact by its R&I (stimulate better urban policies and better urban societies) JPI UE objectives that address urban R&I and the respective R&I policy and governance derive from the general ambitions of the JPI Process (European Commission, 2008), which outlines that JPIs aim to respond to societal challenges through targeted research and innovation strategies, programmes and activities (R&I Objective) and to better coordination and integration of national R&I policies and programmes (R&I Policy and Governance Objective).

Based on the challenges and rationales for joint programming in the field of urban development, a number of long-term strategic objectives relating to the three policy contexts (Urban policies, urban R&I, R&I Policy and Governnace) with a target horizon of 2026 are articulated for JPI Urban Europe in its strategy. The objectives set out were agreed among the participating Member States and provide the frame for the next development phase.

Figure 2 exemplifies that M&E activities of the JPI Urban Europe need to focus not only on R&I objectives, but have to put emphasis on:

Figure 2: JPI UE contributions by overarching policy objectives and basic elements of the logic framework



Source: Meyer et al. (2017)

- the process of R&I policy making including the experimental development of new instruments,
- the governance of the response to the challenge in an overarching policy making context (through coordination of national policies), and
- its influence on the system level (urban development) through its portfolio of actions that focus on the creation of a transdisciplinary urban R&I community and the provision, replication and upscaling of new urban solutions.

The long-term impacts of the JPI Urban Europe are expected to go beyond R&I, but enable system change of urban policies and societies as outlined in the SRIA of the JPI. This also corresponds to the expectations outlined in the ERA priorities. Additionally, these impacts should deliver to the ambitions of the Sustainable Development Goals and the EU Urban Agenda.

M&E activities for transformative R&I policy instruments therefore need to take a broader perspective than other R&I programmes as they seek to deliberately and actively address and exert impact on a defined system level (in this case – liveably European Cities and their green and sustainable growth), which requires action on different levels through different means of actions.

This multi-level-perspective differentiates evaluations of European Partnerships from other R&I policy initiatives, in which the core focus is predominantely on a portfolio of projects and the knowledge creation and knowledge transfer processes that are being stimulated by them.

STRUCTURING M&E ALONG OVERARCHING POLICY GOALS AND OPERATIONALISATION OF IMPACTS

For structuring the M&E acitivities, the three areas/domains of societal objectives, R&I objectives and R&I policy objectives provide a formal way of thinking about the initiative. In order to operationalise the strategic targets of the JPI Urban Europe in a first step 'operational objectives' to be reached have been defined as intermediate steps for approaching the strategic objectives. The operational objectives are more concrete and tangible than the strategic objectives. Secondly, these objectives were then linked to implmentation instruments.

As JPI Urban Europe pursues a number of interdependent objectives at different levels, the initiative makes use of a portfolio of 'instruments' to implement the SRIA in order to meet the objectives. These included at the time of the creation of the M&E system (1) transnational Joint Calls, (2) design and experimentation with new instruments for higher impact (e.g. innovation and alignment actions) (3) a Stakeholder Involvement Platform (SIP), (4) establishment of an effective programme management (PM), (5) Communications and Dissemination (C&D), (6) Institutional Co-operations - Urban Europe Research Alliance (UERA), (7) the continous development of the Strategic Research and Innovation Agenda (SRIA) 2.0, and (8) governance mechanisms to widening participation. The instruments contribute to various strategic and operational objectives of the initiative, interact with each other and with other initiatives at European and national level (See Table 1).

Evaluations, which try to capture the outcomes and impacts of an intervention need to take into account the type of intervention, the targeted beneficiaries and the contexts in which the intervention takes place. Whereas outcomes and impacts of certain interventions like mobilisation of different actor groups and results from projects funded via calls might be measured quite accurately, the overall contribution of JPI UE to tackle urban challenges and contribute to inclusive, sustainable and green growth might only be traced once a coherent set of measures has been set up and is fully active. It also needs to be considered that there is a) non-linear cause-effect relationship, and b) that the long term socio-economic impact is also dependent upon many external factors.

The long-term impact of the initiative should become evident at the level of society and urban policies, as the JPI process has been established to ultimately tackle societal challenges. As indicated in Table 2, the outcomes or intermediate impacts of JPI Urban Europe are targeted to accrue at three different levels. Impacts reached on these levels can be considered as enabler and pre-condition for achieving the desired wider socio-economic impacts.

Table 1: Instruments of JPI Urban Europe to implement the objectives
Source: Meyer et al. (2017)

		Instruments for implementation of objectives							
		Joint Calls	New instr.	SIP	PM	C&D	UERA	SRIA 2.0	Govern.
1. Societal and Urban Policy Objectives									
Contribution to tackle urban challenges, create inclusive, sustainable and green growth in urban economies and eventually improve quality of urban life	1.1. Become a well-recognised source of evidence-based knowledge and integrated solutions for informing European and international urban policies			0	0	0			
	1.2. Foster public sector innovation and capacity building in urban planning, management, and (regional, national, EU, and international) policy making for urban transitions	0	0	0	0	0	0		
	1.3. JPI UE in all its activities mobilise societal actors and stakeholders to co-create ideas, concepts and solutions to better meet societal and cities' needs			0	0	0			
	1.4. Raise visibility of JPI UE in the various target groups, strengthen communication with public and private sector stakeholders and establish as an attractive partner for cities, business and societal actors to optimise and accelerate urban transitions		0	0	0	0	0	0	
2. R&I Objectives									
Enhanced knowledge on solutions for the urban challenge are developed and an integrated urban R&I community is built in Europe	2.1. Setting common research priorities according to the EU Urban Agenda and UN Sustainable Development Goals	0		0				0	
	2.2. Address and connect fragmented socio-technical approaches to sustainable urban solutions and enhance knowledge, research capacity and impact of research on urban transition	0	0		0		0	0	
	2.3. Within the strategic framework, being responsive to urgent urban issues by creating and promptly translating relevant knowledge and evidence	0		0	0		0	0	
3. R&I Policy and Governance Objectives									
Coordination and integration of national R&I policies, programmes and instruments in the urban area on transnational level	3.1. Align national R&I programmes, priorities and activities to enhance competencies, improve the efficiency and increase mutual learning at the level of Member States and the European Research Area	0	0		0		0	0	
	3.2. Widen the portfolio of instruments for urban research and innovation to meet the set ambition and create a testbed for new approaches that are targeted towards co- creation, exploitation and innovation	0	0		0			0	
	3.3. Improve the governance system to maintain cooperation under variable geometry and allow easy access to the partnership for new actors and members	0						0	0

Table 2: Expected Impact of JPI Urban Europe
Source: Meyer et al. (2017)

Expected Impact	Operationalisation of conditional impacts			
1. Societal and Urban Policy Impact				
Contribution to tackle urban challenges, create inclusive, sustainable and green growth in urban economies and eventually improve quality of urban life	Urban solutions based on JPI UE activities have been implemented and translated in (European) cities.	JPI UE in all its activities mobilise societal actors and stakeholders to co-create ideas, concepts and solutions to better meet societal and cities' needs.	JPI UE delivers transnational good practice guidance how to improve urban sustainability and quality of life.	JPI UE is consulted to shape regional, national, European and international policies for sustainable urban development.
2. R&I Impact				
Enhanced knowledge on solutions for the urban challenge are developed and an integrated urban R&I community is built in Europe	Mechanisms and tools have been created that facilitate better circulation and application of urban knowledge and expertise for stakeholders at national, European and international level	Challenge driven RDI approaches (applying a inter- and transdisciplinary research, merging consistently 'excellence' with 'relevance') are 'standard' in many European countries		
3. R&I Policy and Governance Impact				
Coordination and integration of national R&I policies, programmes and instruments in the urban area on transnational level	JPI UE delivers an increase in the number of European countries strategically aligning national policies, programmes and investments around the sustainable urbanisation challenge throughout the innovation system	JPI UE has developed and tested new R&I instruments and framework conditions to tackle the diverse urban challenges and support scale up and exploitation of research results and solutions.	JPI UE benefits from a growing partner network which is driven by transparent and efficient management and governance system	

Taking the elaborated logic framework and operationalisation of impact as basis, the indicators of the monitoring and evaluation system of JPI Urban Europe were then designed to provide a comprehensive view of instruments, addressed types of objectives (R&I, R&I Policy and Governance, Societal and Urban), and measures over the impact cycle (i.e inputs, activities, outputs, outcome/impacts).

Structuring the impact of the Joint Programming process along three impact domains provided a formal way of thinking about the initiative and a tool for building a coherent set of indicators, which consider: 1) the instruments under consideration, 2) their implementation (inputs and activities) and desired results (outputs, outcomes and impacts), 3) tentative sources of information, 4) main stakeholder group being responsible for providing the information, 5) the desired frequency and format for measurement, and 6) the indicator's use for monitoring purposes or evaluation purposes.

For selecting the core set of indicators for JPI Urban Europe, the 'RACER' criteria were applied. RACER stands for relevant, accepted, credible, easy and robust and has been recommended by the European Commission in its Better Regulation Toolbox to assess and select indicators for use in policy making[8].

Table 3 displays a selection of a limited number of outcome/impact indicators that have been tailored to the instrument and the strategic and operational objectives of the initiative. The outcome and impact indicators predominantely address R&I Policy and Governance Objectives and Societal/Urban Policy Objectives rather than R&I objectives. They refer to dimensions that underpin the transformative ambition of the initiative. These include impact on:

- **Structuring the policy field for enabling transformation** - building a coherent European R&I policy approach for sustainable cities: EU Member State commitments to pursue a joint transformative research and innovation agenda is a key ambition of the initiative. Participating EU Member States start to change existing, sectoral oriented regimes of R&I programmes towards the ambitions outlined in the SRIA of JPI UE. Sectoral energy

8 https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-41_en_0.pdf

and mobility programmes are changing their set-up towards trans-disciplinary, integrative approaches. This is measured by an (annual) analysis of the number (and volume) of Member State programmes that relate/correspond to the JPI UE strategies and approaches as defined in the SRIA on the national level (Indicator No. 4), and the extent to which collected information provided by JPI UE is used for practical work of major policy stakeholder groups such as national ministries, funding agencies, and cities (No. 23). For further complementing this type of impact, also the consideration of JPI UE strategies outside the R&I policy domain and collaborations with related policy fields would shed light on the outreach of structural impact.

- **Capacity building for transdisciplinary R&I and user communities:** strengthening of knowledge transfer within the new configurated innovation communities (No. 11); creation and use of european research infrastructures and data on urban matters (No 17,) and positioning of the initiative as a knowledge hub for urban solutions, well-known to the stakeholders (No. 18) are examples in this regard.
- **Creating niches and replicate and upscale urban solutions :** In the SRIA of JPI UE research questions are framed along core dilemmas of users/problem owners rather than technological development tasks. The creation of novel solutions and practices are at the core of the R&I practices of JPI UE. The novelty and sustainability of collaborations between different types of R&I organisations and end-users, joint engagment in market activities (No. 9) and number and type of urban solutions that have been upscaled and replicated (No. 11) are indicators which refer to the ability to create niches and foster transformation through upscaling.

Table 3: Selection of Outcome/Impact indicators for M&E of JPI UE[9]

No	Instrument	Indicators	Strategic Objective	Operational Objective
4	Alignment	# of JPI UE MS programmes that relate / correspond to JPI UE strategies and approaches on the national level (clear definition needed to delineate relevant national R&I programmes)	R&I Policy and Governance Objectives	2.2
9	Joint Call	Share of projects that have engaged in follow up activities: • sustainability of collaborations of enterprises or research organisations with end-users in research, development, and piloting activities • sustainability of collaborations of R&I partners that are collaborating after the end of the project • Engagement in joint market activities for urban solutions	Societal and Urban Policy Objectives	1.4
11	Joint Call	Capacity Building: Follow-up project activities exists to strengthen knowledge transfer and cooperation between differnt types of project partners	R&I Policy and Governance Objectives	3.1
10	Joint Call	# and type of urban solutions that have been upscaled and replicated during or after project funding	R&I Policy and Governance Objectives	3.2
17	UERA	European research infrastructure and data on urban matters is connected/built and delivers new insights on urban development	Societal and Urban Policy Objectives	1.3, 2.2
18	UERA	JPI UE through all its activities is a knowledge hub for urban solutions and well-known to the stakeholders when looking for urban solutions/ well recognised network that influences decision making processes at European level (e.g. operationalised via stakeholder surveys, representation of UERA members in decision making bodies...)	R&I Objectives	2.3
23	Strategy	The extent to which collected information provided by JPI UE is used for practical work of major stakeholder groups dealing with the issue of sustainable urban development and transition (national ministries, funding agencies, cities, business, researchers, civil society)	Societal and Urban Policy Objectives	1.4

Source: Meyer et al. (2017)

9 In 2018 a first pilot monitoring has been performed. Based on the pilot test, some indicators have been refined and made more concrete and applicable. Currently, the entire online monitoring system is being developed and tested, which enables JPI UE to also collect information on the indicators in due time.

