D 5.1. RECOMMENDATIONS FOR THE DEVELOPMENT OF A COMPETITIVE ADVANTAGE BASED ON RRI

Document Information

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Deliverable Leader	Vincent Blok Edurne A. Inigo	WU
Contributing Authors	Aurelija Novelskaitė Raminta Pučėtaitė Andrew Adams Kutoma Wakunuma Tilimbe Jiya Louisa Grabner Lars Lorenz Inés Sánchez de Madariaga Inés Novella	VU VU Meiji DMU DMU Fraun ICoRSA UPM UPM

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Tips to navigate the report

If you can´t read it in full at this point, this is how to best approach the report based on your interests:

I **don't have much time** but am interested in the **main practical, take-away messages**. **I am familiar** with RRI in competitive environments:

- Read the executive summary (below) and the recommendations that are most applicable to you (industry, policymakers, research performing organisations, research funding organizations, investors, civil society, NGO and association bodies).

I **don't have much time** but am interested in the **main practical, take-away messages**. I am **not familiar** with RRI in competitive environments:

- Read the executive summary, the introduction and the recommendations that are most applicable you (industry, policymakers, research performing organisations, research funding organizations, investors, civil society, NGO and association bodies).

I am mostly interested in the **results of the research**:

- Read Section 3.1. for a state-of-the-art on **drivers and barriers of competitive advantage** based on RRI-like practices.
- Read Section 3.2. to see the results of the **survey on attitudes and engagement** in RRI-like practices in relation to competitive advantage
- Read Section 3.3. to learn more about the **case studies** on the management of socio-ethical issues through RRI-like practices in competitive environments, in the bio-economy domain, ICT domain, and transversally, on gender and wider issues of diversity.

I want to know more about the **methods** guiding this study:

- Read Section 2 to learn more about the research design and methods.

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Executive summary

This report analyses the relationship between RRI-like practices and competitive advantage. RRI frameworks have traditionally been less oriented towards their application in competitive environments; hence resulting in limitations to the applicability of some of its main tenets in industry and in the context of the development of a national competitive advantage. Aiming to close this gap and identify how a competitive advantage based on engagement in RRI-like practices across world regions may be developed, a systematic literature review, a survey and case studies were carried out.

Five main drivers of competitive advantage through RRI-like practices were identified: avoiding uncompetitive regulation, increasing social acceptance, incorporating stakeholder needs and tapping into new markets, increasing the efficiency of the innovation process, and reputational effects. On the other hand, four barriers were identified: obstacles during the research and innovation process (such as lengthening the time-to-market), protecting intellectual property, lack of consumer awareness, and barriers derived from the institutional environment.

The survey revealed that, while there are some differences in terms of attitudes and engagement in RRI-like practices across regions, both procedural and outcome dimensions were relevant. However, the application of particular practices in exercising such dimensions showed more variations across regions, reflecting adaption to local environments. In relation to competitive advantage, outcome dimensions and open and transparent innovation processes showed a clear relationship with performance, in particular with customer performance. The reason for this might lie in the increased visibility of such practices to the consumer.

Two cases studies were carried out focusing on the management of socio-ethical concerns through RRI-like practices and their relationship with competitive advantage. The case on the bio-economy domain (on GMOs and gene-editing techniques), identified different responses depending on local regulations and the focus placed on the development of competitive advantages at the micro and macro levels, and showcased the importance of domain specific considerations in RRI-like responses. The ICT case (focused on biometrics and deep learning) highlighted the importance of network approaches and second-order reflexivity, and the need to adapt RRI-like practices to local contexts to maximise their benefits for competitive advantage. Lastly, the analysis of the two cases concentrating on transversal issues (gender equality and diversity) made notable how strategic approaches to RRI and their proper integration in strategy showed an improved relation with competitive advantage.

This study makes a significant contribution to existing research on RRI-like practices and competitive advantage and adds to the literature on business involvement in RRI that has been flourishing despite the tradition of overlooking RRI by actors in competitive environments. Moreover, it provides a set of practical recommendations for industry, policymakers, research performing organizations, research funding organizations, investors, civil society and NGOs and association bodies. These recommendations are oriented towards developing and sustaining a competitive advantage based on RRI-like practices by research and innovation actors, while supported by other stakeholders in the system. The advice is informed by the research study and proposes the need to tailor and adopt bottom-up approaches in the implementation of RRI-practices, integrating RRI-like logics and competitive advantage logics into organizational dynamic, and the need for collaboration among different actors, apart from recommendations particular to each stakeholder.

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Table of contents

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Key definitions

Responsible Research and Innovation (RRI): RRI is "a **transparent, interactive process** by which **societal actors** and innovators become **mutually responsive** to each other with a view to the **(ethical) acceptability**, sustainability and **societal desirability** and its marketable products" (Von Schomberg, 2013).

Procedural dimensions of RRI: dimensions of RRI that are mostly visible during the research and innovation process; such as transparency, mutual responsiveness among stakeholders, or democracy.

Outcome dimensions of RRI: dimensions of RRI that are mostly visible in the outcome of research and innovation; such as sustainability, ethical acceptability or social desirability.

AIRR framework: the AIRR (for anticipation, inclusion, reflexivity and responsiveness) framework proposes a system for **governance of responsible research and innovation processes and outcomes**, based on **anticipation, inclusion, reflexivity and responsiveness** (Stilgoe et al., 2013). This framework is widely used among RRI practitioners to identify and propose RRI practices.

RRI keys: these are the pillars on which the European policy on RRI is sustained. In essence, these keys set the priorities set by the European Commission to incorporate responsibility in research and innovation. The RRI keys are ethics, gender equality, governance, open access, public engagement and science education (European Commission, 2012)

RRI practices: practices that resonate with the AIRR framework and RRI keys in their procedural and outcome dimensions, against the backdrop of free, democratic and market economy societies.

RRI-like practices: because RRI has been mostly studied in the context of free, democratic and market economy societies, mainly European societies, it is not always possible to evaluate and identify practices in other contexts as *strictly* RRI. We refer to RRI-like practices when these resonate with the definition of RRI, e.g., when social desirability, ethical acceptability and sustainability are considered in innovation outcomes, or when ethical considerations are incorporated in the innovation process. Further specification of how RRI-like practices were considered for sample selection are included in the methodology section.

Competitive advantage: is the differential that provides a better ability to compete with others in the market. It is used for two main stakeholders:

- Businesses: for business organizations, competitive advantage is defined as the **leverage that a business has over its competitors**, competing in the market over **better value, better quality or lower prices** (Porter, 1985).
- Countries: at a macro-economic level, competitive advantage is provided by the conditions that allow a country to **compete internationally on a certain marker**. National competitive advantage depends on **factor conditions, demand conditions, related or supporting industries and firm strategy, structure and rivalry** (Porter, 1990).

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RRING geographical areas: RRING defines world regions based on UNESCO's Executive Board Group: Europe and North America (EB I + II); Latin America & the Caribbean (III); Asia and the Pacific (IV); Africa (Va) and Arab States (Vb).

RRING domains: RRING focuses (but it not limited to) four domains: ICT, waste management, bioeconomy and energy.

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1. Introduction: RRI and competitive advantage

In the words of Von Schomberg (2012), Responsible Research and Innovation (RRI) is "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products." RRI has emerged in recent years as a new paradigm to develop research and innovation with society (procedural dimension) and for society (outcome dimension). The European Commission (2012) has strongly backed the introduction of RRI practices in research and innovation processes through six policy keys (open science, ethics, governance, gender equality, public engagement and science education), which serve as a normative anchor for engaged researchers and innovators.

In addition to the six policy keys, a rich literature and practice has emerged aiming to define RRI and promote its understanding among different stakeholders. For instance, the AIRR (anticipation, inclusion, reflexivity and responsiveness) process dimensions (Stilgoe et al., 2013) are widely deployed to understand RRI practices, as are the process and outcome dimensions developed by the RRI Tools project (RRI Tools, 2020), among others.

In a nutshell, RRI practices should imply the following:

- Reflection and deliberation on the purpose of innovation:
  - Why do we innovate?
  - What are the motives?
  - Who benefits and who does not?
- Addressing societal grand challenges, which cannot be addressed by simple, monodisciplinary solutions by individual actors (Voegtlin & Scherer, 2017).
- Co-responsibility among actors for desirable directions of innovation processes (Owen et al., 2013).
- Democratic legitimation (Owen et al 2013).
- Innovation with society: responsiveness to other visions, ideas, values requires deliberation with society.

This approach to research and innovation, with the introduction of this vision, goes beyond the traditional understanding of innovation (the adoption, assimilation or exploitation of a novel product, service, process or business model that adds economic value – (see Crossan & Apaydin (2010) for a review)). It also goes steps further from sustainability-oriented innovation, social innovation and other approaches that focus on the creation of social and environmental value in addition to economic value (see Adams et al. (2016) or (Lubberink et al., 2017) for a review): RRI focuses on both procedural and outcome aspects, therefore introducing new requirements to the innovation process at different stages (Blok & Lemmens, 2015):

- Input: innovation should be aimed to addressing grand challenges.

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- Throughput: the innovation process should be transparent, democratic and mutually responsive.
- Output: the outcomes of innovation should be ethically acceptable, socially desirable and sustainable.

Apart from approximations done in the context of projects funded by the European Union, RRI has mostly resonated within Europe and North America (Macnaghten et al., 2014). A main reason for this is that the premises that RRI frameworks assume (democratic societies and market economies that allow for co-responsibility and democratic legitimation (Owen et al., 2013) are not always present in other world regions (MacNaghten et al., 2014), as noted in the diversity in institutional structures identified in previous projects, such as RRI practice (RRI Practice, 2020). In fact, RRI builds on previous policy instruments developed in the EU and North America (Zwart et al., 2014), which has paved the way for its acceptance in these environments. However, it has been argued that, despite not engaging in the academic debate or responding to public policy arrangements, there are de-facto RRI practices in which innovation actors may engage when addressing socio-ethical issues in the process of innovation (Randles et al., 2016). It is possible, then, to find RRI-like practices outside these regions; however, they have been less documented in research.

