SCIENCE AND SOCIETY

Improve alignment of research policy and societal values

The EU promotes Responsible Research and Innovation in principle, but implementation leaves much to be desired

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H istorically, scientific and engineering expertise has been key in shaping research and innovation (R&I) policies, with benefits presumed to accrue to society more broadly over time (*1*). But there is persistent and growing concern about whether and how ethical and societal values are integrated into R&I policies and governance, as we confront public disbelief in science and political suspicion toward evidence-based policy-making (*2*). Erosion of such a social contract with science limits the ability of democratic societies to deal with challenges presented by new, disruptive technologies, such as synthetic biology, nanotechnology, genetic engineering, automation and robotics, and artificial intelligence. Many policy efforts have emerged in response to such concerns, one prominent example being Europe's Eighth Framework Programme, Horizon 2020 (H2020), whose focus on "Responsible Research and Innovation" (RRI) provides a case study for the translation of such nor-

mative perspectives into concrete policy action and implementation. Our analysis of this H2020 RRI approach suggests a lack of consistent integration of elements such as ethics, open access, open innovation, and public engagement. On the basis of our evaluation, we suggest possible pathways for strengthening efforts to deliver R&I policies that deepen mutually beneficial science and society relationships.

Alignment of R&I objectives with societal benefits, which transcend exclusive economic value, is a globally relevant concern (*3*). Aspiration of stronger science and society interrelationships have been visible in U.S. research management efforts, as well as in Canada and Europe. In H2020, to which the European Commission (EC) allocated nearly €80 billion for the 2014–2020 funding period, the EC enumerated RRI as a priority across all of H2020 activities (a "cross-cutting issue") to deepen science and society relationships and be responsive to societal challenges. To date, €1.88 billion have been invested across 200 different R&I areas (e.g., quantum computing, graphene nanotechnology, human brain research, artificial intelligence) in more than 1100 projects related to various dimensions of RRI (see the figure). Inclusion of RRI in

Horizon 2020 aims to integrate research policy and societal concerns, including about gender in science, and about disruptive technologies such as robotics.

H2020 reflected the commitment of the European Union (EU) to the precautionary principle with regard to R&I policy, and the deepening commitment of the EC to mainstream concerns related to science and society integration (*4, 5*).

RRI principles and practices have been designed to enhance inclusive and democratic modes of conducting R&I to reflect current forms and aspirations of society (*4*). Formal adoption and exploitation of RRI in H2020 coalesced around six thematic domains of responsibility ("keys"): public engagement, gender equality, science education and science literacy, open access, ethics, and governance (*6*). As a relatively young concept, these six keys cover only a part of RRI as it is discussed in the academic literature. Their integration in the European R&I ecosystem was advanced by various political- and policy-level ambitions (*3–5*). The forthcoming Ninth Framework Programme, Horizon Europe (2021–2027), includes further mention of RRI, as well as additional efforts to increase responsiveness of science to society through elements of the so-called "three O's agenda" (i.e., open innovation, open science, openness to the world) (*7*).

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Despite this fairly extensive history of EC investment in mainstreaming activities, a recent survey of more than 3100 European researcher recipients of H2020 funding showed that a vast majority of respondents were not familiar with the concept of RRI (8). Although these findings by no means suggest that researchers are irresponsible, they raise questions about the success of the EC approach to embedding normative targets for responsibility into R&I. The need for systematic evaluation is clear (9). Our study contributes to a legacy of research on the efficacy of framework programmes in light of various EC ambitions (10).

METHODS AND FINDINGS

To answer our question about policy integration and implementation of RRI in H2020, we conducted a mixed method investigation in three stages: (i) desktop research, (ii) interviews, and (iii) case research [see supplementary materials (SM) S10 for details]. First, we collected and reviewed relevant documentation of the four H2020 Programme Sections (Excellent Science, Industrial Leadership, Societal Challenges, Diversity of Approaches) and 19 respective subthemes available on the websites of the EC. This included reviews of documents at the following levels: policy, scoping, work package, calls, projects, proposal templates, and evaluations. Review of documents extended to all three periods of H2020 (2014–2015, 2016–2017, and 2018–2020) and employed the six EC RRI keys as indicators.

Second, we conducted interviews with representatives (n = 257) of seven stakeholder groups within the 19 subthemes of H2020. Third, using natural language processing algorithms, we obtained and analyzed texts describing project objectives of all the H2020 projects (ongoing and finished, n = 13,644) available on the CORDIS Portal, which provides information on EU-funded R&I activities. We examined how proposal language and RRI policies translate into project activities across H2020 using text-mining approaches. We carried out keyword frequency analysis by applying a selection of 10 to 12 keywords (SM S8) associated with each of the six RRI keys. This resulted in an "RRI score" for each of six keys for each H2020 project (SM S13). This subsequent case research covered all three H2020 periods (i.e., 2014–2015, 2016–2017, and 2018–2020).