DISCUSSION & CONCLUSIONS

The analysis of recent policy developments in the EU shows that European R&I initiatives such as the European Partnerships are increasingly transformation oriented in their overall ambition. While R&I policy evaluation has elaborated concepts that allow focussing on the analysis of the effectiveness of public subsidies for R&I in terms of additionalities on inputs, outputs and behavioural characteristics, concepts for monitoring and evaluating the change of R&I policies in a socio-technical-system perspective and the respective influence of R&I policies on these systems have yet to be developed.

The scope of strategic activities that is being performed by European Partnerships characterises them as transformation-oriented intermediaries. They play a key role for 1) designing R&I policy processes through strategic policy coordination, 2) linking actors of different communities, and 3) providing room for experimentation and policy learning through the development of new instruments with a transformative agenda.

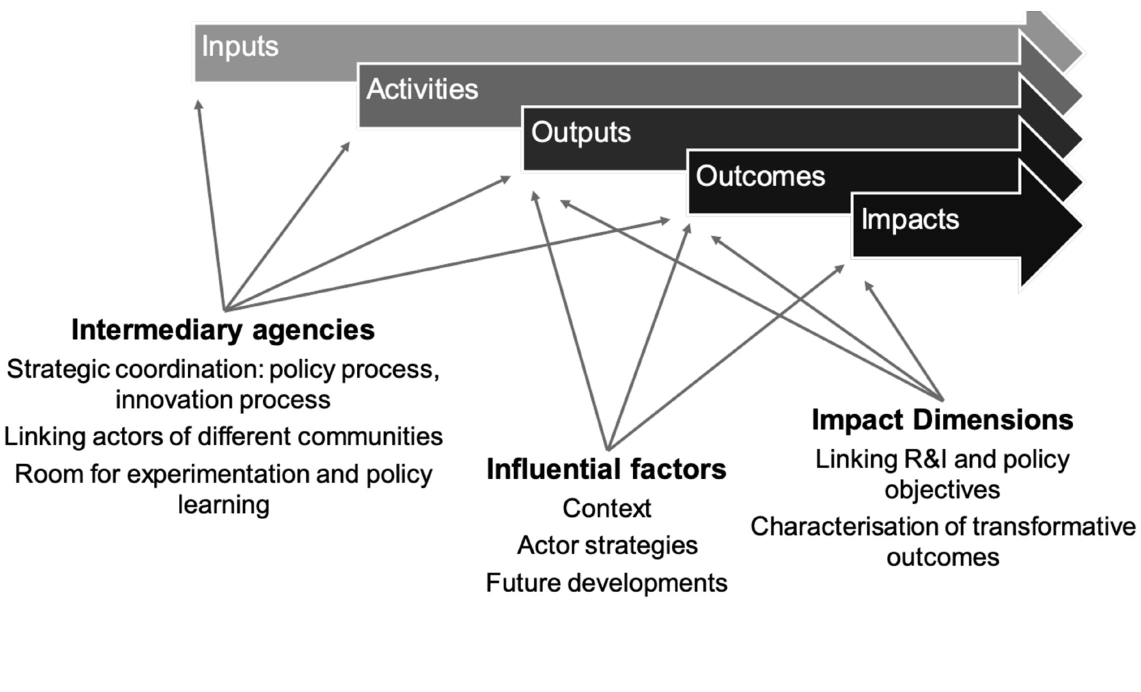
At the core of this agenda, the SRIAs resembles a complex, transformative theory of change, which translates a joint vision of a partnership into operational mechanisms that are supposed to deliver different types of impact. They change the policy discourse and provide new shared visions, new ways of thinking and a changing mode of policymaking with new actors involved. SRIAs are supposed to position actors of different communities around certain challenges, elaborate a joint and common understanding and new approaches towards solving societal challenges on the one hand, while also delineating potential frictions and conflict of interests among different types of stakeholders on the other hand. As such, Strategic Research and Innovation Agendas constitute an integral part of new, transformation-oriented R&I policies.

In their ambition to build a narrative for transformational change, SRIAs take account of 1) influential factors that exert influence on outputs, outcomes and impacts and 2) different impact dimensions that link R&I and other policy objectives. As a main result of a strategic planning activity, SRIAs therefore provide a self-set baseline for evaluations and its pathway to impact, against which these initiatives should be evaluated against. Therefore, the quasi-linear approach of following inputs, activities outputs etc. needs to be overcome in evaluations of transformative R&I policies, by focussing more closely on the role of the involved intermediaries within the socio-technical-system, the influential factors shaping the socio-technical system, and the different impact dimensions that are being targeted by the initiatives (see Figure 3).

The M&E concept of the JPI UE shows that transformative evaluation frameworks need to put stronger emphasis on the linkages of 1) societal and sectoral policy objectives, with 2) R&I objectives and 3) R&I Policy and Governance Objectives. For combining them coherently in evaluation processess, also the different intervention mechanisms (instruments) within and outside the initiative, their interplay with each other, and the impact of influential factors on the outcomes/and impacts have to be scrutinised. In order to get a better understanding on the potential impact of these types of initiatives for driving transformational change, SRIAs and M&E activities would need to take a stronger focus on the external world and the required institutional and regime changes outside the R&I policy domain. This comprises in particular interactions with sectoral top-down oriented policies that actually exhibit a huge impact on the speed of transformation. So far, both SRIAs and M&E systems of partnerships seem to put too little emphasis on these aspects.

The analysis further demonstrates that the intermediation activities of the initiative are framed by a vision and mission that provides a transformative direction to its activities, i.e. to support urban transitions by supporting knowledge creation, setting common priorities, aligning R&I instruments, moderation of science-policy processes and the support of transnational collaboration as well as local capacity building. Against this background it is evident, that transformative R&I policy evaluations need to take a particular strong focus at the governance mechanisms of the challenge oriented approach and the ability to exert impact on policy making processes. Transformation oriented R&I initiatives seek to steer

Figure 3: From linear intervention logics to impact pathways
Source: Own illustration



policy processes in a certain direction and exhibit structural impact on different levels of policy making. Therefore, the role of the intermediary initative for facilitating change, and its capacity to steer the policy process as well as the influental factors that have intended/unintended impact on the interventions have to come to the fore of transformative evaluations .

From an R&I perspective, 1) network formation and capacity building for transdisciplinary R&I and user communities and 2) the ability to create, replicate, upscale and 3) institutionalise and embedd novel solutions in industry sectors are additional elements that transformative R&I evaluations need to focus on. Capacity building elements include the sustainable formation of new networks of R&I actors, policy makers at different levels, and users – as well as the creation of jointly used knowledge, data and infrastructures. In our example of JPI UE this is being enabled through specific stakeholder dialogues, strategic partnerships, joint investments in urban R&I, urban living labs, and project portfolio management activitities. The ability to create, replicate and upscale novel solutions is a key ambition of R&I activities enabled by JPI UE. For enabling replication and upscaling, networks do not only need to form – but reflexice learning processes need to accrue among the network members. Therefore, transformative evaluations do not only need to analyse aspects of network growth and diversity, but also on the ability of involved actors to take up novel concepts/solutions/practices to other locations or contexts and link it to other initiatives.

Our analysis further shows that the managing authorities do not only have an important role to say in the development process of the initiative, but also as regards the design and implementation of the M&E system itself. In transformative R&I policies, the boundaries between the learning functions of evaluation activities, and the legitimation function of assessements become increasingly blurred. The intermediary managing agencies are by large being held responsible for 1) developing complex intervention mechanisms, 2) facilitating policy-learning across the members of the partnerships, and 3) demonstrating accountability. Obviously, this inherently creates tensions and conflicts of interests, which can only be overcome if internal self-assessment activities and external evaluations play well-defined complementary roles in the evaluation process.

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Acknowledgements
This paper draws upon results by European Union's Horizon 2020 research and innovation programme under grant agreement 1) ID: 811171, project ERA-LEARN and 2) ID: 726744 EXPAND - enhancing co-creation in JPI Urban Europe through widening Member State and stakeholder participation.

KEYWORDS

transformation, innovation policy, multi-level-perspective, monitoring systems, theory of change, European Partnerships

INTEGRATING CONTEXT IN THE EVALUATION OF GENDER EQUALITY INTERVENTIONS AND BEYOND

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DOI: 10.22163/fteval.2020.490

ABSTRACT

During the last few decades, the European Union and its member states have promoted gender equality policies in research organizations. However, evaluations of what policy interventions have accomplished have been limited. Based on a co-creation process, involving key European stakeholders, the H2020 funded EFFORTI project has aimed to fill this research gap by developing an evaluation framework to design and evaluate gender equality interventions in research and innovation. The analysis of interventions in a number of European countries has revealed the importance of considering the national and organisational contexts in gender equality policies and evaluation regimes. Context plays a crucial role when it comes to assessing outputs, outcomes and impacts of policy interventions, and needs to be factored into any explanation of change. Hence, evaluation approaches must ensure that design and evaluation of interventions are context-sensitive and theory-based to open the "black box" of programmes, thus avoiding that evaluation only looks at the effects without considering the underlying mechanisms producing them. Based on the experiences generated in the EFFORTI project, we herewith propose a context-sensitive logic model for interventions addressing gender based violence and harassment. The approach proposed may be an inspirational source for policy makers and evaluators working with gender equality interventions in complex contexts and within fields of study beyond gender equality.

BACKGROUND

Gender Equality (GE) is on the top of the EU agenda, as recently confirmed in the new GE strategy, "A Union of Equality: Gender Equality Strategy 2020-2025" (European Commission 2020). GE is also laid down in Article 8 of the Treaty on the Functioning of the European Union: *"In all its activities, the Union shall aim to eliminate inequalities, and to promote equality, between men and women"*. The scientific knowledge about the underrepresentation of women within research and innovation (R&I) systems and the most important hindrances are comprehensive and a plethora of measures and toolkits exist that aim at the promotion of GE. In fact, progress has been made in almost all the EU countries during the past years, but at a rather slow pace. Thus, more evidence is needed that gender equality interventions have an impact and lead to improved R&I outcomes and processes, and innovations better suited to markets (European Commission 2017). Sound evaluation approaches can help to deliver such evidence.

The study presented herewith is based on an evaluation framework developed in the EFFORTI project[1] that adopts a theory of change approach which allows evaluators to systematically integrate various contextual factors in the design of evaluations (for more on the evaluation framework, see Kalpazidou Schmidt and Graversen 2020). One of the core assumptions of the developed evaluation framework is that context is important when evaluating the effects of gender equality measures in research and innovation systems (cf. Patton, 2008; Rog, 2012). Different contexts require different policies and measures to promote gender equality but also influence in various ways the effects of these interventions. The careful consideration of the context is also important for the transferability of results and the formulation of policy recommendations. By context, we mean the team, organisational and national contextual factors that facilitate or impede the intervention process. In this article, however, we focus on the latter level. By national context we mean the national or European framework conditions in force, which influence the effectiveness and efficiency of GE interventions. Typical contextual factors are the structure and competitiveness of the national research and innovation systems; the structure and main components of the welfare systems; labour market characteristics; existing gender equality policies including legislative measures; participation of women in tertiary education; horizontal and vertical gender segregation; gender pay gap or the share of women in decision-making positions (Reidl et. al 2019).

1 see www.efforti.eu

R&I INVESTMENTS, EVALUATION CULTURES AND GENDER REGIMES

Several countries were involved in this study and in the development and validation of the evaluation framework developed in EFFORTI, namely Austria, Denmark, Germany, Hungary, Spain and Sweden. These countries represent liberal, conservative, social democratic, Eastern and Western European model types of welfare regimes and research and innovation systems. This means, first, that they vary as to R&I expenditure, the share of female researchers, the size and variety of the R&I performing institutions and the R&I outputs and outcomes. A comparison between the studied countries reveals that Denmark and Sweden show a high constant R&I investment intensity level, followed by an increase in the proportion of women among researchers (2005-2015). Austria shows a similar pattern, but had a slightly lower increase in the share of female researchers during the same period. In Spain a slight decrease of R&I investment intensity has been noticed during the same period followed by a slight increase in the proportion of women among researchers while Hungary increased the per capita expenses on researchers but shows a decreasing share of women in R&I. Germany encounters a siginficant growth rate for female researchers between 2008 and 2015 (European Commission 2019) and a steady increase of R&I expenditures as well (OECD Research and Development Statistics RDS). Thus, a differentiated pattern emerges as to the development of the share of women researchers compared to the R&I investments (Striebing et al. 2020).

Second, these welfare state types represent different legal traditions, which have consequences for understanding the various policy approaches to promote gender equality. The countries represent hence different types of gender regimes in Europe, i.e. key policy logics of states in relation to gender (Striebing et al. 2020). Social democratic welfare countries, like Sweden and Denmark are considered as innovation leaders with high R&I investments, and public gender regimes that require gender mainstreaming and encourage a public debate about gender workplace equality and equal sharing of care responsibilities. Other countries, like Germany and Austria, which are strong innovators, are modelled on a conservative welfare state type characterized by a school system that requires one parent (usually the woman) to work part-time (Reidl et al. 2017) and modernizing domestic gender regimes. As regards Spain, which is a moderate innovator, gender equality policies in R&I appear to be comparable to Austria, showing a modernizing domestic gender regime, while Hungary with a low capacity to innovate shows an ambiguous gender regime (Striebing et al. 2020).