One of the main issues with RRI; however, is that it has failed to resonate with some stakeholders hitherto, even when considering *de facto* RRI. The disengagement of industry, despite its protagonist role in research and innovation (particularly in the product development stage), is notable (Scholten & Blok, 2015; van de Poel et al., 2017). Previous research has noted the limited applicability of the RRI frameworks to industrial, competitive environments (Blok et al., 2015; Blok & Lemmens, 2015) (Blok & Lemmens, 2015). RRI research and practice has greatly overlooked the value-creation and competitiveness discourse, which might explain why other frameworks such as sustainability-oriented innovation or open innovation have been more widely adopted in industry (Lubberink et al., 2017).

The need to integrate competitive advantage in the RRI discussion in order to improve its acceptance by actors operating in competitive environments to has been signaled by previous research (e.g. Ceicyte & Petraite, 2018; Garst et al., 2017; Martinuzzi et al., 2018); however, little is known about how industry engages in de facto RRI (particularly in regions other than Europe and North America), and what effects this has on their aim of developing a competitive advantage, despite some research being done on drivers of competitive advantage through RRI (Ceicyte & Petraite, 2018; van de Poel et al., 2017).

This report aims to open this black box, by providing a research-based analysis of the relationship between RRI/RRI-like practices and competitive advantage, in order to support recommendations for different stakeholders involved in RRI and RRI-like practices either as protagonists or in a supporting role in different world regions. The following subsections provide an overview of RRI in competitive environments and the challenges of examining the relationship between RRI and competitive advantage from a global perspective and summarize the objectives of the study. Then, Section 2 introduces the design and methods deployed to conduct the research, followed by the main research findings. After that, Section 4 provides recommendations for different stakeholders, and the document closes with general conclusions.

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1.1. RRI in competitive environments

Applying RRI concepts as discussed in competitive environments, particularly industry, is not easy, since there is a need to sustain a competitive advantage in addition to fulfilling the socio-ethical requirements above. At the micro level, the implementation in commercial innovation processes is different from basic research, which is the context for which many of the RRI frameworks have been developed. Figure 1 shows a diagram of the linear innovation process, which shows the evolution from basic to an applied research and pre-competitive and competitive development processes. Traditionally, each of these stages is carried out by different actors and presents different characteristics, with the degree of collaboration diminishing towards the last stages of competitive development, when research and innovation actors need to compete in the market to capture the value of the research and innovation outcomes.

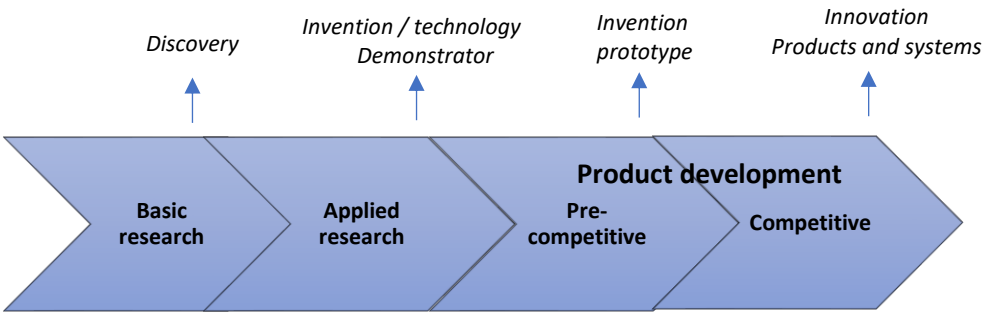

Figure 1. Simplified, linear model of the innovation process (adapted from Montagna & Cantamessa (2019).

To be able to benefit from research and innovation processes at the competitive stage, research and innovation actors – mostly industry – need to develop a *competitive advantage,* that is, a differential that puts them in a better position than their competitors to profit from the innovation (Porter, 1985). Because of this, at the micro-level (in terms of the innovation process in industry), RRI has several limitations (Blok & Lemmens, 2015):

- Input: addressing grand challenges. What does this mean for industry? First, issues arise concerning who defines what grand challenges are. Industry might look for normative anchors such as the SDGs or the six pillars. However, there might be more targeted challenges to address, such as challenges in the industry (e.g., the potential misuse of artificial intelligence in the ICT domain), or challenges particular to the local context identified through stakeholder consultation.

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- Throughput: transparent, democratic and mutually responsive. The implications of these throughput requirements are particularly challenging in competitive environments, because of the following:

    - Information asymmetries: competitive advantage is often based on information asymmetries and obtaining or developing certain knowledge or information that allows a company to distinguish itself in the market and develop a first mover advantage, based on products and services new to the market. Therefore, the call for transparency and mutual responsiveness can be slightly naïve in competitive environments, since these differences in information between stakeholders are the very basis of the advantage of innovative companies. A way in which this has been addressed is the development of standards at the pre-competitive stage, where companies share information for the development of the whole industry (see, for instance, the industry standards for nano cosmetics).

    - Power imbalances: how mutually responsive can innovation processes be, when the company takes ultimate responsibility for the development and output of the process? Since responsibility is not collective, to what extent should stakeholder consultation influence the results of the innovation, when industry will bear the economic and ethical responsibility? In addition, some players have more power and ability to influence than others (e.g., larger NGOs over smaller ones, or the government instead of the more dispersed 'public opinion').

- Output: socially desirable, ethically acceptable and sustainable innovation. Whichever the direction that the innovation process aims to take, and despite taking measures to avoid unintended consequences, the outcome of the introduction of an innovation in the market is not fully predictable. In addition, stakeholders' views change over time.

At the macro level, RRI is seen as a manner of achieving a competitive advantage at the country / region level (Porter, 1990), by allowing for the development of innovation of superior quality. To this extent, it is significant that RRI differentiates itself from other policy frameworks that aimed to include ethical, legal and social aspects in research and innovation (ELSI) by adding a socio-economic dimension to it, including "valorisation, employment and competitiveness" (Zwart, Landeweerd, & van Rooij, 2014:11). The European research and innovation policy for international cooperation (European Commission, 2012b), which is set to strengthen the Union's economic and industrial competitiveness, aims to create win-win situations, in which the involvement in RRI practices will result in an increased competitive advantage as region.

For this reason, policy-makers are also a key stakeholder when examining RRI and competitive advantage, since competitive advantage can also be analysed from a macro-perspective. However, the competitiveness aspect of RRI policy has not been so widely explored, with the focus placed on other aspects of policy-making such as the definition of normative anchors (such as the six keys) and their impact on research projects and research evaluation.

Then, industry and policy-makers are the focal stakeholders, at the micro and macro levels, when examining the relationship between RRI and competitive advantage. However, these two actors do not operate in isolation in the economic system or in the development of research and innovation

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processes – particularly in the context of RRI and research and innovation with and for society -. Other stakeholders participate in such innovation processes; sometimes as co-responsible, sometimes in a supporting role, sometimes in an advocacy or adversarial role. Consequently, it is also relevant to understand how these actors approach the relationship between RRI and competitive advantage, and to provide recommendations to these actors as well aiming to create such "win-win" situations.

1.2. The opportunities and challenges of researching on RRI at a global level, and its relation to competitive advantage

Examining RRI from a global perspective comes with some associated difficulties. The concept originates as largely Eurocentric, aiming to address issues in the European context, and presupposes some baseline social conditions that are not a given locally. For example, the call for democratic legitimation (Owen et al., 2013) is of difficult applicability as a governance framework in non-democratic societies.

Despite this, the concept of RRI has gradually gained attention in other world regions (e.g. Chaturvedi et al., 2016; Macnaghten et al., 2014; Yang & Han, 2017). RRI shows potential at the outcome level to help tackle grand challenges, although the definition of what these grand challenges are and the normative anchors to address them at the procedural level may differ according to local values. For this reason, throughout this report we refer to RRI-like practices. With this term, practices that resonate with the definition of RRI are included, even if they do not fully correspond with the European definition of RRI.

When examining the relationship between RRI and competitive advantage, there are some shortcomings, but also some advantages of doing so with a global perspective. On the one hand, it is possible that the understanding of competitive advantage varies between countries or world regions, since societies may value the ability to compete in the market and the acceptable ways to do so differently. On the other hand, the focus of competitive advantage and the need to compete in the market functions, to a certain extent, as an equalizer, since market institutional logics are shared by the focal actors when discussing competitive advantage. Still, differences are acknowledged in the research design, and welcomed in the research results, since they allow for mutual learning between world regions.

1.3. Outline of the report and research questions

Aiming to better understand the relationship between RRI and RRI-like practices and subsequently provide evidence-based recommendations to promote and develop competitive advantage based on RRI, our main research question concerns the relationship between RRI and competitive advantage. First, the introduction and research design and methods are presented in Chapters 1 and 2. Then, several sub questions were formulated, for which corresponding subtasks were drafted, as illustrated in Figure 2. Based on this research, recommendations for different stakeholders and conclusions are provided.