At each of these stages we produced reports for each corresponding subtheme (SM S11). The resulting body of 19 reports was then systematically reviewed for levels of policy integration. The policy-integration levels were qualitatively assessed with the EC's own indicator assessment (6).

How well is Responsible Research and Innovation represented in Horizon 2020?

Limited high-quality reference to Responsible Research and Innovation (RRI) suggests that it has largely been referred to without proper understanding, or as an empty signifier. Data combine all four Horizon 2020 (H2020) program sections and reflect the amount and quality of representation of six RRI keys and three "O's," across three levels: samples of internal H2020 program documents, H2020 stakeholder interviews, and H2020 project objectives. Comparison across keys within a given level is straightforward; all values are drawn from the same underlying materials. Comparison across levels within a given key should focus on relative proportions of the four colors within a given level, not on absolute values; analyses drew upon different types and amounts of underlying materials in each level. See supplementary materials for details.
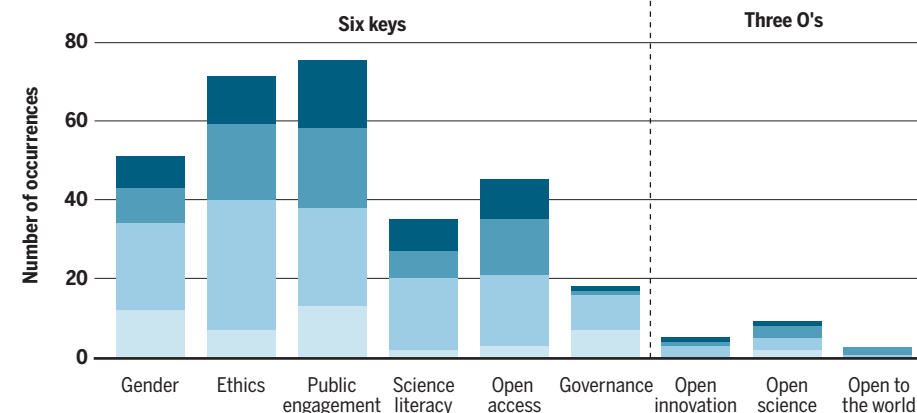
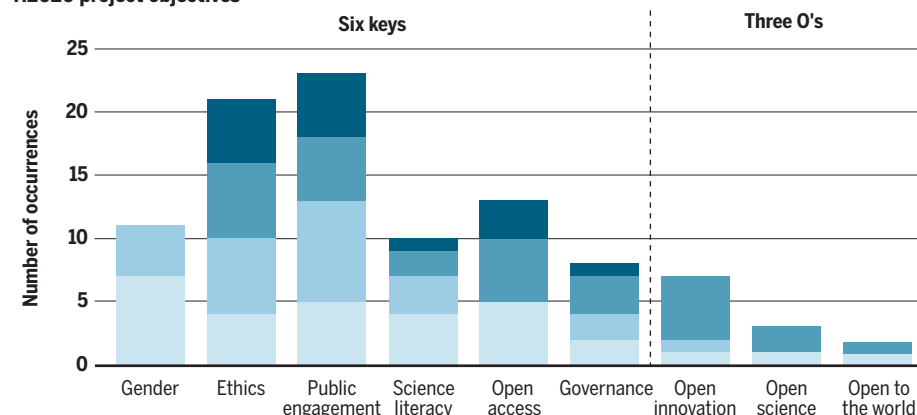**Quality of representation**
● High ● Some ● Limited ● Superficial

Internal H2020 documents
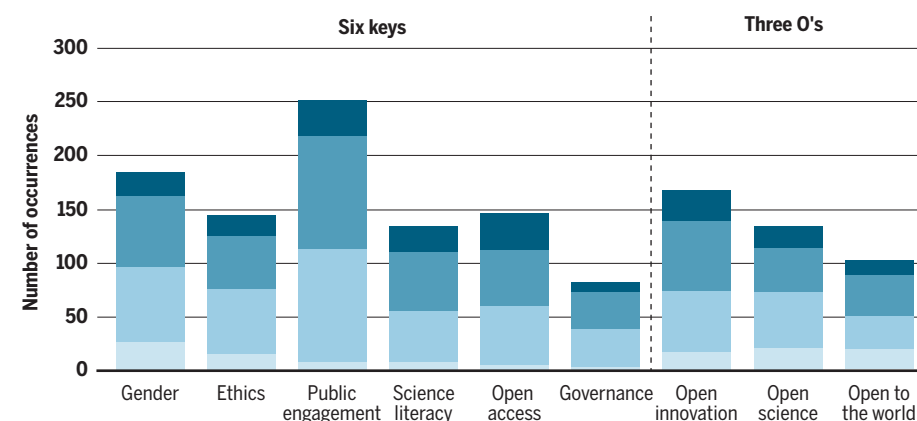
H2020 stakeholder interviews