Third, the studied countries represent very different evaluation cultures, which have an influence on addressing and evaluating GE interventions. The development of an evaluation culture and capacity building vary among the studied countries in terms of establishing a vivid culture of evaluation and carrying out systematic evaluations of programmes and institutions. Thus, the intensity and quality of evaluations of interventions is highly dependent on the degree of development of the national evaluation culture. Some interventions are not monitored - no data gathering mechanisms are built into the intervention, while others are monitored but no evaluation or impact assessment is carried out. In countries where strong evaluation cultures exist (such as Austria, Denmark, Germany and Sweden), the programmes are more comprehensively evaluated than for example in Spain or Hungary where the evaluation culture is weaker (Reidl et al. 2017).

METHODOLOGICAL APPROACH

Several methodological steps were undertaken to develop, test and validate the evaluation framework based on studies in seven national settings (Palmén et al., 2018). For the development of the framework, a thorough literature review was conducted, including the analysis of numerous smart practice examples. This step ended up with a comprehensive list of gender equality as well as research and innovation indicators that refer to the macro level (national level), the meso level (organisational) and the team level. In order to provide for relevant national context variables, a secondary data collection was carried out, where longitudinal data were identified, which describe the most relevant context variables for gender equality measures in European research and innovation systems. Concretely, besides the She Figures, numerous data from Eurostat, the Research and Innovation Observatory and the OECD were used to identify country differences. In addition, international comparative reports as well as national sources of information have been utilized that complemented the international datasets. Finally, expert interviews in the seven EU countries under investigation helped fill in still existing gaps that could not be covered by secondary data and sources.

This work was complemented with case studies to validate the evaluation framework. The case study work was based on the development of templates for the case description and common interview guidelines. Overall, 19 case studies of gender equality in R&I interventions were conducted, being implemented in Austria, Denmark, Germany, Hungary, Spain and Sweden. Each case study used documentary analysis and between four and twelve semi-structured interviews per case were carried out with policy makers, programme managers, practitioners and beneficiaries. A logic frame and a theory of change were developed for each case based on analysis of the design, implementation and impact assessment of each case. The feedback from the case study work supported the validation of the produced evaluation framework.

Based on the logic model and conceptual evaluation framework developed in the EFFORTI project, in the following section, we present an example of a stylised logic model for evaluation of interventions addressing gender based violence and harassment (GBVH) in research and innovation to illustrate the significance of the contextual factors for the effectiveness of interventions.

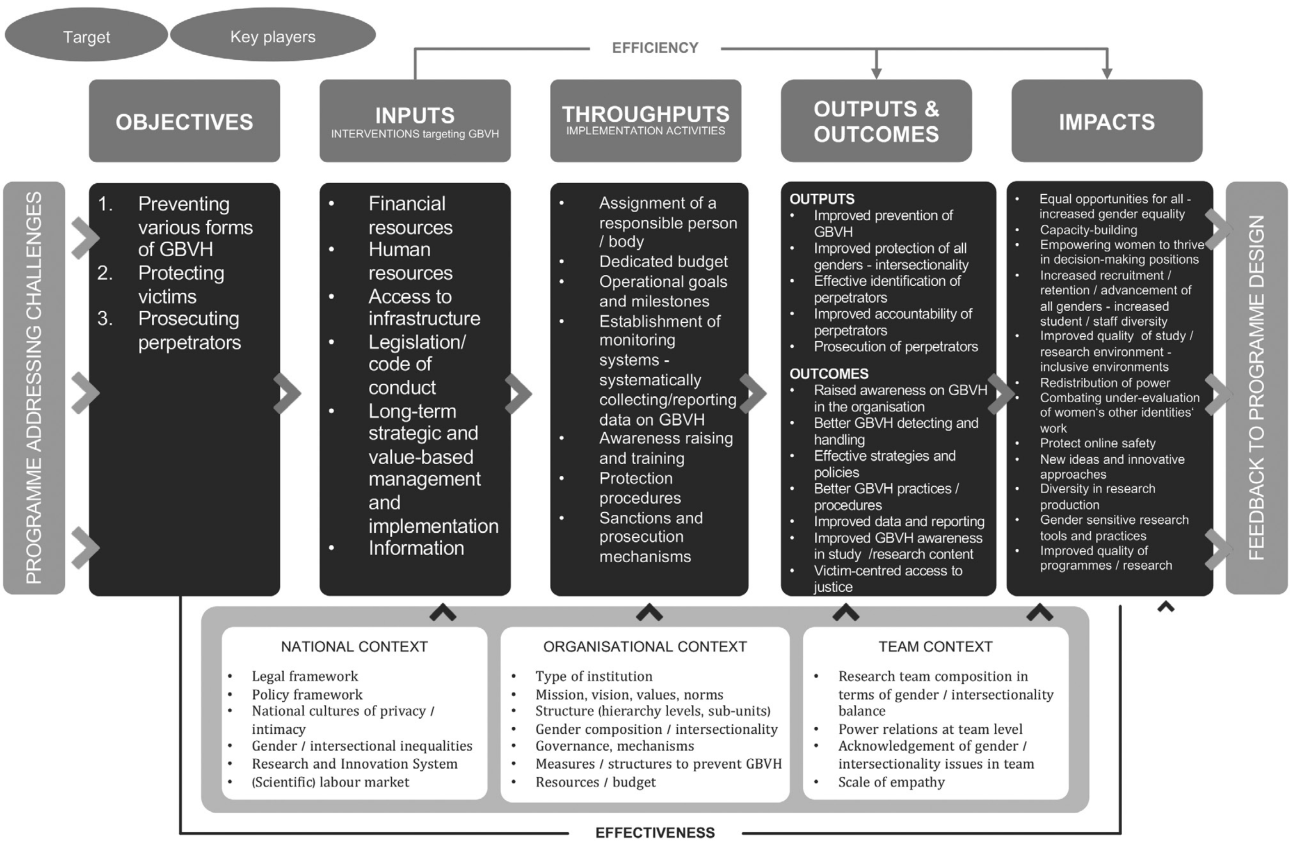
2 For more details about how the theory of change can be incorporated into an actual evaluation practice see Vogel (2012b) and Mayne and Johnson (2015).

AN EXAMPLE OF A POTENTIAL CASE APPLICATION OF THE EFFORTI LOGIC MODEL

Context plays a crucial role when it comes to assessing measured outputs, outcomes and impacts of interventions. Adopting the theory of change approach enables and indeed requires factoring the context into any explanation of change (Kalpazidou Schmidt and Graversen 2020, Palmén et al. 2018)[2]. Theory-based evaluations are used to open the "black box" of programmes, thus tackling complex settings. The "black box" issue refers to an evaluation approach that investigates programs primarily in terms of effects, without paying attention to how effects are produced (see Astbury and Leeuw 2010, Mathison 2005, Bush et al. 1995). Theory-based evaluations address in which way and under which conditions an intervention contributes to the intended and unintended impact (Döring and Bortz 2016). Theory-based approaches allow hence for assessing how particular means and instruments work to contribute to outcomes and impact in certain contexts. Theories are made explicit and evaluations build on elaborated assumptions while the engagement of all actors in the evaluation process makes the different kinds of stakeholders' assumptions transparent (Stame 2004). The theory of change approach uses evidence to identify, verify or challenge these assumptions and map the linkages between input, throughput, output, outcome, impact and context (Vogel, 2012a). For the evaluation practice, the theory of change is converted into an intervention logic model in order to reduce complexity and thus ease the empirical work and make feasible the concrete design and implementation of the evaluation of an intervention in a particular setting.

Below (figure 1) we apply the intervention logic model developed in the EFFORTI project to measures addressing gender-based violence and harassment (GBVH), offering a stylised model that incorporates the contextual factors in the intervention and evaluation process. Based on this intervention type, the presented model illustrates the various steps in the design and evaluation on the horizontal axis – inputs, implementation activities, and outputs, outcomes, and impacts – differentiated along three levels (team, organisational and country level), that allow for a comprehensive multi-level perspective, identifying the results of the policy measure and its preceding impact pathways. It is important to mention that the proposed logic model for evaluations of interventions addressing GBVH, although developed based on the experiences of the EFFORTI conceptual evaluation framework, has not yet been subject to concrete applications.

Figure 1: Stylised logic model for evaluation of interventions addressing GBVH



Source: own compilation

2 For more details about how the theory of change can be incorporated into an actual evaluation practice see Vogel (2012b) and Mayne and Johnson (2015).

CONTEXTUAL CONDITIONS

This model is unique in its ability to account for potential contextual influence factors, at a team, organisational and national context level (see figure 1, three boxes at the bottom). As shown in the figure, the effectiveness of the intervention against GBVH is highly dependent on these frame factors. This consideration of contextual factors emphasises the frameworks' dynamic and responsive nature, and enables a more comprehensive and systemic depiction of the complex link between interventions aimed at improving conditions as regards GBVH and cope with its effects.

At the national level, countries have different types of research organisations (ROs) and higher education institutions (HEIs). The countries vary as well in terms of national legislative and policy contexts as regards GBVH and as to the mechanisms and instruments available to prevent and combat GBVH. This includes reporting, compiling data, and preventing GBVH, protecting victims and prosecuting perpetrators within HEIs and ROs, and in the awareness and willingness of their citizens to report GBVH (FRA 2014).

Countries vary in terms of legal references to potential biases including as to gender, minority status, age, parental status, academic position, sexual orientation, disability. They also vary in terms of their adoption of international frameworks that encourage, and in some cases, oblige states to take action to collect national data on sexual violence and harassment, to take measures to prevent violence and discrimination and to uphold the equality and dignity of their citizens. Such international frameworks include the UN Convention on the Elimination of all forms of discrimination against Women (CEDAW), the UN Convention on the Elimination of all forms of Racial discrimination (CERD) and the UN Convention on the Rights of Persons with Disabilities (CRPD) (United Nations 1965; 1979; 2006). Other international frameworks include the Council of Europe Convention on Preventing and combatting Violence against Women (FRA 2014), the EU Victims Directive and their orientation to the ILO global standards aimed at ending violence and harassment in the world of work (European Commission 2019).

The risks for GBVH are also maximised where structural inequalities exist and opportunities related to paid employment/academic success are ad hoc and dependent on individual powerful figures, who may enact toxic masculinities (national, organisational and team context). The difficulties of reporting GBVH and collecting data are also maximised in these circumstances (national and organisational context). Thus, particular attention needs to be paid to those in structurally dependent relationships, which are likely to facilitate GBVH: for example, relationships between PhD students and their supervisors; between exchange students or those in precarious positions and their line managers (team context). GBVH may also occur when differential cultural resources are drawn on by those in similar positions in the organisational hierarchy, for example, undergraduate students or minority staff (organisational and team context).

CONCLUDING REMARKS

Through the development and validation of a theory-based evaluation framework that aims to systematically integrate context factors at various levels, it became evident in the EFFORTI work that the context regarding research and innovation systems should always be taken into account when designing gender equality policy interventions and evaluations. Research and innovation systems are complex involving a variety of stakeholders and vested interests, thus it is not always clear whether an intervention works in the anticipated way and which effects it has.

Ever complex interventions require increasingly complex evaluation approaches and acknowledging of the limitations of evaluations in dynamic contexts such as research and innovation systems. Complex systems involve multiple variables interacting in non-linear ways to produce outcomes and impacts. Evaluation is a complex concept in itself, implemented in complex systems. The design and instrumentation of evaluation must consider the complex systems in which the interventions operate. It is not adequate to present reality as a simple causal model - the models we use should address the complexity of systems (Kalpazidou Schmidt and Cacace 2019; Kalpazidou Schmidt et al. 2020).

The theory of change approach helps to mitigate the risks related to complexity in dynamic contexts and allows, at least to a certain extent, to open the "black box" – and answer the key questions, how and why a policy works, in which context and how to assess it. This particular way of designing and conducting evaluations based on a theory of change approach has proved to be a valuable tool to consider as to how different factors contribute to achieve impact.

Complex contextual conditions and choices as to evaluation approaches are characteristics also of other fields of study, different from GE in research and innovation. The approach proposed herewith may hence be an inspirational source for policy makers and evaluators working with interventions in complex contexts in other fields of study.

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Acknowledgements
The paper is based on the H2020 funded project EFFORTI (Grant agreement No 710470).