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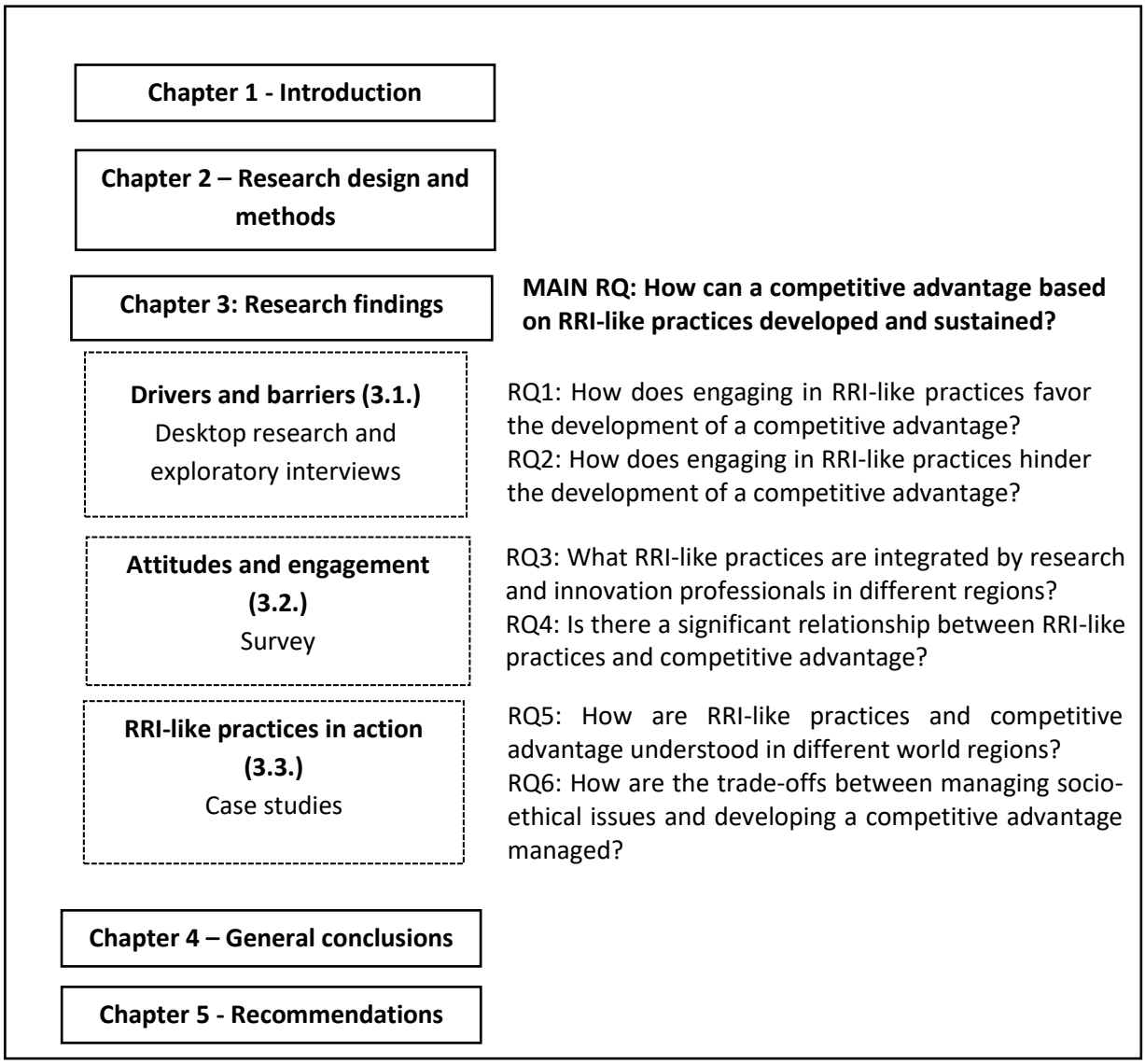

Figure 1. Outline of the report and research questions

In the context of this research, recommendations are also provided for stakeholders that are largely in collaboration with the focal actors (industry and policy-makers) in the development of research and innovation processes and policies: research performing organizations (RPOs), research funding organizations (RFOs), investors, civil society, and NGOs and association bodies.

2. Research design and methods

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2.1. Worldview and theoretical lens

The study uses a constructivist worldview (Creswell, 2009), since the aim is to comprehend the existent RRI practices and their relationship with competitive advantage. Few research studies have been published on the topic; hence the aim is to understand the different realities of RRI-like practices in different world regions, and how they interact with the development of a competitive advantage. This is based on an interpretivist approach, with the aim of understanding the phenomena that occur in a social context (Strauss, 1987).

Grinbaum & Groves (2013)define innovation as a future-creating activity, and one of the purposes of RRI is to guide innovation in, to the maximum possible extent, avoiding unintended consequences and providing socially desirable results. The better-established framework for this is AIRR – anticipation, inclusion, reflexivity and responsiveness (Stilgoe et al., 2013). Each of these dimensions can be served by an array of different practices. In addition, the project RRI Tools (2020), aiming to collect existing practices, summarised the process dimensions as the following: diverse and inclusive, anticipatory and reflective, open and transparent, and responsive and adaptive to change. Lubberink et al. (2017) performed an extensive review of industry practices that resonate with these dimensions, and that might help to identify de facto RRI practices in industry. Because these practices have been identified based on practice rather than defined ex ante, this framework might be particularly useful in the exploration of RRI outside the EU and North America.

Besides process dimensions, in order to account for the outcome dimension of RRI-like practices at a global level, the UN's Sustainable Development Goals (SDGs) were deployed. While the six keys provide a policy grounding for the European Union, local development needs and societal values support distinct normative anchors. However, tackling the SDGs, which are defined with a global scope, is a shared objective in different world regions which helps to identify actors that also take into consideration the outcome dimension in RRI-like practices.

2.2. Research design

The research follows a multiphase mixed methods design (Creswell & Plano Clark, 2011). The research began with desktop research on RRI and competitive advantage, and indicators of RRI / RRI-like practices in the focal stakeholders. This desktop research revealed that existing research on the topic of RRI in relation to competitive advantage was scarce, particularly outside the region of Europe and North America, which led to carrying out exploratory interviews to complement the desktop research. These tasks informed the development of a quantitative survey, which was conducted along two case studies on the management of RRI in the ICT and bio-economy sectors. All these research activities inform the recommendations provided in this report. Figure 3, below, provides a graphical explanation of the research design, while the next subsections offer further detail about the research methods in each of the stages of the study.

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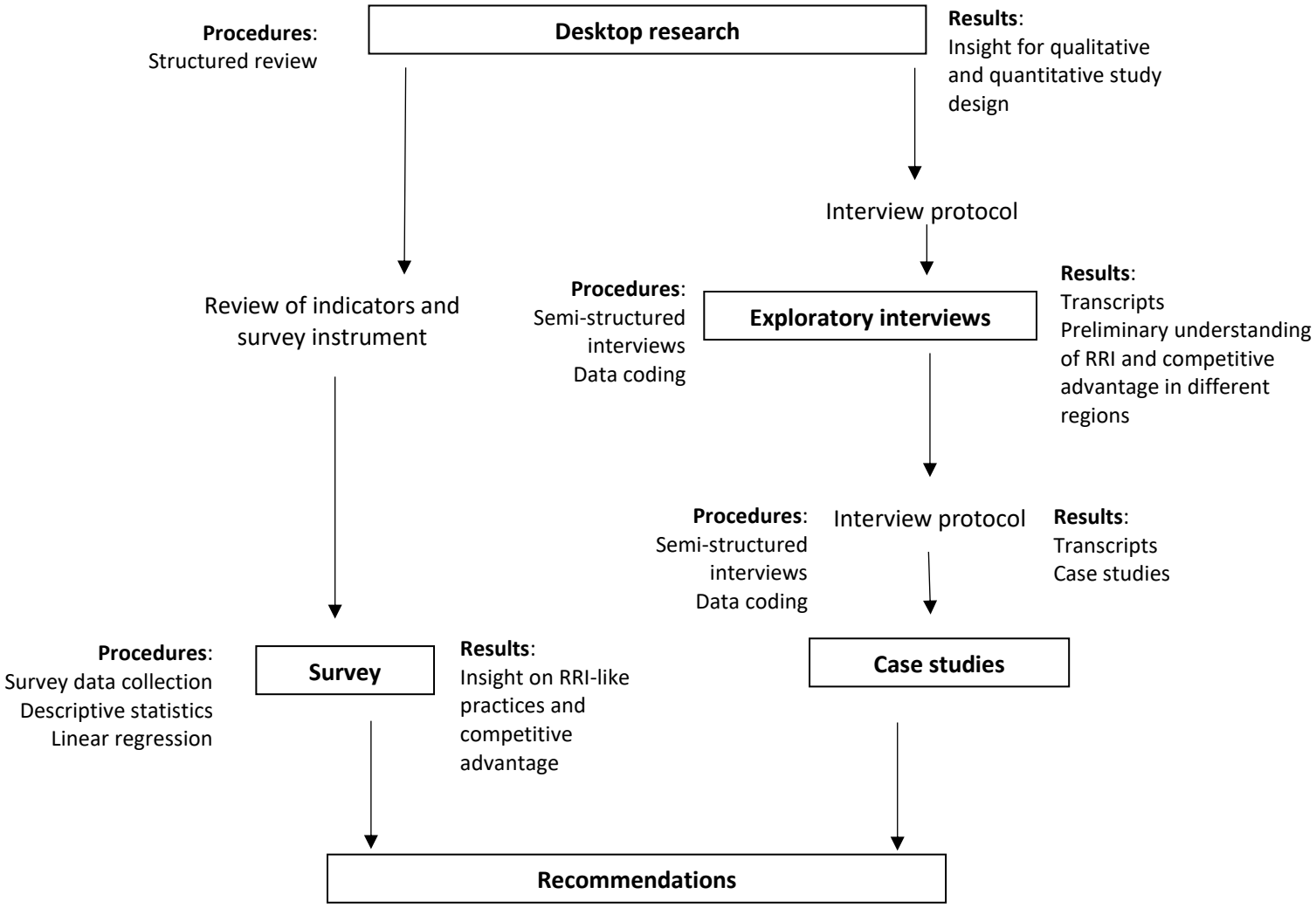

Figure 2. Research design of the study

As observed in Figure 3, two strands of research were conducted. Both started with the desktop research, which as a starting point, provided insight on previous indicators which were taken into consideration in the development of the survey of the quantitative strand of the research design. The desktop research was also complemented with the exploratory interviews to respond questions about drivers and barriers of RRI, and informed the development of the interview protocol for the case studies, which, in turn, focus on observing RRI-like practices in response to socio-ethical issues in a particular domain in the different regions. The insights obtained through the qualitative and quantitative strands, in response to the different research questions, inform the recommendations for different stakeholders.