H2020 project objectives

This assessment demonstrates which elements of the RRI framework were initially defined by the policy-makers (desktop level), which RRI attributes the stakeholders were most aware of (interview level), and which RRI elements were manifested in project proposals (case level) (SM S12; see the figure). RRI as a concept has been present in most of the four Programme Sections of H2020, and particular RRI policy elements emerge as prominent in certain subthemes, especially those addressing societal challenges or explicitly promoting the uptake of RRI. But RRI overall has largely been referred to either without proper understanding of its definition, or as empty signifier, suggesting lack of compliance with the EC's interpretation of the RRI concept (see the figure; SM S9). Integration of the three O's agenda, contemplated as a successor to the RRI framework, lagged behind that of the six RRI keys; a finding consistent with introduction of the agenda in the later stages of H2020.

DISCUSSION

Our results suggest that the integration of the RRI framework into H2020 has fallen short of stated EC ambitions. Our data show substantial discrepancies between the inclusion of RRI concepts within official subtheme documents (e.g., on policy and work programme levels), and awareness of RRI by interviewees working on projects funded by such subthemes (see the figure). Absence of RRI keys across the majority of programme subtheme evaluation criteria is a telling example.

Such evidence suggests that (i) the RRI framework is still an evolving concept, the development of which hinders its proper understanding by those who are supposed to use it; (ii) such individuals have only superficial understanding of the notion for its effective exploitation; and (iii) although the RRI framework is present on the declarative, strategic policy level (scoping and subtheme general description), it wanes in funding calls (policy operationalization) and is largely absent in evaluation criteria used in proposal assessment. Collectively, these points further suggest that applicants have little in the way of consistently aligned incentives to regard RRI as relevant in proposal design and submission.

Although (i) and (ii) are primarily a matter of a lack of adequate information, awareness and training, (iii) points to limitations of European science policy efforts related to the pursuit of RRI. Such translation failures are typically caused by interplay of different logics of negotiation at the different levels (11), a linear model of innovation appealing to scientific excellence in R&I (12), actors' resis-

tance to change, path dependencies, cognitive boundaries, and competing policy agendas (13). As the issues covered by RRI are normatively claimed to be of high relevance by political decision-makers, as evidenced in several EC documents, we conclude that the problem is one of policy integration strategy and implementation (14). The lack of clarity in conceptualizing RRI for research policy and governance, the limited understanding among key stakeholders, and the concept's conflation with other—often conflicting—policy goals (e.g., scientific excellence, economic value, technological readiness) hinder the emergence of a specific RRI-oriented policy frame (15). Such conflicting policy goals are palpable at the core of European research funding (e.g., supporting either mission-oriented innovation or curiosity-driven basic research in key funding instruments) and highlight the structural tensions between the normative ideals and potential instrumentalization (3).

There are some limitations of this study that must be taken into account when interpreting results. First, the measurements were cross-sectional and though representative, are not exhaustive. Generalizability of findings could be increased if the study were to extend in a longitudinal fashion and possibly to better elaborate causal relationships among factors. Second, although we employed mixed methods in our investigation, the number of interviews and case studies could be further increased to provide additional qualitative information about the dynamics of RRI at the project level. Third, as the framework programme remains ongoing, our analysis was not able to evaluate the entire H2020 corpus. Although the results indicate evidence of patchy RRI implementation, highlighting the need for more consistent support to help align EC science policy and societal values, the progress made is nontrivial, given the history of science (1).

A clear discrepancy exists between the expressed strong normative position on RRI and its integration in concrete policies and practices. Fully integrating RRI as a strong normative position into research funding and governance is a necessary but not sufficient first step to creating a working policy system that drives RRI integration. Longer-lived investments are needed for building a shared understanding and awareness of the relevance of responsibility in R&I among key stakeholders. Integrating responsibility into research funding further requires RRI to shift from a "cross-cutting issue" to a "strategic concern" that receives consistent and sustained embedding in call texts and project selection criteria. This will require "policy entrepreneurs" who can stimulate interactions across subthemes to foster alignment of RRI integration and

translation. In addition, a range of integration policies are required at the system level and within subthemes, in which the issue of RRI is adopted as a goal. This is pertinent as, in case of such integration failures, it is often the normative position that is called into question instead of the implementation strategy, or actual integration pathway. The EC would benefit from enhancing previous efforts to integrate RRI and so affirm its role as a leader of ethically acceptable and societally responsible R&I on the world stage. Otherwise Europe needlessly undercuts its ability to direct research toward tackling societal challenges in ways compatible with its values. ∎

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