KEYWORDS
Evaluation, Gender Equality, Context, Logic Model, Gender-based Violence and Harassment, Research and Innovation

THE CONCEPT OF INNOVATIVE CAPACITY AND ITS IMPACT ON INNOVATION OUTCOMES

ILLUSTRATED BY THE EXAMPLE OF THE GERMAN AEROSPACE INDUSTRY

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DOI: 10.22163/fteval.2020.491

ABSTRACT

This paper investigates the impact of innovative capacity on innovation related outcomes, such as publications, patents, process and product innovations as well as technology readiness levels (TRL). Innovative capacity is derived from three indicators, namely human capital, relational capital and structural capital. For our estimation model, we use a unique dataset on innovative capacity and innovation activities by companies of the German aerospace sector. We find that the concept of innovative capacity has a strong impact on the analysed innovation dimensions. It can explain innovation outcomes in early stages by using patents and publications as innovations related outcomes. We find the strongest explanatory power of the model when we look at the impact of innovation capacity on product innovations. We also find some evidence by investigating the impact of innovative capacity on process innovations. This is different for the changes in TRL. Here we do not find any significance that innovative capacity influences the speed of technology development. However, the overall findings are promising: Innovative capacity is a relevant concept explaining innovation outcomes of firms within high-tech sectors, like the aerospace industry in Germany. A second basic result of our analysis is that self-reports by experts, who are in charge with innovation processes, deliver – at least to some extend – reliable data. For this reason, we are able to confirm statistically our theoretical assumptions, that innovative capacity is relevant for innovation outcome.

1. INTRODUCTION

Even though innovation is hard to measure, there is a general agreement that the capability to innovate and to bring innovation to market successfully is a crucial determinant of competitiveness at the firm level, at industry level and at the national level. Therefore, innovation is essential for growth in employment, production and welfare. Besides the general economic importance, innovation helps to address global challenges, such as climate change and sustainable development.[1]

Given all these positive effects, innovation became a central target of policymakers. Many countries implemented national strategies to promote innovation and enhance its economic impact. Moreover, in 2000 the EU created the Lisbon Agenda to make Europe the most competitive and the most dynamic knowledge-based economy in the world. However, after nearly twenty years of innovation policy it has become obvious, that there is no simple switch that policy can turn to push innovations. Actually, the success of innovation policy has been quite different across countries, regions and time and it is difficult to identify individual factors for success or failure. What is clear is that there is no single policy method to promote innovation, but rather a mix of policies. Among them, the accumulation of human capital in schools and universities, basic research, public infrastructure and private research activity play a very important role. To support innovation, policy must improve the regulatory and institutional framework for innovative activities. In addition, public investment in science and basic research is needed to develop general-purpose knowledge and technologies that build the foundation for further applied research and innovations. Finally, in particular to create employment and growth effects, it is necessary that basic research is transferred into industrial applications (OECD 2007). To some extent the transfer is in the interest of individual firms and therefore takes place without public support. However, as research and innovation activities often have positive externalities, there are good reasons for giving public support to private innovation activity. Here, a mix of direct and indirect instruments such as tax credits, direct support and designed public private partnerships might be appropriate (cf. Aghion et al. 2009: 681).

The speed of transfer from new ideas to innovative products, services and production processes differs between industries and firms of different size. In general, high-tech industries and larger firms manage the transfer more quickly than smaller firms and low-tech industries (Baesu et al. 2015). One reason is that they are more used to innovation, i.e. they have internal research capacities and they are better integrated in research networks. The concept of innovative capability was therefore recognised as the explanation of innovations success (Cohen and Levinthal, 1990). The concept is especially important when it comes to an evaluation of publicly funded R&D programmes. Absorptive capacity is one of the most important aspects of the innovative capability of a company or organisation in general. Cohen and Levinthal describe absorp-

1 For a general discussion see OECD (2011) and Álvarez-Herránz et al (2017) for recent empirical investigation.

tion capacity as the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends (op. cit., p. 128)". From this perspective, absorption capacity refers to the general ability of an organisation to recognise external information and opportunities (e.g. new technologies, new organisational forms) and to use them for their own (innovation) purposes.

The significance of innovation as a source of growth and welfare contrasts with the lucidity and measurability of innovation. In particular, there is neither one single generally accepted definition of innovation (cf. Baregheh et al. 2009: 1324; Gault 2018: 617ff.) nor an accepted way to measure innovation activity. Paul Krugman (1991a, p. 53) has surrendered the possibility of directly measuring innovative activity because, "knowledge flows are invisible; they leave no paper trail by which they may be measured and tracked, and there is nothing to prevent the theorist from assuming anything about them that she likes."

In summary, neither the input of innovation activity nor the innovation output is precisely measurable. Consequently, a wide number of diverse indicators is used to approximate the input or the output in the process and to show how innovative an organisation is or how many innovations are established by an organisation. On the output side, the most commonly used indicators are the number of patents and publications. While counting these numbers gives a quantitative impression of innovation activity, the numbers clearly fail to measure the qualitative importance of innovations.

The input side of innovation is even more difficult to measure (cf. Carayannis & Provance 2008: 94f.). Hence, different approaches have been used for measuring innovative capacity. Ter Haar (2018) composed a meta-analysis by scrutinising the wide range of various concepts for measuring innovation. While there are also qualitative approaches of measuring the ability to create innovations, most of them aim at a quantification (cf. Ter Haar 2018: 413f.). Furthermore, approaches and indices differ in the addressed level. Some concepts focus on the country-level, while most of them concentrate on the company-level, for example Goffin and Mitchell (2010) or Tidd and Bessant (2014). Other approaches use the team- or employee-level as their basis. Based on the various theoretical frameworks, the methods use a variety of different indicators (cf. Ter Haar 2018: 414ff.).

This paper contributes to the understanding of effectiveness of public technology programmes by analysing the German Aeronautic Programme (LuFo), that supports research and innovation in the German civil aviation industry. Our unique dataset gives a detailed description of all LuFo-funded projects in industrial firms, research institutes and universities. For the innovation output we can use different indicators such as patents, publications, dissertations, product and process innovations or technology readiness levels (TRL)[2]. As indicators for innovation input, we can use the R&D spending and public funds. In addition, we have information of the type of institution and its size.

For the use of Technology Readiness Levels for impact assessments see Kerlen and Hartmann (2014).

Most importantly, we also have a variety of indicators for the innovative capacity at the beginning of the project. Therefore, we can test the importance of innovative capacity for the success of the innovation process.

The paper is structured in the following way. First, we introduce the German LuFo programme, which is the source of our data set. Then, we explain the concept of innovative capacity in more detail. Sections 4 introduces the dataset and first statistical results. Section 5 presents the results of our estimations and testing. In section 6 we shortly summarise our main findings.

2. THE AERONAUTIC R&D PROGRAMME OF THE GERMAN GOVERNMENT

The Federal Government's aviation research programme aims to support Germany as a high-tech location and to contribute to the competitiveness of the domestic aviation industry. It further contributes to achieve the "Strategic Research and Innovation Agenda" (SRIA) of the "Advisory Council for Aviation Research and Innovation in Europe" (ACARE 2018) of the EU Commission. The following five central "Challenges" are relevant in this context: (1) Addressing social and economic needs, (2) Maintaining and expanding industrial technology leadership, (3) Protecting the environment and energy supply, (4) Ensuring safety, and (5) Prioritising research, test environments and education systems. The SRIA environmental targets (ACARE 2018) have a cross-sectional impact on technology development and aim at reducing fuel consumption and emissions.

Building on these overarching objectives, the LuFo funding programme focuses specifically on the innovation system and current developments in Germany. Aircrafts are highly complex and elaborated technology systems. Major characteristics are remarkably long research, development and product cycles: the transfer of technologies to market maturity is time intensive and needs careful preparation in form of certification. This makes it common that results from current publicly funded research projects enter with a time lag of 10 to 20 years into newly developed aircrafts. The concept of innovative capacity is therefore highly relevant as it can be assessed earlier than other intended effects of the funding as e.g. new aircraft or components being introduced into the market.

Another goal of aviation research is to maintain and expand the technological core capabilities required to develop products and services for aircraft. The broadening and deepening of the competences of employees working in the industry and a further strengthening of the research infrastructure are further goals pursued by LuFo.

The overall economic objective of LuFo is to preserve and sustainably expand jobs in Germany along the entire value chain of the aviation industry, from research, development and production to maintenance and overall (MRO) services. In order to strengthen the competitiveness of companies, value-added activities as well as technological approaches to increasing productivity are supported. A current focus is the digitisation of aviation-specific manufacturing processes and products (under the keyword Industry 4.0). Artificial intelligence (AI) has been added as a new focus in LuFo VI. The objectives of the German LuFo programme are

2 For the use of Technology Readiness Levels for impact assessments see Kerlen and Hartmann (2014).

coherent with the European "Flightpath 2050" (European Commission 2011) strategy.

Aviation is more and more oriented towards social needs and requirements (including a reduction in noise and harmful gas emissions and an increase in flight safety). This is in line with international targets by the International Civil Aviation, which defined the so called (ICAO 2018) standards. New technologies are one key element to address the relevant environmental and sustainability targets. This has brought the German Ministry of Economic Affairs and Energy to implement the new funding line "Electric and Hybrid Flying".

In order to strengthen Germany's international position as a relevant aviation industry actor, an additional aim of LuFo is to support diversification of the supply industry. For this reason, there is a separate funding line directly focusing on small and medium-sized companies (SMEs). A further objective is to reduce the shortage of skilled workers and to support the development of skills, by supporting cooperative projects of industry and research institutions. Research institutions are approached individually in a funding line "eco-efficient flying", which has recently been expanded in LuFo VI to include the topic of "disruptive innovation".

3. THE CONCEPT OF INNOVATIVE CAPACITY AND HYPOTHESES

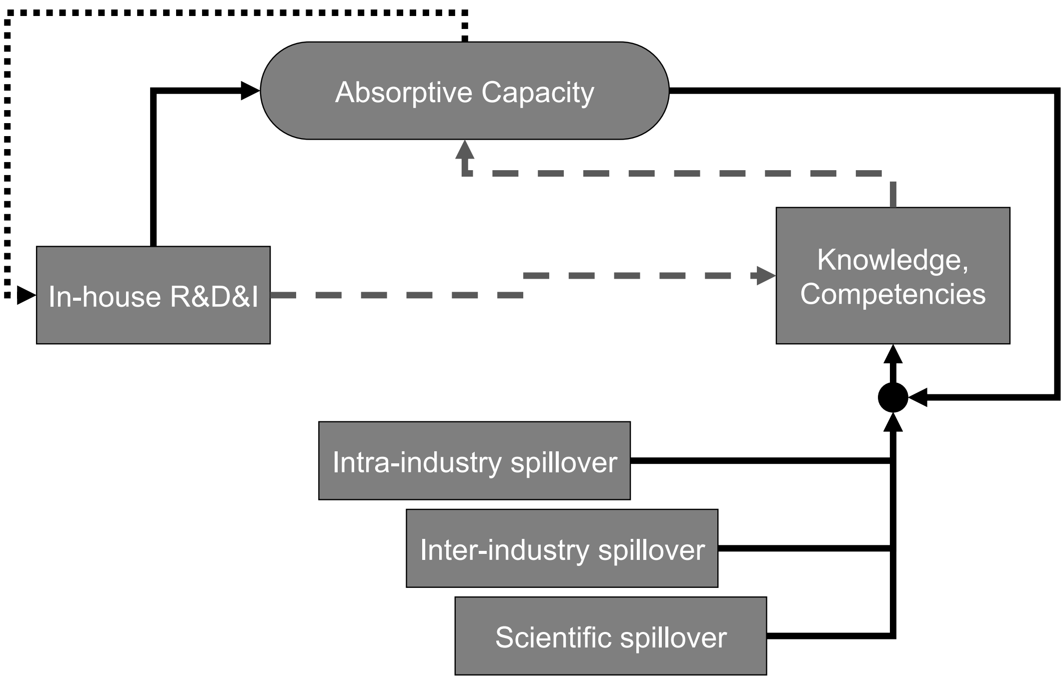
As pointed out earlier, the most important aspect of the innovative capacity of an organisation is its absorptive capacity, referring to its general ability to recognise external information and opportunities (e.g. new technologies, new organisational forms) and to use them for its own innovation purposes.

Figure 1 shows the interdependencies between absorptive capacity, external knowledge, own research, development and innovation (R&D&I) with regard to the organisation and the knowledge and competences within the organisation. Absorptive capacity is essential, as it determines the extent to which external information enhances firm specific R&D activities. Different dimensions of knowledge flows can be distinguished: the dimension of the own industry (intra-industry spill-over), other industries (inter-industry spill-over) and the science system (science spill-over).

Absorptive capacity itself is in turn determined by relevant knowledge and competences in the organisation. This not only refers to specialized gatekeepers who observe external developments, but ultimately to all employees who are affected by innovation: "Even when a gatekeeper is important, his or her individual absorptive capacity does not constitute the absorptive capacity of his or her unit within the firm. The ease or difficulty of the internal communication process and, in turn, the level of organizational absorptive capacity are not only a function of the gatekeeper's capabilities, but also of the expertise of those individuals to whom the gatekeeper is transmitting the information. Therefore, relying on a small set of technological gatekeepers may not be sufficient; the group as a whole must have some level of relevant background knowledge, and when knowledge structures are highly differentiated, the requisite level of background may be rather high" (Cohen und Levinthal 1990).