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2.3. Desktop research

2.3.1. Structured literature review on the relationship of RRI-like practices and competitive advantage

The first step of the research was to conduct a desktop research of the state-of-the-art in the relationship between RRI and competitive advantage. A structured literature review was conducted, since they are useful to understand the history of a topic, evaluate insights and shortcomings and explore future research possibilities (Massaro et al., 2016).

A search was conducted in the Web of Science in December 2018. Despite the relatively recent coining of the term "RRI", in order to include previous practices resonating with RRI-like practices additional search terms were included, so that practices outside the European Union would be better reflected. Some quasi-synonym terms we also included for "competitive advantage", as illustrated in the search equation in Table 1. For the same reasons of exclusivity, the search was not limited by time of publication. The search equation was applied in English and Spanish.

Table 1. Search equation for the structured literature review

RRI and RRI-like practices		**Competitive advantage**
RRI RI Responsible Research and Innovation Responsible Research Responsible Innovation ELSI Ethical, Legal and Social implications Research ELSA Ethical, Legal and Social Aspects Research Participatory Technology Assessment Inclusive research Socially inclusive research Inclusive innovation Socially inclusive innovation Inclusive science Socially inclusive science	**AND**	Competitive Advantage Competitiv* Market performance

The initial search yielded 2141 documents, reduced to 840 when removing duplicates. In order to be included in the sample, the paper had to discuss the relationship between RRI- or practices resonating with the framework for RRI outlined by Owen et al. (2012); the practices identified by Lubberink, et al. (2017); or the six keys of RRI defined by the European Commission (2012) - and their relationship to competitive advantage.

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After application of the selection criteria and a review of the abstracts, 133 articles were considered potentially relevant for the study. After reviewing full documents with respect to the inclusion criterion, the final sample consisted of 82 articles. While the results of this part of the desktop research provided a preliminary understanding of the relationship between RRI-like practices and competitive advantage, the results showed several limitations that called for the additional exploratory interviews to gain a better overview of the state-of-the-art. The first limitation refers to the research design of the analysed manuscripts, since most of them were conceptual or normative, while a small number of them relied on single case studies. Therefore, little empirical evidence was provided in the papers. Second, the literature was significantly concentrated on (Western) Europe, and only a small number of studies covered other world regions, with most of the presence of other regions looking at China and Brazil, countries that have participated in several European projects on RRI.

2.3.2. Integrative literature review on tools and indicators for RRI and competitive advantage

The structured literature review on RRI-like practices and competitive advantage yielded some documents on indicators, it was observed that, to a significant degree, these were not necessarily covered by scholarly papers, but rather, included in policy papers or the results of previous projects. Therefore, these had not been incorporated through the structured literature review.

Consequently, an integrative review was conducted (Torraco, 2005), selecting the documents to be reviewed through a snowballing approach. This is particularly relevant in this task, since there is significant previous work on the development of tools and instruments for the two focal stakeholders in this report (industry and policy-makers) carried out in the scope of European Commission funded projects. While some of this research has been published as journal articles, the practical and managerial implications of many of them led to their publication in other fora.

The review of indicators was designed as a bridging task between the state-of-the-art and the development of further research instruments; therefore, the aim of this task was to identify the most relevant indicators to examine RRI-like practices and competitive advantage and the micro and macro levels from the quantitative and qualitative approaches.

2.4. Exploratory interviews

As noted above, the results of the desktop research on RRI-like practices and competitive advantage yielded insufficient information to understand their relationship. Consequently, exploratory interviews were conducted to further understand this relationship in the participants' own experience and feed into the development of subsequent research instruments. This subtask follows an inductive-deductive approach (Pratt, 2009), aiming to understand inductively the differences based on geography in the relationship between RRI-like practices and competitive advantage that cannot be inferred from the literature.

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2.4.1. Sample

The sampling strategy involved interviewing at least one practitioner whose organization was involved in RRI-like practices in each of the geographical areas. The target cases practiced RRI or RRI-like practices and were selected based on "best practices" in their geographical region. These best practices involve a) tackling a socio-ethical concern (global, regional or local) – outcome dimension – and b) produced new products, services, processes or business models in the last years, and c) engaging in at least some of the RRI-like activities in business as identified in the systematic review by Lubberink et al. (2017) – procedural dimension.

Since the aim was to obtain information about RRI-like practices and competitive advantage, market actors (i.e., businesses) were the preferred sample. Marketing or innovation managers were targeted as prime respondents, since they are expected to be the most involved with RRI-like practices and concerned with competitive advantage; however, this was also assessed on a case to case basis. In order to determine to what extent the interviewee was involved in the RRI-like activities and has a concern with competitive advantage, the next criteria were followed to identify appropriate interviewees (traditional positions that cover these functions are listed as examples, but focus was be placed on function, not work title):

- The interviewee has a procedural (e.g., innovation manager, project manager) or strategic (e.g. CEO, strategy manager) involvement in innovation, and / or is responsible for the performance and marketing of new products / services / processes (e.g. quality manager, marketing manager, product manager).
- The interviewee is aware of the socio-ethical intention behind the innovation process.
- The interviewee engages in collaborations with other stakeholders.

Based on these criteria, seven interviews were conducted (interviewee characterisation provided in Table 2). As it may be noted from Table 2, it was not possible to obtain an interview with an actor fulfilling these criteria in the Arab States region.

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Table 2. Interviewee characterization for exploratory interviews

#	Region	Country	Industry	Interviewee	Gender	Type of organization
A	Asia & the Pacific	India	Energy	Head of Regulatory Affairs	Male	MNE
B	Asia & the Pacific	Japan	ICT	Corporate Chief Engineer	Male	MNE
C	Africa	Malawi	ICT	CEO	Male	SME
D	Africa	Malawi	Bioeconomy	CEO	Male	Start-up
E	Europe & North America	Serbia	Bioeconomy	CEO	Female	SME
F	Europe & North America	Netherlands	Bioeconomy	Chief Scientific Officer	Male	Start-up
G	Latin America & the Caribbean	Uruguay	Bioeconomy	CEO & Innovation Manager	Male	SME

2.4.2. Data collection

Data was collected through semi-structured interviews, lasting between 25 and 55 minutes, focusing on the interviewee's understanding of RRI-like practices, and how they drive or hinder competitive advantage. The interview protocol designed for the interviews is shown in Appendix 1. Data was collected in the first half of 2019, and were conducted by phone (except for the interview in Japan, for which the interviewee preferred to respond in writing), in English (except for the interview in Uruguay, which was conducted in Spanish and translated to English).

Some secondary data was also collected, either when provided by the interviewee (mainly, company archival data and corporate news), or as prior contextualization research, answering the following questions:

- What is the name of the organization?
- What is the geographic scope of the organization?
- What domain does the organization belong to? What is the specialization of the organization within said domain?
- What practices of the organization lead us to believe they conduct de facto RRI (Randles et al., 2016) and competitive advantage, based on the project definition of RRI and previously identified RRI industry practices?
- What is the name of the interviewee? (Contact details, which will be anonymized for storage for RRING project use and compliant with the GDPR).

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- What is the interviewee's role (general tasks and activities and involvement in RRI-like activities)?

2.4.3. Data analysis

The recordings from the interviews were transcribed verbatim and analysed through thematic analysis (Gioia et al., 2013), in order to find patterns in the data, by a single coder. The first round of coding was open, with codes emerging from the data, while latter rounds of codification were performed in contrast with the previous findings from the literature ("data sandwich" approach: theory-data-theory, Pratt, 2009). The codebook for analysis was built by two researchers, inductively (based on the first round of emergent codes in open coding) and deductively (based on the results of the structured literature review). The codebook can be found in Appendix 2.

2.5. Survey

A quantitative survey was launched, in order to capture further width of empirical evidence on the relationship between RRI-like practices and competitive advantage. The survey instrument was developed based on the previous research in the study, and other research activities in the RRING project (mostly Work Package 3). The survey covered five major topics: RRI-like practices, competitive advantage, contextual factors, and the SDGs. Further detail about the sample and data collection and the variable development and data analysis are provided below.

2.5.1. Sampling and data collection

Since the objective of the survey was to obtain maximum breadth of data, it was launched in the five geographical regions. The survey had a focus on businesses and policy-makers, but was addressed to all stakeholders, aiming to increase the understanding for the recommendations for other stakeholders as well. Following a strategy of random sampling without replacement (Särndal et al., 2003), 740 responses were obtained. Data was collected from October 2019 to February 2020 via an online questionnaire, that was distributed by email invitation (50552 invitations) and social media. Based on the number of email invitations, the response rate was about 1.46%. The very low response rate threatens representativeness, a common bias in online surveys (Bethlehem, 2010); however, the descriptive statistics for key organizational characterization variables depicted in Table 3 show a fair spread of responses. This is sufficient to draw some preliminary conclusions, based on this analysis and this being the first reported global survey on RRI and competitive advantage, although there is a clear overrepresentation of organizations in Europe and North America (47.50%).

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Table 3. Frequencies of key sample variables

Key variables	Frequencies				
Region of operation	*Arab States*	*Asia and the Pacific*	*Europe and North America*	*Latin America & the Caribbean*	*Sub-Saharan Africa*
	8.60%	16.50%	47.50%	6.00%	18.90%
Domain	Bio-economy	Energy	ICT	Waste management	Other
	16.90%	21.30%	22.30%	13.30%	24%
Type of organization	*Business*	*Policy-maker*	*Other organizations involved in research and innovation*		
	19.70%	10.50%	66.60%		
Gender of the respondent	*Female*	*Male*	*Other*		
	37.10%	61.40%	0.80%		

By ensuring anonymity of responses both in the email invitation and the opening of the questionnaire, social desirability bias was addressed (Taylor et al., 2009). The variables were defined following the procedures described in Section 3, and the data were analysed following standard statistical methods.

2.6. Case studies

As part of the effort to strengthen the empirical knowledge on the relationship between RRI-like practices The methodology used to achieve the objectives above was a qualitative case study (Yin, 2009). The essence of using a case study methodology is that it allows for analytical generalization and the development of theory and practice on which to build the recommendations (Eisenhardt, 1989).

Based on recent debates in media on controversial issues for each of the domains, two domains were selected for further investigation, with the following issues for each of the domains:

- ICT: machine / deep learning and racial bias in identity recognition (including facial recognition, and other forms of biometric recognition such as fingerprint or voice). This case involves a normative social-ethical implication: discrimination bias or inequality by design, but also a technical "data representation bias" at the core of deep learning. They learn from data that does not represent to the same extent the individuals who must deal with those technologies or are affected by them; in this regard they reflect known existing societal inequalities but could also introduce new ones - if not anticipated, reflected and actively (normatively) corrected.
- Bio-economy: the application of CRISPR-CAS and other gene-editing techniques. Gene editing techniques have been controversial and have been regulated differently in different regions, with European regulations being the most stringent. Recently, CRISPR-CAS was included under the GMO regulation in the European Union. These techniques are considered by some to be dangerous because of risks posed to biodiversity and unanticipated consequences of manipulating genomes; however, they are also perceived to be a potential contributor to

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solving sustainability problems, such as food security (SDG 2); particularly, in the context of climate change, and genetic diseases (SDG 3).

In addition, other socio-ethical challenges and how they are managed through RRI-like practices were identified inductively. Gender equality issues were also considered as a transversal issue.

2.6.1. Sample

Sampling was carried out based on socio-ethical issues (as identified in media and context documents) in each of the domains (ICT and the bio-economy). This identified practices compatible with RRI to address such socio-ethical issues that lead to competitive advantage (or not), as well as other practices that are not compatible with RRI, but are commonplace in each of the regions to handle socio-ethical issues, and their relationship with competitive advantage. This allowed for the exploration of how the socio-ethical issues are managed in different regions, with industry (including MNEs, SMEs and start-ups) and policy-makers as the focal point, but also exploring how other stakeholders participate in decision-making, standard-setting, and in the establishment of requirements in the research and innovation process. The selection of stakeholders (other than industry) was determined based on the prior desk research and snowballing during the interviews. These stakeholders were either collaborating with the focal stakeholders (e.g., research, certain NGOs), or shaping the context for the development of their activities (e.g., critical NGOs, civil society, policy-makers)

Since gender equality concerns were examined as a transversal issue in each of the cases. In context of sampling, the following were considered:

- Issues related to gender equality (e.g. biometrical reading of gender basing on binary approach; feminization of ICT machines providing services).
- Products/topics directed to particular gender (e.g. waste management as much as it is women's concern at home).
- Informants' gender.

Based on these criteria, the interviewees were selected, as collected in Table 4.

Table 4. Interviewee characterization for exploratory interviews

#	Case	Region	Country	Type of stakeholder	Main activities	Role in the organization	Gender
A	ICT	Europe & North America	Ireland	Industry, multinational	Artificial intelligence	Researcher	Male
B	ICT	Europe & North America	Lithuania	Industry	Digital intelligence	CEO	Male
C	ICT	Africa	Several countries in Africa	NGO / SME (hybrid organization)	Provider of biometric technology	Partnerships manager	Female
D	ICT	Europe & North America	Lithuania	Research	Artificial intelligence	Expert, university professor	Male

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E	ICT	Europe & North America	Germany	Industry	Identity recognition technology	Chief Scientific Officer	Male
F	ICT	Europe & North America (and others)	Spain, LAC, Asia	Industry (multinational)	Biometric recognition	Deputy manager	Female
G	ICT	Europe & North America	Ireland	Policy-making agency	Business promotion	Contact point for European programmes	Male
H	ICT	Europe & North America	Germany	Think-tank / NGO	Ethics of deep learning	Project manager	Female
I	ICT	Asia & the Pacific	Japan	Industry	Biometric recognition	Innovation manager	Male
J	ICT	Latin America & the Caribbean	Perú	Research	Artificial intelligence/ biometrics	University professor, researcher	Male
K	Bioecon.	Latin America & the Caribbean	Colombia	Research	Biotechnology research, ethics	University professor	Female
L	Bioecon.	Asia & the Pacific	China	Research	Ethics of biotechnology	University professor	Male
M	Bioecon.	Africa	Nigeria	Research	Biotechnology	University professor	Male
N	Bioecon.	Europe & North America	Netherlands	Industry	Gene-editing	Chief Innovation & Technology Officer	Male
O	Bioecon.	Europe & North America	Netherlands	Research	Gene-editing and CRISPR-CAS in agriculture	University professor	Male
P	Bioecon.	Europe & North America	Netherlands	Civil society	Student	Activist	Female
Q	Bioecon.	Europe & North America	Lithuania	Industry	Gene-editing	CEO	Female
R	Bioecon.	Latin America & the Caribbean	Colombia	Industry	Industry association	Executive director	Female
S	Bioecon.	Asia & the Pacific	Japan	Research	Gene-editing	University professor, regulator	Male

The aim was to have maximal geographical coverage within the issues selected for each of the domains, in order to evaluate how these issues have been approached in different contexts. The sample was determined based on preliminary research on the main actors for each of the issues in each of the domains. The cases were selected based on the background desktop research, that the cases are involved in practices that may be consider RRI (see, for instance, Lubberink et al., 2017), or,

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if not possible for some regions, are addressing the SDGs. Self-identification with RRI-like practices and the researcher's positive assessment based on their knowledge on RRI practices identified in the literature were considered sufficient criteria for inclusion in the sample.

In any case, in order to determine to what extent the interviewee is involved in the RRI-like activities and has a concern with competitive advantage, beyond primary interviewee referral, the following criteria were followed:

- In the case of industry, the interviewee has a procedural (e.g., innovation manager, project manager) or strategic (e.g. CEO, strategy manager) involvement in innovation, and / or is responsible for the performance and marketing of new products / services / processes (e.g. quality manager, marketing manager, product manager). The interviewee engages in collaborations with other stakeholders.
- In the case of other stakeholders, the interviewee is in a position to provide sufficient knowledge about the context for the socio-ethical issue at hand in each of their regions; either because of their research record, collaboration in or criticism of the development of the technology.

2.6.2. Data collection

Data was collected through semi-structured interviews, lasting between 20 and 85 minutes, focusing on the interviewee's understanding of RRI-like practices, how they drive or hinder competitive advantage and enable their organization to manage identified socio-ethical issues, and gender issues. The interview protocol designed for the interviews is shown in Appendix 3. Data was collected between October 2019 and March 2020, and were conducted over phone call, video call or in person. The interviews were conducted in English or the native language of the interviewee (B, D, F, I, J, K, Q, R, S). Interview L was conducted mostly in English, with the occasional assistance of an interpreter.

Secondary data was also collected, to provide further contextualization and triangulate data for those regions where it was not possible to gain access to multiple stakeholders. Secondary data also answered the following questions, prior to interviews:

- What is the name of the organization?
- What is the geographic scope of the organization?
- What domain does the organization belong, and what are the main socio-ethical issues that if faces?
- What is the size of the organization?
- What practices of the organization lead us to believe they conduct de facto RRI (Randles et al., 2016) and competitive advantage, based on the project definition of RRI and previously identified RRI industry practices?
- What practices of the interviewee lead us to believe they conduct or support de facto RRI (Randles et al., 2016) and competitive advantage, based on the project definition of RRI and previously identified RRI industry practices (Lubberink et al., 2017)?

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- What is the name of the interviewee?
- What is the interviewee's role (general tasks and activities and involvement in RRI-like activities)?

2.6.3. Data analysis

Data was analysed by two independent coders through thematic analysis (Eisenhardt et al., 2016; Gioia et al., 2013) following a codebook developed based on the theoretical and empirical insight obtained in previous tasks (the codebook can be found in Appendix 4). After a first iteration, the researchers reconvened and redesigned the codebook, including new inductively developed codes related to the socio-ethical challenges encountered in each of the cases. After two rounds of data coding, the Krippendorff's Cu-α for inter-coder reliability was 0.642, which was deemed satisfactory given the open-ended nature of the data. The codebook can be found in Appendix 4.

2.7. Indicators to measure the relationship between RRI and competitive advantage

Several previous studies have looked at key performance indicators for RRI, but not in relation to competitive advantage. The first part of this section looks at previous research on indicators for RRI, particularly in relation to the focal actors of competitive advantage; that is, industry and policymakers. The second part of this section explains how these indicators informed the empirical work within the study and the variable development for the survey.

2.7.1. Previous research

Since the outset of RRI, a significant effort has been made to define indicators that would measure progress in the development of such practices. Almost from the beginning, even when practices were not so clearly defined yet, the need for good policy development and governance frameworks led to the development of indicators. However, these efforts are mostly oriented towards policy development for science and basic research, which make them difficult to apply in the context of competitive environments or for actors concerned with competitive advantage. Indicators have been proposed at three levels: macro (oriented towards research policymaking); project (oriented towards measuring the implementation of RRI in research projects) and industrial-organizational (oriented towards assessing and monitoring RRI-progress within organizations). The second and third of these have most often included elements considering competitive advantage.