Public funding therefore aims at improving individual as well as organisational learning to enhance the innovative capacity as a core prerequisite for actual innovation of an organisation. Within research programmes individual learning is targeted by giving opportunities for academic research (e.g. in forms of dissertations) or by changing informal learning conditions, e.g. by introducing new, more intellectually

Figure 1: Absorption capacity and its relationship to knowledge and competences (modified from Cohen und Levinthal 1990, p. 141, taking into account enlargement proposals by Zahra und George 2002 and Schmidt 2005).



demanding tasks and operating procedures, or new organisational structures and processes. Public funding also aims at influencing organisational learning directly: Organisational learning can be conceptualised as building up on the organisation's intellectual capital which encompasses the three dimensions of human capital, structural capital, and relational capital (e.g. Kerlen and Hartmann (2014); Globisch et al. (2011); Alwert (2006)).

1. **Human capital:** this refers to the knowledge, skills, competences, motivation and attitudes of the employees of a company and determines the extent to which important external developments in science and industry are perceived and how these developments then flow into business processes. The company's own R&D also requires corresponding competencies, not only in the R&D departments, but ultimately (almost) throughout the entire company.
2. **Structural capital:** this refers to structures (e.g. organisational structure, but also technical infrastructures) and processes (e.g. work and communication processes) that influence the innovation capability of the company. Questions such as these arise here: How is research and development organised within the company? How does R&D interact with other departments, how is it communicated across departments? How learning and innovation-oriented is the corporate culture? How learning intensive are the working conditions for individual employees resulting from the company organisation?
3. **Relational capital:** This includes relationships with external partners in business, science, education, politics and administration. Especially important are relationships along the value chain, in one's own industry, with research institutions and training providers. These relationships serve to obtain information that is relevant in the innovation context (e.g. new technologies, new business models), to carry out R&D projects jointly with external partners and not least to develop other aspects of innovative capacity (e.g. development of human capital through cooperation with education providers).

In the context of publicly funded innovation processes, the concept of innovation capacity is very helpful to address outcomes of R&D programmes in early stages. During the funding period (in general three years) the exploitation of R&D results as innovation can hardly be observed especially in high-tech-sectors like the aerospace industry, due to long research and development cycles. Different to this, innovative capacity in the dimensions of human, structural and relational capital can be perceived before the R&D results are commercially exploited and, therefore, can be part of an impact assessment.

If this is true, we should be able to measure the impact of innovative capacity on innovation related outcomes. This would demonstrate that the concept is indeed suitable to assess the achievement of the programme's objectives at an earlier stage. Based on the theory presented above, we define the following hypotheses for our econometric approach, in order to test the impact of innovation capacity on innovation. As proxys for innovation we use different indicators like scientific publications, patents, training of PhD students, product innovation, process innovation and technology readiness levels. Following this reasoning, to test our overall hypotheses that innovative capacity has an important impact on innovation, we proceed by defining the following five specific hypotheses.

- H1: High innovative capacity at the beginning of the project leads to a high number of publications.
- H2: High innovative capacity at the beginning of the project leads to a high number of patents.
- H3: High innovative capacity at the beginning of the project has a positive effect on the training of PhD students.
- H4a: High innovative capacity at the beginning of the project favours product innovation.
- H4b: High innovative capacity at the beginning of the project favours process innovations.
- H5: High innovative capacity positively influences the speed of technology development (TRL jumps).

We test these hypotheses using data collected for an impact assessment of the German Aeronautic R&D programme (Wangler et al. 2019).

4. DESCRIPTIVE STATISTICS

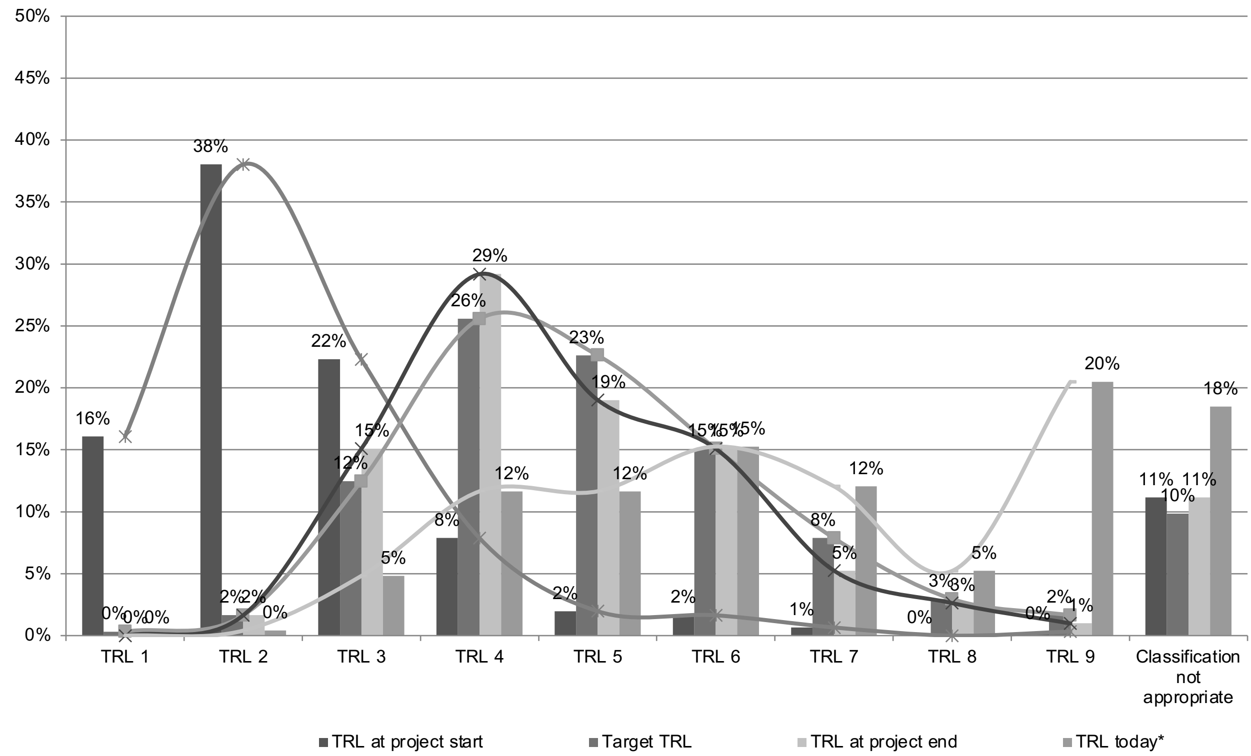
For our empirical investigation we use a unique dataset on the German civil aviation industry. It contains data from two different sources: the input-data (funding dataset) and the survey data based on an online-questionnaire gathering information on firms participating in the LuFo programme. The dataset is representative in that it encompasses information on all main industry actors, including original equipment manufacturers (OEMs) and main suppliers (Tier I to Tier n) along the whole value chain. In addition, university and research institutes are covered. Overall, the dataset consists of 2097 projects that received publicly funded supported for R&D. However, the dataset has missing variables and shrinks, depending on the variables integrated into the econometric model. This leads to much lower N's when estimating our econometric models.

The following results summarise some major statistical outcomes from Wangler et al. (2019). With regard to the overall spending on R&D projects, between 2007 and 2018 a budget of 3246 Mio. Euro has been realised. With 1781 Mio. Euro the share of public funding was about 52 percent. The remainder of 1464 Mio. Euro was contributed by the participating companies. Most of the projects have been cooperative projects, with three or four partners. Almost half of the projects are carried out by large companies, about a third by research organisations and about 16 percent by small and medium-sized enterprises.

Within the publicly funded projects, technologies are being advanced along several TRL. Figure 2 shows that most projects start at TRL 2 – technology concept and/or application formulated – (TRL at the start) and advance two technology stages (TRL at the end of the project) on average. The flattening of the curves illustrates that within some projects higher TRL are targeted and achieved. Curves for target TRL and TRL at the project's end are very close to each other: 75 percent of the projects are able to realise the targeted technology readiness level, 21 percent reach only a lower level (without own illustration). 20 percent of the technologies developed are marketable at the time of the survey: they reached TRL 9 – actual system proven through successful mission operations – at the time of the survey.

50 percent of the projects are expected to deliver marketable results in the near future. The projects proved to be of high relevance for the partners involved. 84 percent of the companies and 85 percent of the research organisations continue research and development on the topic area beyond projects' end dates. LuFo also fosters long-term research partnerships. About half of them can be considered as enduring cooperations.

Figure 2: TRL-Levels (Wangler et al. 2019)



LuFo IV, UN, n = 305
**82% der Projekte wurden weiterverfolgt*

Knowledge transfer is another programme outcome. Nearly all research organisations present their research results on conferences and 87 percent publish articles in research journals. Companies are playing an important part in knowledge transfer as well. 71 percent of them present their results in conferences and 62 percent publish articles. 30 percent of companies and research organisations file patents with an average of 4,5 patents per project in companies and 1,3 patents per project in research institutions. Research organisations are especially important for technology spill-over. 63 percent of the results of their projects can be used within the aviation industry and 20 percent in other industries. But companies play their part in technology transfer as well. Results of their projects can be used by other organisations within the aviation industry by 40 percent and by 4 percent in other industries. LuFo is also important for research cooperations between universities and private companies. In nearly 50 percent of the projects in enterprises and over 80 percent of the projects in research organisations, dissertations are written. Almost three quarters of these students pursue a career in the aviation industry or related research institutions.

For companies by far the most important benefit resulting from funded projects is the development of new products and processes, underlining the importance of LuFo to foster innovation. Over 59 percent of the enterprises state that they introduced a new or significantly improved product or process within the last three years prior to the survey. The participating companies also self-report relatively high scores on all dimensions of innovative capacity with higher scores at the end of the programme than in the beginning. They attribute a significant share of this improvement to their participation in LuFo. For research organisations LuFo plays an even more vital role. Maintaining and improving their position in the scientific community is attributed to LuFo in comparison to other research programmes even more strongly than by LuFo funded companies.

Regarding LuFo's objectives almost two thirds of the projects declare that they are contributing strongly to creating a competitive and efficient aviation industry, followed by contributing to an environmentally friendly aviation industry. Overall LuFo's impact is very strongly related to maintaining research competencies. Keeping competitiveness and innovative capacity up in the long run are the most important aspects. As a result of participating in LuFo, companies engage in continuous improvements of products and processes and were able to improve their innovative capacity.

5. ESTIMATION RESULTS

For our estimation model we build on this data and use patent applications, dissertations, product and process innovation as well as TR-levels as major output variables. We use determinants such as R&D spending and R&D personnel or company size (SMEs vs. OEMs) as control.

Based on the theory introduced at the beginning of our paper, the indicators on innovative capacity of private companies, with their dimensions (i) human capital, (ii) structural capital, and (iii) relational capital, are of major interest. The measurement for these variables refers to the beginning of the publicly funded projects. Table 3 gives an overview of the relevant questions and the weighting of the indicators to measure innovative capacity. The data in innovative capacity is based on the assessment of R&D managers, who are in charge with innovation processes.

Finally, we are able to use other indicators as control variables such as the size of the firm measured by revenue, the change in TRL, and R&D personnel. Table 6 (appendix, p. 19) gives an overview on the indicators and some relevant basic statistics. Table 7 (appendix, p. 19) shows the correlation matrix.

Table 1: Innovative Capacity

Human capital	Indicators	Weight
Indicator 1 (scale 0-5)	The personnel working in R&D have technological knowledge that allows research and development at an internationally outstanding level.	1/3
Indicator 2 (scale 0-5)	The personnel involved in the production have the knowledge and skills that allow production at a very high level technologically.	1/3
Indicator 3 (scale 0-5)	The company is able to keep its employees' knowledge and skills up to date by taking appropriate measures (e.g. various forms of further training, learning at work, temporary staff exchanges with research institutions, knowledge management systems, etc.).	1/3

Structural capital	Indicators	Weight
Indicator 1 (scale 0-5)	There are one or more organisational units responsible for R&D whose structures (e.g. subdivisions) enable them to carry out research and technology at an internationally outstanding level.	1/5
Indicator 2 (scale 0-5)	There is an R&D department equipped with resources (e.g. enough personnel) that enables conducting research and technology at an internationally outstanding level.	1/5
Indicator 3 (scale 0-5)	The R&D department has a technical infrastructure and tools (e.g. IT, measuring instruments, production technology for the manufacture of models and prototypes) that enable it to carry out research and technology at a high level.	1/5
Indicator 4 (scale 0-5)	Cooperation between R&D and production departments is organised in such a way that knowledge and experience can be exchanged in both directions.	1/5
Indicator 5 (scale 0-5)	The employees in our company very often have to learn new things in their work or solve problems creatively.	1/5

Relational capital	Indicators	Weight
Indicator 1 (scale 0-5)	Our company is very well networked with suppliers and customers, so that it is possible to carry out R&D projects and other innovation projects together - outside of public funding.	1/5
Indicator 2 (scale 0-5)	Our company is very well connected to research institutions, so that it is possible to jointly carry out R&D projects and other innovation projects on an internationally outstanding level.	1/5
Indicator 3 (scale 0-5)	Our company is very well connected to educational institutions - vocational and university education - so that we can meet our qualification needs through training and further education at a high level.	1/5
Indicator 4 (scale 0-5)	Our company has a good public image (for example, we are perceived as an economically efficient and innovative company or as an attractive employer).	1/5
Indicator 5 (scale 0-5)	We provide transfer services in terms of technological knowledge between the aviation industry and other industries.	1/5

Innovative capacity	Indicators	Weight
Indicator 1 (scale 0-5)	Human capital	1/3
Indicator 2 (scale 0-5)	Structural capital	1/3
Indicator 3 (scale 0-5)	Relational capital	1/3

In order to test our main hypotheses we define innovation in three different ways:

1. We analyse the impact of innovative capacity on innovations as measured by the number of patents, publications and dissertations.
2. Innovation is defined as a binary variable [0,1], i.e. innovations (product and process innovation) occurred or not.
3. We define innovations by the change in the technological readiness level (TRL) during the project. For comparability of the models we establish a baseline model with our controls and integrate step by step our main variables of interest about innovative capacity.

5.1 IMPACT OF INNOVATIVE CAPACITY ON PATENTS AND PUBLICATIONS

As estimation model we choose a poisson regression with fixed effects, which seems appropriate as the outcome variable consists of count-data and a small sample size. For our control variables (revenue= REV, technology readiness level = TRL and R&D personnel = R&D_PERS) we do not get any significant outcome for our model with patents as the dependent variable. This is different when we use publications as the dependent variable. Some of the control variables are significant. We find strong evidence that innovative capacity has a positive effect on patenting as well as publication performance of companies in the dimensions of human capital and structural capital. Integrating the three indicators on innovative capacity together into the estimation model (Model 4), shows highly significant results also.

The regression results with patents as the outcome variable (Table 1) show strong positive results for the factors human capital and structural capital and innovative capacity as aggregated indicator across all three capital dimensions. However, for relational capital we do not find any significant result. We interpret the negative and non-significant result for relational capital in case of patenting activities thus that in case of cooperation, innovation is more like an open science project. The more firms cooperate, the less likely it is that they patent their ideas.

When we look at publications, we get similar results. Strong positive correlation is found for human capital, structural capital and aggregated innovative capacity. Relational capital is still insignificant but has a positive effect, which supports the hypothesis. We also test the impact of innovative capacities by using dissertations as the dependent variable (Table 8, appendix, p. 19), but do not find any significant result. A possible explanation could be, that firms are less focused on dissertations, compared to research institutes and universities.

Based on these findings we are able to confirm H1 and H2, namely "high innovative capacity at the beginning of the project leads to a high number of publications as well as a high number of patents".

Table 2: Patents as Independent Variable

	(1)	(2)	(3)	(4)
	Patents			
REV	-4.85e-10	-5.64e-10	-4.06e-10	-3.86e-10
	(-1.32)	(-1.61)	(-1.32)	(-1.31)
TRL	0.0334	0.0519	0.00657	-0.00347
	(0.37)	(0.58)	(0.07)	(-0.04)
R&D_PERS	0.00152	0.00161	0.00154	-0.000108
	(0.80)	(0.82)	(0.72)	(-0.06)
HC_t1_U	**0.525*** **			
	(2.59)			
SC_t1_U		**0.782*** **		
		(3.64)		
RC_t1_U			-0.237	
			(-0.90)	
IC_t1_U				**0.657** **
				(2.45)
N	59	59	50	50
bic	148.2	140.0	136.7	130.8

t statistics in parentheses

p < 0.10, ** p < 0.05, *** p < 0.01

Table 3: Publications as Independent Variable

	(1)	(2)	(3)	(4)
	Publications			
REV	-1.83e-12	5.12e-12	1.35e-10**	1.27e-10**
	(-0.16)	(0.51)	(2.45)	(2.32)
TRL	**-0.152****	0.00225	0.0524	0.0641
	(-2.19)	(0.03)	(0.54)	(0.66)
R&D_PERS	**0.00471****	**0.00734*****	-0.0157	-0.0155
	(2.54)	**(3.71)**	(-0.75)	(-0.74)
HC_t1_U	**0.476*****			
	(3.34)			
SC_t1_U		**0.677*****		
		(5.28)		
RC_t1_U			0.220	
			(1.04)	
IC_t1_U				**0.326***
				(1.67)
N	52	52	40	40
bic	238.2	212.1	93.81	91.83

t statistics in parentheses * p < 0.10, ** p < 0.05, *** p < 0.01

5.2 IMPACT OF INNOVATIVE CAPACITY ON PRODUCT AND PROCESS INNOVATIONS

We proceed with the estimations using product innovation and process innovation as dependent variables and we use the indicators on innovative capacity as explanatory indicators. Therefore, the estimation is based on a logit-model. As control variable we implement revenue to capture the effect of the size of the companies. As a robustness check, we also include productivity calculated as revenues by number of employees (REV/EMPL). As a result, the findings are robust. For product innovation we find a rather strong relationship on all three dimension: human, structural and relational capital. The aggregated indicator on innovative capacity is also significant.

Table 4: Product-Innovations as Independent Variable

	(1)	(2)	(3)	(4)
	PROD_INNO			
REV	4.55e-12	4.83e-12	2.25e-11	1.70e-11
	(0.17)	(0.18)	(0.78)	(0.60)
HC_t1_U	**0.356*****			
	(2.58)			
SC_t1_U		**0.357*****		
		(2.68)		
RC_t1_U			**0.503*****	
			(2.87)	
IC_t1_U				**0.564*****
				(2.99)
N	192	192	153	153
chi2	7.299	7.834	10.35	11.18
bic	220.3	219.8	167.6	166.8

t statistics in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

Table 5: Process-Innovations as Independent Variable

	(1)	(2)	(3)	(4)
	PROC_INNO			
REV	-3.38e-11	-2.85e-11	-2.06e-11	-2.30e-11
	(-1.13)	(-0.97)	(-0.68)	(-0.74)
HC_t1_U	**0.333****			
	(2.45)			
SC_t1_U		0.194		
		(1.52)		
RC_t1_U			**0.296***	
			(1.82)	
IC_t1_U				0.274
				(1.59)
N	192	192	153	153
chi2	7.057	3.151	3.801	2.971
bic	225.0	228.9	179.1	179.9

t statistics in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

Based on the same model we look on the impact of innovative capacity indicators on process innovations. Here we only find significant outcomes for human capital and relational capital. We do not find any significant result for structural capital and the overall innovative capacity. When we further control for SMEs, the estimation remains constant, however the positive significant result for relational capital and process innovation outcome is not persistent. This seems to be plausible, as innovation in SMEs is first of all a factor depending on human capital, structural capital and innovative capacity are factors that are significantly more distinct within bigger companies.

Based on these findings we come to the conclusion that our concept of innovative capacity has high impact on product innovations. The evidence on process innovation is not that obvious. We therefore find H4a confirmed while we reject H4b. That the findings are insignificant for process innovations is somehow counterintuitive at first glance. However, as process innovations are very company specific we find that human capital is one major factor explaining process innovation. Some weak evidence is found for relational capital, meaning that firms need a good network to be able to source technologies which are necessary to adapt innovative processes within the firm. Structural capital is also important within this context, but according to our regression it is less important compared to human capital and relational capital as it turns out to be insignificant. For our overall indicator on innovative capacity we also do not find any significant result for its impact on process innovation.

Table 6: Process- and Product Innovations as Independent Variable controlling for SMEs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PROD_INNO					PROC_INNO		
REV	1.42e-13	1.63e-13	1.64e-11	1.24e-11	-3.89e-11	-3.47e-11	-2.81e-11	-2.99e-11
	(0.01)	(0.01)	(0.59)	(0.45)	(-1.21)	(-1.10)	(-0.84)	(-0.88)
SME_Dummy	**-0.837****	**-0.845****	**-0.737***	-0.710	**-0.681***	**-0.779****	-0.646	-0.677
	(-2.24)	**(-2.27)**	**(-1.65)**	(-1.58)	**(-1.84)**	**(-2.13)**	(-1.50)	(-1.56)
HC_t1_U	**0.279***				**0.265***			
	(1.95)				**(1.88)**			
SC_t1_U		**0.291****				0.125		
		(2.11)				(0.94)		
RC_t1_U			**0.412****				0.211	
			(2.26)				(1.23)	
IC_t1_U				**0.468****				0.174
				(2.37)				(0.95)
N	192	192	153	153	192	192	153	153
chi2	12.40	13.07	13.12	13.70	10.48	7.755	6.074	5.435
bic	220.5	219.8	169.9	169.3	226.8	229.5	181.8	182.5

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.3 IMPACT OF INNOVATIVE CAPACITY ON THE SPEED OF TECHNOLOGY DEVELOPMENT

As a final research question we look at the impact the concept of innovative capacity has on the speed of technology development using (TRL2-TRL1) as the dependent variable. We use OLS to regress the impact of innovative capacity on TR-Levels. We use REV as our control variable and have further integrated an SME dummy. The estimation results do not show any significant results. We therefore have to reject H5. There is no significant correlation between innovative capacity and the speed of technology development. This might have to do with the specific characteristics of the aerospace sector with its long processes and complex procedures in developing a technology. Speed is not a major characteristic of innovativeness in the aerospace industry, developing new products can take more than one decade. The negative sign of our coefficients might be a hint in this direction. The results, however, are insignificant (see Table 9, appendix, p. 19).

6. SUMMARY OF THE MAIN FINDINGS

Our findings are promising. There is strong evidence that innovative capacity influences innovation outcomes positively. The results are robust with respect to the indicators used for innovation, i.e. patents, publications and product innovations. However, we find relatively weak evidence for the relationship between innovative capacity and process innovations, and no evidence is found for the relationship between innovative capacity and the speed of technology development or on doctoral theses.

This brings us to the conclusion, that innovative capacity is a useful model in order to – at least partly – explain innovation processes within high-tech-industries. We established the model of innovative capacity for assessing outcome related R&D effects of publicly funded research. The econometric results underline that it is legitimate to use innovative capacity as an early indication for innovation success. This is even more relevant, when publicly funded R&D projects are designed in order to support developments in human, structural and relational capital. Then, the strengthening of innovative capacity will increase innovation outcomes in later stages. A second basic result of our analysis is that self-reports by experts, who are in charge with innovation processes, deliver (at least to some extend) reliable data. For this reason, we are able to confirm statistically our theoretical assumptions, that innovative capacity is relevant for innovation outcome.

Though promising, our results have some limitations. Firstly, our findings are limited to the aerospace sector with its sector-specific characteristics. It would be interesting to see if our findings also hold true for other sectors. Secondly, more research is needed to come to a better understanding how the importance of innovative capacity changes along the innovation related time-cycle. Thirdly, as this is a first paper addressing the impact of innovative capacity on innovation, more evidence is needed to further demonstrate the robustness of our results.

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KEYWORDS
innovative capacity, innovation, aerospace industry, human capital, structural capital, relational capital.

APPENDIX

Table 7: Data

Variable		Obs	Mean		Std. Dev.	Min	Max
PAT	Patents	1,291	.6111541		3.011966	0	67
DISS	Dissertations	1,291	.3826491		.9863296	0	10
PUB	Publications	857	1.37923	2.633747	0	40	
TRL	Technology Readyness Level	658	4.989362		2.359903	0	10
REV	Revenue	798	3.42e+08		3.48e+09	0	7.81e+10
R&D_PERS	R&D Personnel	1,261	12.77872		93.17354	0	1900
PROD_INNO	Dummy for product innovation.	1,338	.1748879		.3800132	0	1
PROC_INNO	Dummy for process innovation.	1,338	.171151	.3767817	0	1	
HC _t1_U	Human Capital at the beginning of the R&D project	194	3.199313	1.148361	0	5	
SC _t1_U	Structural Capital at the beginning of the R&D project	194	3.083505		1.199411	0	5
RC _t1_U	Relational Capital at the beginning of the R&D project	154	3.227273		1.067908	0	5
IC _t1_U	Innovative capacity at the beginning of the R&D project	154	3.171284		.9819707	0	5

The correlation of these main variables is summarised by the following correlation matrix.