At the research policy level, some of the best-known efforts have been carried out as part of the MORRI (2018) project, which has its follow-up in the Super-MORRI project (currently ongoing), which provide indicators for the six keys. Earlier, the European Commission set up an expert group on policy indicators, to develop measures to monitor the progress of RRI in the European Union based on the

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six policy keys, plus environmental sustainability and social justice (Strand et al., 2015). This report has served as a baseline for further developments on RRI indicators, a notable feature of them being the fact that they present both process and outcome dimensions to be measured. MORRI developed such indicators (36 in total) focusing on the six policy keys (gender equality, science literacy and science education, open access, public engagement, ethics and governance). However, in terms of their applicability for competitive advantage, they do not take into consideration aspects essential to the behavior of actors in competitive environments (e.g., the need to protect business secrets). Other studies at the macro level aimed to examine innovation performance and science in society (Tsipouri, 2012). While indicators of innovation performance at the macro-level are well-established (e.g., number of patents, % of GDP invested in R&D), this is not the case for indicators of research and innovation *in society*. Tsipouri (2012) deployed national context and policy debates, direct citizen involvement, the existence of policies building up the role of science in society as indicators. However, the study presents methodological constraints that complicate the comparability and applicability of the quantitative innovation performance data, and the data for science in society, which was obtained via reports.

At the level of research projects, Daedlow et al. (2016) developed a set of criteria to frame socially responsible research; which include the following: approach to complexity and uncertainty, ethics, integrity of approach, interdisciplinarity, reflection on impact, transdisciplinarity, transparency, and user orientation. While these criteria allow the identification and monitoring of whether socially responsible research processes are being carried out, they are based on theory and previous conceptual frameworks, and have not been sufficiently tested as indicators in practice.

At the organizational level, there have been some efforts to define key performance indicators, particularly for industry. One of the first projects aiming to do so was the Responsible Industry project, which listed the following key performance indicators for business actors (Responsible Industry, 2015):

- Strategic value of the project to the customer
- Companies' own project management skills
- The R&D culture
- Communication and cooperation quality
- The role of societal aspects such as sustainability and health
- Technological project superiority
- Recall of products in case of non-compliance with socio-ethical criteria
- Safety of the service
- Reliability of the service
- Customer satisfaction
- Top service product quality
- Innovativeness
- Usability

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- Productivity.

As part of the same project, CSR (Corporate Social Responsibility) tools and standards were analyzed to assess their applicability to RRI. The analysis included ISO standards, as well as global initiatives through which businesses report on certain indicators, such as the Global Reporting Initiative or the UN Global Compact were analyzed. While these initiatives in CSR are certainly valuable, most of them refer to outcome dimensions or general management practices, and do not capture the full scope of RRI-like practices. As noted by Blok (2018); the accountability emphasis of CSR Is backward-looking, while RRI is forward looking, to the extent that innovation is a future-creating activity (Grinbaum & Groves, 2013).

Another relevant project in the development of RRI in industry was COMPASS (COMPASS, 2020), which was recently completed. While COMPASS did not aim to provide key performance indicators for RRI in industry, it did provide an overview of practices that could be considered as RRI-like in industry: mainly, social innovation, open innovation, environmental and ethical considerations for responsible innovation and gender issues and workplace equality. Following the axes provided in COMPASS, several industry practices that are more widely acknowledged under the umbrella of other concepts could be considered as RRI-like practices. In this line of thought, (Lubberink et al., 2017) provided a systematic review of practices in social and sustainable innovation that led to the identification of industry practices that were compatible with the AIRR framework's dimension. While these are not indicators as such, they are signs of *de facto* RRI in enterprises.

Other key performance indicators for RRI in industry defined by van de Poel et al. (2017) were divided into categories: organizational and RRI itself. The RRI indicators for industry in this case were divided into diversity and inclusion (gender equality and engagement), anticipation and reflection (legislative landscape, assessment and public and ethical issues), responsiveness, and adaptive change, openness and transparency (intellectual property and confidentiality and open access) environmental sustainability and social sustainability.

Another relevant study on RRI in industry in relation to key performance indicators was carried out by Yaghmaei (2018) who defined three dimensions for indicators, scored in accordance to maturity levels of RRI in industry (Stahl et al., 2017). These three dimensions are: RRI awareness, RRI implementation an RRI assessment. 12 indicators are proposed within these dimensions:

- RRI awareness:
  - Moral value awareness
  - Acknowledgment of moral values in the company's strategic plan
  - Acknowledgment of standards and regulations
- RRI implementation
  - External RRI, that is, the collective action with external stakeholders
  - Engagement with third party networks, for example civil society organizations
  - Internal RRI; mainly, employee engagement
  - Embedding moral values in business processes,
  - Anticipatory design

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- Transparency

– RRI assessment

- Risk identification and risk management
- Impact assessment
- Technology assessment.

While these indicators are very valuable in understanding progress in industry, they are based on their application in a case study and are not operationalized in practice which made them difficult to apply in the context survey, which aimed to capture visions of various stakeholders. However, the awareness and implementation dichotomy informed the approach as attitudes and engagement. Nevertheless, these were identified as relevant key performance indicators for industry during the desktop research.

The most comprehensive collection of RRI practices, in terms of applicability to different actors, was gathered by RRI Tools, which aims to create a community of practice (Groves, 2017), and is, consequently, deliberately inclusive in the selection of categories to be evaluated as RRI. RRI Tools has in fact been one of the most effective initiatives in knowledge development and promotion of RRI practices. RRI Tools proposes processes that are diverse and inclusive, anticipative and reflective, open and transparent, and responsive and adaptive to change in order to achieve ethically acceptable, socially desirable, and sustainable outcomes (RRI Tools, 2020).

2.7.2. Building indicators for RRING

The indicators identified as part of previous studies were highly useful for sampling purposes within the study, since it is difficult to determine beforehand what RRI-like practices look like when using a constructivist approach. A strong effort was made in the study to employ a bottom-up approach; therefore, for the qualitative studies a grounded understanding of what RRI-like practices are was derived from practices described by the respondents. However, in order to sample appropriate organizations, the framework of the review provided by Lubberink et al. (2017) served as the benchmark against which organizations were selected in the qualitative tasks. This framework was also used in other studies for RRI in industry such as the one developed by van de Poel et al. (2017). Therefore, the practices of RRI identified for industry in the systematic review where are the indicators selected for the qualitative studies.

When it comes to developing quantitative indicators for the survey, the constructivist research design called for the application of frameworks that 1) were not strictly based on Eurocentric approaches such as the six keys frameworks; 2) were applicable to different organizations since the survey was addressed to all innovation actors beyond industry and policymakers; and 3) were applicable to a wide catching set of practices that would involve both procedural and outcome dimensions. To that extent, the framework dimensions identified in the RRI Tools project were encompassing of all of these selection criteria (RRI Tools, 2020).This resulted in seven blocks: diversity, gender equality, inclusion of ethnic minorities, societal risk management, societal needs, open and transparent methods and processes, and ethics.

In order to develop indicators for each of the dimensions three aspects were taken into consideration. First, attitudes toward underlying values in RRI-like processes were taken into consideration; to

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evaluate this, a reference sentence was included and the level of agreement with this sentence was measured through a Likert scale. Second, actual engagement in RRI-like practices was measured, and third, in order to obtain further detail about how this engagement in RRI like practices, a multiple-choice question in which many possible practices could be selected was included. The survey questions can be found in Appendix 5. Based on the responses two index variables were developed to measure performance in RRI-like practices, one related to attitudes, and one related to engagement, for which the variables were first transformed into a dummy (yes=1, any other response=0).

Questions about competitive advantage were also included for the focal actors who develop a competitive advantage. The measures of competitive advantage by Hooley et al. (2005) were selected for business, since they are well-established and appropriate for cross-sectional studies (since they report relative to the previous year and to competitors). These include dimensions for financial, market and customer performance relative to competitors and relative to the previous year. For policy-making organizations, self-developed compound measures of impact performance and local sustainability performance were included. The items for these measures are included in Appendix 6.

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3. Research findings

The following subsections present the results of the research activities that support the recommendations for stakeholders. The first section summarises the results of the state-of-the-art, based on the desktop research and the exploratory interviews. Then, Section 3.2 presents the results of the case studies, and the last section showcases the main results of the survey.

3.1. State-of-the-art of RRI and competitive advantage: drivers and barriers

The relationship between RRI and RRI-like practices and competitive advantage is a complex one. As mentioned above, some of the tenets of RRI seem to be in opposition to some of the factors to achieve a competitive advantage. For example, the openness and transparency requirements conflict with the achievement of competitive advantage through information asymmetries (Blok & Lemmens, 2015). On the other hand, openness may lead to the development of better innovations and making better use of knowledge, as suggested by open innovation practices (Chesbrough, 2003; Long & Blok, 2017a). In fact, in their study on motives for business organization to engage in RRI, Garst et al. (2017) showed how RRI was promoted in companies not only because of moral motives or the desire to do the right thing, but also by instrumental motives sustained by ensuring firm survival (see Figure 4).

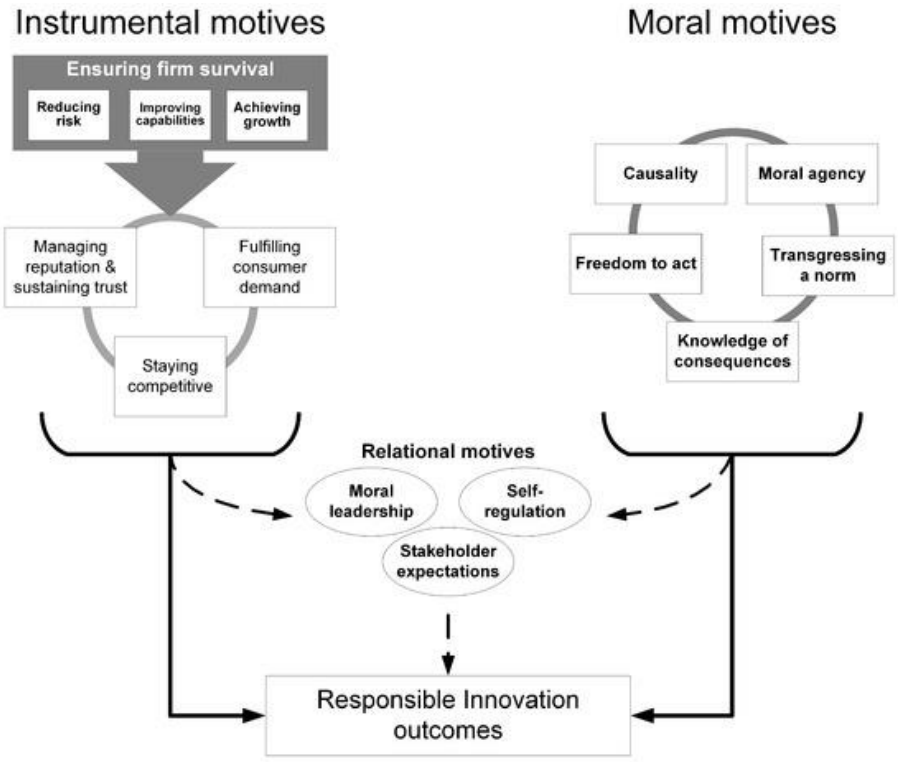

Figure 4. Business motives to engage in RRI (extracted from Garst et al., 2017)

In any case, in a market environment countries and business organizations need to compete; for this reason, they have instrumental motives – as well as moral ones - guiding their actions. This highlights the relevance of including instrumental considerations in RRI understanding, promotion and

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implementation, and understanding how RRI might, on the one hand, drive the development of a competitive advantage, but also how it might hinder such development, in order to identify solutions and provide recommendations. Nevertheless, these considerations vary among stakeholders, regions and domains. For instance, the motivation to protect public goods should be higher in the case of policy-making organizations than privately-owned businesses. In the case of regions, the relationship between RRI-like practices and competitive advantage may change because of diverse societal values – e.g., the urgency of economic development or the value of privacy might change across societies –. In addition, the domain and context in which the actor operates will also result in the development of competitive advantage based on different factors; for example, the consumer market is more driven by shopping experience and emotions, which favours competitive advantage based on brand differentiation, while the business to business market is driven by mostly rational buyers and advantages are more based on value-for-money (Kotler & Armstrong, 2010).

In order to operationalize this relationship, the state-of-the-art looks at drivers and barriers to competitive advantage based on RRI, looking at different stakeholders and regions.

3.1.1. Mapping the state-of-the-art

As noted in the previous section, the study started with a desktop research of 82 documents analysing the relationship between RRI-like practices and competitive advantage. A preliminary bibliometric analysis was conducted to assess the state-of-the-art.

Figure 5 shows the results of the structured literature review by year of publication.

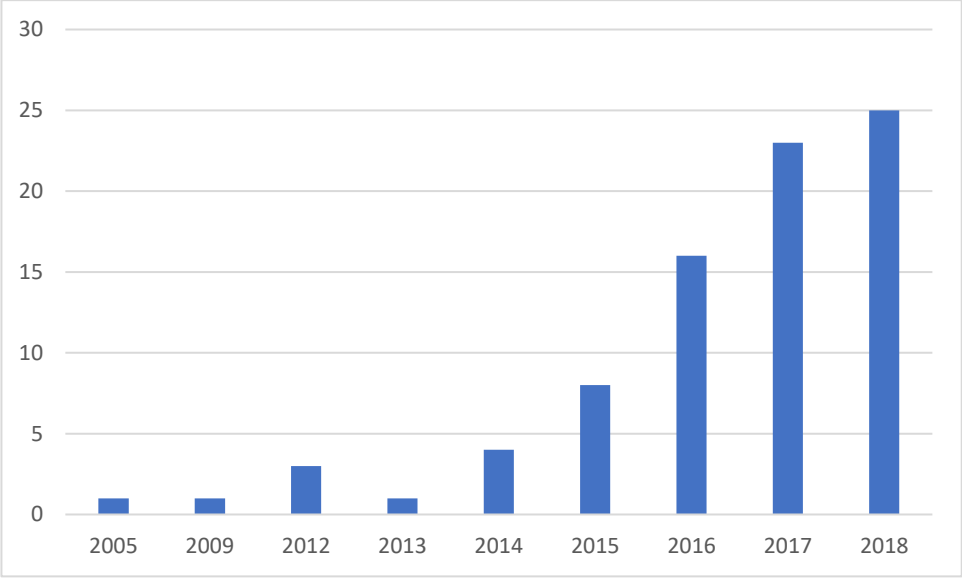

Figure 3. Frequency of year of publications in the results of the literature review

The articles were published from 2005 to 2018, and as noted in the table, there is an increasing interest trend in the last years, particularly after 2012, when the European policy keys and several seminal articles on RRI were published (European Commision, 2012a; Owen et al., 2012; Von Schomberg,

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2012). However, it is prominent that the research is still greatly Eurocentric, as noted in Table 5, and Figure 5, below, which shows the countries of origin of the documents and how they are interrelated.

Table 5. Results of the literature review by region of interest

	Frequency	Percent
Africa	6	7.3
Arab States	1	1.2
Asia & the Pacific	9	11.0
Europe & North America	55	67.1
Global	9	11.0
LAC	2	2.4
Total	82	100.0

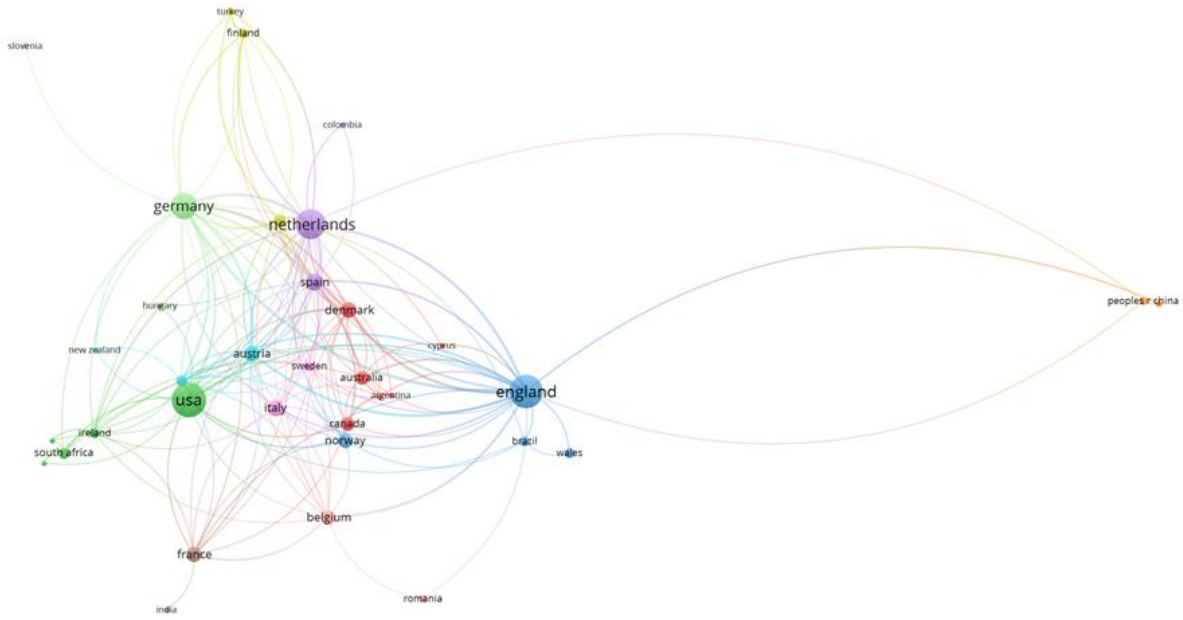

Figure 6. Network diagram of countries represented in the desktop research (made with VOS Viewer)

As observed in the figure, the majority of the research represented is written by authors from the region of Europe and North America, who are also more closely linked to others; this cluster also presents links with research in South Africa, New Zealand, India, Brazil, Argentina and Colombia. China also represents a significant cluster; however, the literature strand is developing with looser ties to the European cluster.

The network of keywords illustrated in Figure 7 shows five main clusters around RRI and competitive advantage: emerging technologies, corporate social responsibility and sustainability, ethics and research integrity, tackling socio-ethical issues (such as health, big data or privacy) and participation and engagement.

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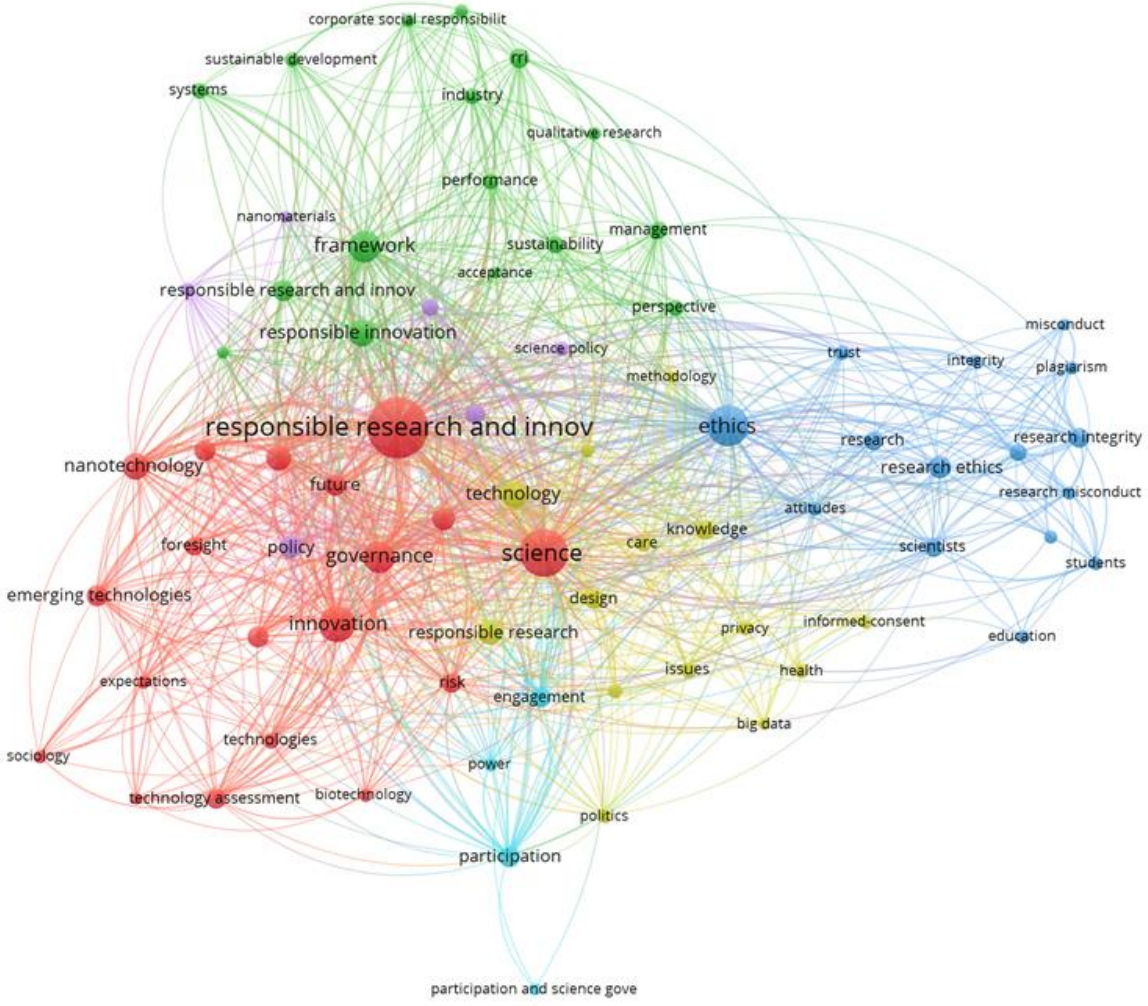