Table 8: Correlation Matrix

bbs=42	PAT	DISS	PUB	TRL	REV	R&D_ PERS	PROD_ INNO	PROC_ INNO	HC _t1_U	SC _t1_U	RC _t1_U	IC _t1_U
PAT	1.0000											
DISS	-0.0620	1.0000										
PUB	-0.0457	0.8303	1.0000									
TRL	-0.1092	-0.0907	-0.0384	1.0000								
REV	-0.0463	0.3697	0.6323	-0.0026	1.0000							
R&D_PERS	-0.0541	0.0876	0.0941	-0.3668	0.1801	1.0000						
PROD_INNO	-0.1442	0.1125	0.0742	0.1097	0.0444	0.2020	1.0000					
PROC_INNO	-0.1954	0.1261	0.0822	0.0140	0.1126	0.2208	0.6581	1.0000				
HC _t1_U	0.0955	-0.0080	0.1617	-0.0692	0.2045	0.0153	0.1889	-0.0482	1.0000			
SC _t1_U	0.1802	0.0139	0.1341	-0.1971	0.0518	-0.0762	0.0627	-0.1745	0.7089	1.0000		
RC _t1_U	-0.0709	0.1362	0.0783	-0.3361	-0.0757	0.3298	0.1356	-0.1026	0.5295	0.5239	1.0000	
IC _t1_U	0.0935	0.0493	0.1483	-0.2288	0.0754	0.0830	0.1459	-0.1316	0.8783	0.8971	0.7753	1.0000

Table 9: Dissertations as Independent Variable

	(1)	(2)	(3)	(4)
	Dissertations			
REV	4.73e-11	4.37e-11*	2.33e-10	1.93e-10
	(1.59)	(1.71)	(1.15)	(1.06)
TRL	-0.164	-0.0878	0.150	0.0593
	(-0.81)	(-0.45)	(0.49)	(0.20)
R&D_PERS	-0.00120	-0.00247	-0.0639	-0.0480
	(-0.26)	(-0.51)	(-0.84)	(-0.70)
HC_t1_U	0.0753			
	(0.21)			
SC_t1_U		0.503		
		(1.43)		
RC_t1_U			1.048	
			(1.17)	
IC_t1_U				0.318
				(0.45)
N	49	49	38	38
bic	51.49	48.95	28.66	30.32

t statistics in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

Table 10: Speed of technology development (Delta TRL)

	(1)	(2)	(3)	(4)
	Delta TRL			
REV	7.48e-12	6.78e-12	6.51e-12	6.29e-12
	(0.69)	(0.63)	(0.57)	(0.54)
SME_ Dummy	-0.0139	-0.00407	0.0108	0.0159
	(-0.14)	(0.09)	(-0.14)	(0.14)
HC_t1_U	-0.0182			
	(-0.45)			
SC_t1_U		-0.00155		
		(-0.04)		
RC_t1_U			-0.000390	
			(-0.01)	
IC_t1_U				0.00827
				(0.13)
Intercept	0.452**	0.378**	0.348	0.310
	(2.37)	(2.12)	(1.22)	(1.08)
N	88	88	69	69
r2	0.00788	0.00530	0.00550	0.00580
F	0.204	0.137	0.107	0.113
bic	92.49	92.72	77.34	77.32

t statistics in parentheses * p < 0.10, ** p < 0.05, *** p < 0.01

DRIVING FROM THE FRINGE INTO SPOTLIGHT

THE UNDERRATED ROLE OF STANDARDS AND STANDARDIZATION IN RTDI POLICY AND EVALUATION

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DOI: 10.22163/fteval.2020.492

1 INTRODUCTION

In an article of 2018 for the Japanese chapter of the AIIPI (Association for the Protection of Intellectual Property of Japan), authors Yang & Kim ask the rhetoric question what autonomous driving, artificial intelligence, blockchain, big data, and Internet of Things (IoT) all have in common. Their answer is that *"they are disruptive, evolutionary, and affecting all of us" and, more importantly, that "…they also rely on…'standards' – common protocols to ensure interoperability among our devices."*

Standards – understood, according to the International Standard Organization (ISO), as documents produced *"…by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context"*[1] – are an important instrument in the toolbox of policy makers in various domains. Done the 'right' way, standards and the process leading to such standards (i.e., standardization) help to foster and diffuse innovations; to ensure economic competitiveness; as well as to allow for high safety, health and environmental protection levels when using products or services.

This general understanding is, however, a rather recent phenomenon. It is also reflected in the evolution of the research on standardization. For example, with respect to the important relationship between innovation and standardization, there were just 13 academic papers written on the subject in 1995 (Choi, et al., 2011). The number of papers on this topic henceforth increased constantly to around 70 publication p.a. some 15 years later. Despite the respective relevance of the topic, traditional RTDI policy has been treating the topic of standards & standardization rarely as a topic of particular interest. In traditional depictions of the national innovation system, "standards and standardization" feature at the fringes, as part of the "infrastructure" of the system (Kuhlmann and Arnold, 2001).

National innovation system reviews rarely tackle the topic in adequate depth - the 2018 OECD review of the Austrian innovation policy, for example, mentions standardization only briefly in two places (OECD, 2018): first, with respect to 5G where it is said that the *"standardization process is on-going"* and that Austria, in terms of 5G deployment, is *"…lagging in 5G rollout behind leading countries such as Japan and Korea."* (p. 118). In the second place, the statement is simply that some of Austria´s ACR (Austrian Cooperative Research) institutes[2] - *"…are strongly involved in standardization activities at the national, European and international level."* (p. 169). Most notably, there is no mention of standards and standardization in the chapter on the policy mix to support business R&D and innovation. The OECD report hereby reflects that many countries, including Austria, do rarely have dedicated support mechanisms and programs in place to foster (quality) use and development of the standards and standardization system.

In this paper, we try to tackle this issue and discuss a) the evidence as it relates to the role of standards and standardization for research and innovation policy, and b) briefly outline possible reasons why the topic of standards and standardization may not receive the necessary attention. Furthermore, the paper presents an outline to policy developments and support mechanisms c) in place at the European level, d) at national level in Germany (which could be seen as being internationally, in Europe, in the lead in this field) and e) in Austria, all of which aim to improve the usage and development of standards. Eventually, the paper concludes by summarizing possible areas of action for policy makers and implementers as well as implications for evaluators of RTDI programs, institutions and policies. The paper is based on literature and document review complemented by three interviews conducted with an innovation agency and a standards-developing organization (SDO).

1 See https://www.iso.org/sites/ConsumersStandards/1_standards.html, last accessed 5 October 2020. This notion of being voluntary sets standards / standardization, importantly, apart from the policy instrument of government regulation. Government regulation makes the application of working principles laid out in the regulation mandatory by law.

2 ACR institutes denote a group of non-university private research institutes in Austria heavily involved with applied research for the benefit of SMEs (https://www.acr.ac.at/english/, last accessed 5 October 2020).

2 THE CURRENT EVIDENCE BASE REGARDING THE ECONOMIC IMPACT OF STANDARDS

2.1 BENEFITS AND EFFECTS

A body of literature has developed over the past 20 years that tries to assess the economic impact of standards. Within those, a bulk of studies attempts to link macro-economic indicators (such as GDP, productivity) to the use of standards. Such studies draw on a production function that attempts to answer the question to what extent the output variables (e.g., GDP) can be attributed to the input variables (e.g., use of standards).

E.g., Blind, Jungmittag and Mangelsdorf (2012) use the Cobb-Douglas Production function which distinguishes as input variables capital input, workforce (labor input) and technical progress (otherwise also called total factor productivity). Technological progress is hereby the result of three components: technological knowledge generated within the country, technological knowledge created abroad and the diffusion of this knowledge. The big problem with this rather abstract function is to operationalize it with variables for which there exists empirical data. That data should, at least as proxies, reflect "technological creation" and "technological diffusion". In the said study Blind, Jungmittag and Mangelsdorf, use the number of patents filed over time in Germany and the licensing expenditures IP generated over time as proxies for the two knowledge generation variables. The number of standards created over time is utilized as proxy for knowledge dissemination.

Without divulging into a discussion on the advantages and deficiencies of using these specific variables for measuring what is supposed to be measured, the methodological approach highlights one significant aspect of current thinking about standards: as a channel for disseminating knowledge, for knowledge / technology transfer. This thinking pushes patents – otherwise a variable also widely discussed in terms of merits to measure technology transfer – somewhat back in a presumed "tech transfer value chain", as input variables. The authors state in this context (p. 4):

> *"To ensure continual economic growth it is not sufficient to only create new knowledge through research and development. This knowledge must also be broadly disseminated so that as many companies as possible can make use of it. Standards that are developed in consensus with the participation of companies are particularly suitable for disseminating technical knowledge. Standardization experts record the current technological standard in documents, thus facilitating its broad diffusion in the market. As opposed to information in patents, which are subject to intellectual property rights, the information codified in standards is accessible to all and therefore its dissemination is not restricted."*

Using regression analysis, the analysis of Blind, Jungmittag and Mangeldsdorf suggests that standards may accrue an economic benefit in Germany of some €16.77b a year, corresponding to some 0.72% of Germany´s GDP (time frame of the analysis: 1960 – 2006). Similar types of studies have been carried out for other countries, e.g. for the UK (Hogan et al, 2015) for the Nordic countries (Grimsby et al., 2018) (in both cases using labor productivity as dependent variables) or for Australia (Standards Australia, 2013). The results of all these studies point into the same direction.

Another body of studies, which is particularly interesting in the context of RTDI policy, looks at the interrelation between standards/standardization and innovation. To this end, comprehensive literature reviews of the available evidence have been carried out by Swann (Swann, 2010, updating earlier work of 2000) and, most recently, by Blind (2017). The table below provides a summary of effects: it can be seen that standards/standardization may have positive as well as negative effects on innovation.

Table 1 Functions of standards and their effects on innovation

Function of standards	Positive effects on innovation	Negative effects on innovation
Compatibility/ interoperability	Network externalities	Monopoly power
	Avoiding lock-in to old technologies	Lock-in to old technologies in case of strong network externalities
	Increasing variety of system products	
	Efficiency in supply chains	
Minimum quality / safety	Avoiding adverse selection	Raising rivals' costs
	Creating trust	
	Reducing transaction costs	
Variety reduction	Economies of scale	Reducing choice
	Critical mass in emerging technologies and industries	Market concentration
		Premature selection of technologies
Information	Providing codified knowledge	

Source: Blind (2017)

2.2 BARRIERS

Given the number of benefits one can accrue from standards and standardization, and in general the significance of standards for innovation, the question remains why standards / standardization are seemingly not getting more attention in RTDI policy making. A number of barriers are identifiable, among which the following stood out in discussions with interview partners during the writing of the paper:

- The fact that standards and standardization may have positive or negative effects on innovation may trigger a certain reluctance on the policy side to engage more with the topic. In interviews, we were provided with anecdotal evidence that this factor has played a role in the past in policy making in some countries when the question was for the competent authorities to place standards and standardization on the agenda. Indeed, finding the right balance in standards such that benefits are maximized while possible disadvantages (such as certification / compliance costs) are minimized is a key aspect policy makers and standards developers face. This challenge is faced also in adjacent policy areas, such as with the Intellectual Property (IP) system, where similarly good balances between the rights of right holders and non-right holders must be sought.

- There is clearly a lack of awareness on the processes and functions of standards and standardization, exacerbating the reluctance as noted in the bullet point above. In interviews, the need was expressed to address this issue with a variety of stakeholders and through a multitude of channels: in education, where teaching on standards and standards economics is scarce and patchy with relevant institutions; with researchers, who will have to do learning on the job when dealing with standards (provided they recognize their significance and potential when drafting the proposals); with policy makers and innovation support agencies, who may need handles on how to deal with this topic; etc.
- Connected to both items, there may be a perceived lack of 'sexiness' of the topic, according to interview evidence. Standards and standardization may be associated with rather dry and old topics and institutions which handle things like how plugs look like or what sizes sheets of paper should have. Too little may be known about the significant role of standardization in topics like Artificial Intelligence, e-mobility, sustainability, etc.
- The standards / standardization system has been repeatedly the subject of criticism in that it supposedly represents only (large) "insider" industry communities. Hence, there is a need to promote transparency and foster the participation of different stakeholder groups, including the research sector, SMEs, special interest groups (see also Blind, 2017).
- The standards / standardization system has been equally criticized for being rather slow, given that it requires consensus to be reached in the respective communities. In fact, there are examples where single industry participants have chosen to push ahead with own solutions rather than waiting for a standard to be established (one of the more recent examples was Apple´s choice to develop its lightning connector (Müssig, 2020)). Apart from the fact that there are, conversely, also ample of success stories, SDOs (Standard Developing Organization; e.g., organizations like DIN) have developed sorts of "standards light" which can be developed faster and do not require full consensus. The respective instruments of "DIN specifications (DIN specs)" or the "CEN Workshop Agreement (CWA)" by the European standardization body CEN are to be mentioned in this context. They exemplify also instruments of the standardization system that may be particularly suitable for R&D projects and also attainable within the running time of a project as project outputs.

3 STANDARDIZATION AND INNOVATION SUPPORT – THE EUROPEAN DIMENSION

At the European level there is considerable activity and support going on regarding standardization. However, it is arguable whether the majority of activities happen only within the standardization system and constitute actions to which classic innovation policy is mostly myopic. To mention is, first of all, that the European Commission is heavily involved in the development of standards, e.g. in the course of regulatory and law-making activities. There is clearly laid out work division between the EC and the three European standardization organizations (CEN – which brings together 33 national standard developing organizations generally for standards; CENELEC – specifically responsible for the electrotechnical engineering field; ETSI – for telecommunication), backed up also by law (Regulation 1025/2012).[3]

The system of harmonized standards should be highlighted at this point.[4] These are European standards created by one of the said three European standardization bodies by request of the European Commission. Respective standards have been created in many technology fields, such as electric/electronic engineering (e.g., Low Voltage Directive, Radio Equipment Directive), toys (e.g., Toys Safety Directive), Medical Devices, Chemical substances (REACH), etc. The use of these standards remains voluntary, i.e. manufacturers, operators and conformity assessment bodies are free to choose to apply the standard for assessment of conformity with legal requirements or to use another technical solution.

Further to that, one can see also focal activities of the European Commission in certain areas of standardization. This is, for example, the development (and support of the development) of standards in the ICT sector; the area of making standards and standardization system more accessible to SMEs; or the activities around the topic of standard-essential patents (SEPs) and the respective licensing practices.

A key document in the context of the European standardization policy is the „Joint Initiative on Standardisation" from 2016, which is part of the Single Market Strategy. The Strategy *„…sets out concrete actions to further drive innovation, raise awareness of the importance of standards, and improve the representation of European SMEs' interest internationally."*[5] The Initiative maps out various domains and defines activities within them (domain 1 being awareness and education; domain 2 being coordination, cooperation, transparency and inclusiveness; domain 3 concerns competitiveness and the international dimension). Some 15 actions have been defined within these domains. Notable among these are particularly the greater use of standards in public procurement (action 11); standardization to support digitization (action 14); improving the representation of SMEs and other stakeholders in the standardization process (action 15); programs for education in standardization/training and awareness (action 3), or – to be underlined particularly in the context of this article – linking research

3 https://ec.europa.eu/growth/single-market/european-standards_en, last accessed 3 November 2020
4 https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards_en, last accessed 5 October 2020
5 https://ec.europa.eu/growth/content/joint-initiative-standardisation-responding-changing-marketplace_en, last accessed 3 November 2020

and innovation with standardization (action 2), which reads as follows (European Commission, 2016, p. 2):

„It is important to highlight the link between research, innovation and commercialisation using standardisation as early as possible in order to exploit to a maximum the outcomes of current and future research and innovation projects from, for example, Horizon2020 or from other existing technical platforms. An early in-depth analysis should be carried out of where, when and how standardisation can help to boost innovation in European innovation programs. It would also be helpful to increase the use of standards by business to foster market access for their innovation. Those standardisation deliverables supporting research and innovation projects that have been realised so far will be assessed and the development of pilot projects may also be taken into consideration."

A concrete activity that has evolved in this context are the BRIDGIT-I and BRIDGIT-II projects (BRIDGE – Bridging the Gap between Research and Standardization). The projects ran from 2013 to 2015 and then from 2017 to 2020 (BRIDIGIT-II will be hence closed soon). The aim was/is to *„…overcome the barriers between the standardization world on one hand and on the other the European research and innovation community"*.[6] BRIDGIT-II, as continuation of BRIDGIT-I, is co-funded by CEN-CENELEC and the EU/EFTA and assembles a number of national SDOs under the lead of DIN to a) increase the capacity of CEN-CENELEC member SDOs to engage with the RTDI community (*„especially by participating in Horizon 2020 actions"*, Ibid.) and through mentoring programs/seminars; to support higher engagement of national SDOs with the local/national RTDI system; to assess the role of standardization in Framework Programs; to create a repository of tools for the RTDI community; to disseminate the results.

Against this backdrop, the project introduced the concept of an "integrated approach", which is outlined in a PDF document as a guide for SDOs on how to link standardization with (EU) research projects (CEN/CENELEC, 2015). In essence, the integrated approach provides a) for rationales to advertise and evangelize the topic of standardization to research organizations and b) provides for a process by which standardization is to be considered and integrated into R&D projects. As – perhaps surprising – a core element of the process is the approach to have standardization bodies participate in R&D projects as consortium partner.

This may look odd because one could assume that organizations like DIN, Austrian Standards International, etc. are public agencies like a patent office or an innovation agency. With such agencies, one would not expect participation in funded R&D projects to be a strategic business case. The case of SDOs seems different. It must be remembered that SDOs are private organizations that operate under a different logic than public entities. In interviews, it was also revealed that SDOs may see their know-how of handling processes that lead to consensus among many discussants as an asset and business case beyond actual standardization.

The interviews have revealed that the majorly found operating mode for catering for the standardization topic in European research programs (Horizon Europe) is to have the topic clearly mentioned in call texts and working programs (e.g., as desirable outputs or outcomes). This should alert researchers to the significance of standardization for their proposals and the potential attractiveness of SDOs as consortia partners.

We were told in interviews that BRIDIGIT results indicate that, in this context, projects with SDO participation have been observed to have a higher chance of obtaining funding than projects without SDO participation. Against this backdrop, it is noteworthy that under the heading of what national standardization bodies can offer as a) "solution" to researchers preparing proposals as well as b) to national policy makers, it is said in the aforementioned "integrated approach": *"…An appropriate integration of standardization can improve the results of the evaluation of project proposals and thus contribute to shares in European funds".* (CEN/CENELEC, 2015, p. 14). BRIDGIT and SDOs have created a number of case studies showing successful integration of the standardization topic in Horizon projects.

4 RTDI COMMUNITIES AND STANDARDIZATION AT NATIONAL LEVELS

4.1 GERMANY

Evaluators in the RTDI arena usually will hardly come across the topic of standardization in (national) RTDI funding, majorly because specific funding programs to foster the creation of standards rarely exist and the topic of standardization is mostly not catered for in „regular" support programs, at least not in a systematic way. The exception to that rule is Germany, where the Federal Ministry for Economic Affairs and Energy (BMWi) has been operating a respective support program for many years.

The support program WIPANO (WIssenstransfer durch PAtente und NOrmen, engl.: knowledge transfer through patents and standards)[7] currently has one funding line (we denote this as funding line 1) where SMEs and firms (with up to 1,000 employees) can obtain a grant if they intend to start participating in standardization committees within SDOs.[8] The funding is in the form of a grant that covers 70% of costs with a total ceiling of €40,000 per firm/project. The grant is payable in distinct installments ("Leistungspakete") which cover the following costs/areas: Advice concerning and actual participation in standardization committees (€20k max); searches on/within standards documentations (€10k max); development of a DIN Spec (€10k max). The maximum running time for funding line 1 is 36 months. This funding line has been only recently introduced.

The second funding line is specifically for technology transfer from university/research to industry. The funding concerns collaborative R&D projects where at least one partner is a firm and a maximum of 70% of work (expressed in working time) is accounted for by universities or public research organizations (PROs). The projects are to focus on the transfer of R&D results into standardization processes and, ultimately, the development of (drafts for) new standards. Universities and PROs

6 https://www.din.de/en/innovation-and-research/research-projects/innovation-and-education/bridgit2-276692, last accessed 5 October 2020
7 https://www.innovation-beratung-foerderung.de/INNO/Navigation/DE/WIPANO/wipano.html, last accessed 5 October 2020
8 The exact requirement is that the firms should not have engaged in standardization committees in the past three years.

can have 85% of their costs covered, participating SMEs up to 80%. The running time of the respective projects is set at a maximum of 24 months. This funding line has been in existence in varied forms and under different names since around 2006.

WIPANO has been regularly evaluated – its predecessor programs date back to the early 2000 years –, with the most recent evaluation having been undertaken by Fraunhofer ISI in 2019 (Kulicke et al., 2019). The evaluation concerned the entire WIPANO program, not only the funding lines for standards. As regards the standards funding lines, the major results were the following:

- At the time of the evaluation, the number of funded projects in the SME funding line (funding line 1) was still considered rather low, due also to a longer design and preparation phase for setting up the current form of the funding scheme. Between 2016 and end of 2018, WIPANO approved funding in both funding lines for a total of 172 projects and granted €16.75m to the various firms and consortia members.
- 66% of the beneficiaries were firms, 34% universities/PROs. 31% of beneficiaries were SMEs, which is regarded as a success, which could be, however, still enhanced. Both funding lines address a specialist community, where standards and standardization play a significant role. Awareness of the funding possibilities outside of this core interest group was regarded as low and is hence an area of improvement.
- In order to increase visibility and awareness, the evaluation suggests addressing specifically experts with experience in technological fields and presumably working in contexts close to the topic of standardization.
- The authors also suggest a number of measures to increase the attractiveness of the program for SMEs, however, also to wait a bit longer with specific measures until further project results materialize. Generally, though, the evaluators underline the need for a specific funding scheme for SMEs as implemented with funding line 1.

In interviews, we were also told that due to regulatory requirements, funding line 2 had to be modified over time such that it would only support larger projects. This has opened a gap for smaller undertakings, which is closed by a funding scheme offered by DIN itself called DIN Connect. DIN Connect has as target SMES and start-ups with innovative project ideas and with potential for standards and standardization.

Overall, all funding activities are embodied into a national standards strategy, the so-called "Normungspolitisches Konzept" (BMWi, 2009; due to be updated).

4.2 AUSTRIA

In contrast to Germany, there are no dedicated funding mechanisms in Austria to support standards in R&D projects. However, there is a strategy for standardization in place from March 2016 which defines six goals with corresponding action lines (Austrian government, 2016): a) Policy advice through a steering committee; b) fostering of transparency and participation in standardization; c) contributions to European/ international standardization; d) strengthening of competitiveness and support for RTDI; e) contribution to sustainability goals; and f) support as well as complementary action for government regulatory activities. The strategy specifies a series of activities to increase awareness on the topic (including also the inclusion of standardization into curricula of relevant educational institutions) as well as a call for early consideration of standardization in research projects and in the dissemination / transfer of research results.

The question remains, though, whether this specific strategy is taken duly into consideration in RTDI policy making. The OECD Innovation Policy Review of Austria suggests that this is rather not the case, and the current Austrian RTDI strategy mentions standardization only superficially in few places (Austrian government, 2011). Still, the aspiration is there with Austrian Standards International, the Austrian SDO, to play a stronger role in the Austrian RTDI system. This is underlined by placing the topic of innovation prominently on its homepage, by engaging heavily with the BRIDIGIT project and hereby also involving actors from the RTDI community – most notably, Austria´s research promotion agency FFG. However, in interviews it was consensus that this is only the beginning of a journey.

5 CONCLUSIONS AND RECOMMENDATIONS

This paper has sought to analyze the topic of standardization and standards in relation to the RTDI system. While it has shown that attempts are being made to literally bridge the gap between the two worlds, it is also clear that more spotlight on the standards topic is needed to reap the potential benefits when innovating and supporting innovation. Recommendations go towards both the researcher/evaluation community as well as to policy makers and implementers:

- Researchers and evaluators should seek to address the topic of standardization and standards more pro-actively. While increasing ground has been covered by scholars on the basic picture regarding economic impacts of standards, there is need for more granular evidence, particularly in fields like open innovation research (where it is easily understandable that standardization can be seen as a form of open innovation, yet this seems to be hardly reflected in open innovation literature) or technology and knowledge transfer research. In the context of the latter, the topic of indicator development seems a particularly pristine field. For example, the still valid Commission recommendation of 2008 on the management of intellectual property in knowledge transfer activities discusses a variety of channels for technology transfer, but not standards or contributions to standardization (European Commission, 2008). The EC Expert Group on Metrics for Knowledge Transfer from universities and Public Research Organizations (PROs) suggests and discusses numerous indicators, none of which with a link to standards or standardization (European Commission, 2009). Given that the macro-economic models as discussed in this paper treat "standards" specifically as a channel for knowledge transfer, this is truly surprising and – in terms of consistency within innovation research – actually concerning. Starting points are e.g. developments such as the concept of standard-relevant publications in bibliometrics (Blind, 2019).
- The RTDI and standards policy developer and implementer should more strongly collaborate with each other, also outside

of dedicated projects like Bridgit. There is most likely a need, not only at European, but also at national level, to discuss how standards and standardization can be better integrated in innovation policy/strategy and program designs (such as by wording of specific standards' related goals of innovation policy in key technology areas, where relevant); in the way standards and contributions to standards should be handled and assessed in appraisals of R&D proposals. There needs to be a clearer understanding of a possible and good role of SDOs and hence better integration of these organizations in the RTDI systems, moving them from the fringes of the cast of actors in the innovation systems into appropriately more central places. Similarly, SDOs and actors of the standardization system must also build capacity for understanding the functioning of RTDI systems and their actors more profoundly. Mutual exchanges, awareness raising and also examining possible good practices (such as the WIPANO funding schemes in Germany) are here the starting points.

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Acknowledgments
The author would like to thank Mr. Karl Grün (Austrian Standards); Mrs. Andrea Höglinger (FFG); Mrs. Katja Krüger; Mr. Mario Beier (both DIN) for having agreed to be interviewed. Similarly, the author would like to thank Harald Grill (Technopolis) for providing important feedback.

KEYWORDS
Standards, Standardization, Intellectual Property, IPR, Innovation, Innovation Policy

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ZVR-Zahl: 937261837
ISSN-Nr. 1726-6629
DOI: 10.22163/fteval.2020.485