Figure 7. Network of keywords in the desktop research (made with VOS Viewer)

Such diversity of keywords is also represented in the choice of publication outlet. While some journals are highly represented in the sample, the publications are mostly spread. Table 6 presents the journals that were represented by 3 or more publications (with a total of 39 publications in 5 journals), while other outlets were only represented by 1 or 2 papers (the complete list may be found in Appendix 7).

Table 6. Representation of journals in the results of the structured literature review

	Frequency	Percent
Journal of Responsible Innovation	8	9.8
NanoEthics	9	11
Science and Engineering Ethics	4	4.9
Sustainability	15	18.3
Technology in Society	3	3.7
Others	43	52.4

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Lastly, an analysis of the types of papers was carried out. There were no quantitative studies examining the relationship between RRI-like practices and competitive advantage. As illustrated in Table 7, 56% of the papers relied on secondary data (conceptual and normative papers, literature and policy reviews, and modelling). The majority of the manuscripts analysing primary data used case study methodology.

Table 7. Types of papers in the structured literature review

	Frequency	Percent
Action research	2	2.4
Conceptual	17	20.7
Literature review	10	12.2
Modelling	1	1.2
Normative	17	20.7
Policy review	1	1.2
Qualitative	34	41.5
Total	82	100.0

As expected, due to the competitive advantage component, the focal stakeholder for most of the papers (56.1%) are industry and policy-makers, although there is also a significant 8.5% focused on researchers, as illustrated in Table 8. The rest is divided among other stakeholders, often in combination with industry and policy-makers (see Appendix 7).

Table 8. Focal stakeholders in the results of the structured literature review

	Frequency	Percent
Industry	25	30.5
Policy-makers	16	19.5
Industry and policy-makers	5	6.1
Researchers	7	8.5

The preliminary analysis of the literature presents several limitations and paves the way for the exploration of this relationship within the empirical efforts in this report and further. These limitations are summarised in the following:

- Eurocentrism: even when recognizing de facto or RRI-like practices as the departure point of the study, the great majority of studies are concentrated in North-West Europe. Some research is found in other regions, but a global outlook is missing.
- Most of the literature is normative or conceptual, with only a few studies based on several cases. No quantitative studies were identified.

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The next sections present the results of the state-of-the-art, involving both the desktop research and the exploratory interviews.

Besides the limitations identified during the bibliometric analysis, from a content perspective, most of the studies that do incorporate RRI and competitive advantage do so as a background condition, but do not actually explore the relationship and trade-offs between them in depth. Some authors do provide particular insights on RRI-like practices and competitive advantage (see, for instance, Ceicyte & Petraite, 2018; Gurzawska et al., 2017; Lees & Lees, 2018; Yang & Han, 2017), while for others it is an added consideration to the main issue covered in the manuscript (for example, the ability to compete in the international research market through adequate legislation presented by Jouanin et al. (2018) or the achievement of ethical and social acceptability of artificial intelligence – leading to cost-efficiency – though RRI in Winfield & Jirotka (2018)). It was decided to include studies that touched upon this relationship even if it was not the focus of the paper in order to further enrich the study. This was also combined with the exploratory interviews.

3.1.2. RRI as a driver of competitive advantage

RRI-like activity might drive the development of competitive advantage for different stakeholders. Already from its conception within the European Union policy programme, RRI was designed as an element of competitive edge as a region, providing an advantage based on the management of socio-ethical issues and unanticipated consequences of research and innovation (Schroeder et al., 2016; Zwart et al., 2014). Some literature has aimed to identify sources of competitive advantage for industry based on the procedural framework of RRI. Ceicyte & Petrayte (2018), for example, in their study of networked RRI, associated anticipation with a first mover advantage, since it helps with regulation and technological vigilance; reflexivity with the development of better products, since there is further appraisal during the innovation process; transparency and inclusion with a better assimilation of information and commitment of collaboration, and responsiveness with enhanced reputational effects and brand management.

The literature review and the exploratory interviews resonated with these and showed how RRI contributed to competitive advantage through different sources. At the macro level, competitive advantage is derived from factor conditions, demand conditions, related or supporting industries and firm strategy, structure and rivalry (Porter, 1990), while at the macro level, it is determined by better value, better quality or lower prices (Porter, 1985). Under this framework, five main drivers of competitive advantage were identified. The interplay of these at the macro and micro levels and are further explained below.

3.1.2.1. Avoiding uncompetitive regulation

At the macro level, regulation sets the rules of the game, and the *structure* under which economies developed. From an economic perspective, governmental regulation is designed to protect the public good and set the rules of the game under which players need to operate. This need to protect the public good may limit the scope of innovation; hence limiting the capacity of researchers, firms and countries and regions to grow based on the development of a technology. Under the so-called

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precautionary principle, regulation might prevent advances in a domain when the consequences for the public good cannot be clearly anticipated. An example of such application of the precautionary principle is the ban on GMO-based foodstuffs in the European Union, which prevailed for several years (Hartley et al., 2017). In addition to governmental regulation, standards and moratoriums are often agreed on by players in a particular domain, when there are risks derived from the uncertainty in the development of a technology (Malsch, 2013; Rodriguez, 2018; van Hove & Wickson, 2017). Although regulation is set to provide protection of the public good (sometimes resulting in a loss of competitiveness from a strictly economic, first mover advantage perspective), it might also provide the wrong incentives from an ethical and sustainability point of view, by supporting some technologies over others or rushing developments in a certain direction (Cavicchi et al., 2017).

Under this understanding, RRI and RRI-like practices are indicated as a more adequate way to balance the risks of research and innovation, sustainability outcomes and keeping and developing a competitive advantage (Jouanin et al., 2018; Wallach et al., 2018). Under this view of RRI-like practices, anticipatory, deliberative and inclusive processes should result in a better understanding and risk management practices than those provided by regulation. Consequently, the need to halt ongoing research and innovation processes – threatening, then, the future research capacity of a region – would not be as acute, as long as sufficient preventative measures based on RRI practices are in place. Jouanin et al. (2018) illustrate this in the case of wheat with hypoimmunogenic gluten, whose development has been paused in the European Union because of the ruling on CRISPR-CAS gene-editing techniques. Other propose that RRI practices will lead to social alignment with, rather than social control of, innovation policies, hence leading to the development of better policies which balance risks and socio-economic interests (Dreyer et al., 2017; Ribeiro et al., 2018).

From the perspective of the firm, it was noted that anticipation allowed to be prepared when new regulation arrives, facilitating staying a step forward from legislation and competitors. Not only is the company prepared for future changes in regulations, it can also build a competitive advantage based on sustainable and ethical growth, as noted by the Head of Regulatory Affairs of Company A, in India:

> "*Obviously when we talk about ways to wealth, sustainability becomes a part of it. It falls under the overall umbrella of sustainability and that's how it goes. Within sustainability, we want to ensure that we take care of the safety, the environment, health, safety, and environment. Also, the participation of both genders and the community*".

3.1.2.2. Social acceptance

One of the tenets of RRI, from an outcome perspective, is to develop *ethically acceptable and socially desirable* outcomes (Von Schomberg, 2013). This is reflected in two main effects in relation to competitive advantage. First, increasing science education and engaging in open science and open innovation practices with transparent processes, helps to develop regulations and policies that are aligned with both science and society. Taking on the example of GMOs, while the majority of scientists were convinced at the time that consumer safety was guaranteed, the regulation advocated for a ban for a number of years based on the low levels of consumer acceptance of such products (Hartley et

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al., 2017). Therefore, increasing public knowledge through public engagement and science education should lead to scientifically informed policies.

In that sense, remaining open and transparent with the public, as well as engaging in public deliberative processes – often involving first and second order reflexivity – drives the acceptance of emergent technologies by society (L'Astorina et al., 2015; Winfield & Jirotka, 2018). The case of emergent technologies is particularly prominent, since they are often met with further public outcry, and halting their development results in a loss of competitive advantage, as illustrated in the previous subsection. In that sense, engaging in RRI-like practices provides technologies with a social licence to operate, and a sense of success within the company, as noted by the engagement practices of Company A, a large Indian company:

> "*The more you try to involve the local people, give them the jobs, give them the satisfaction of working in a big organization while staying in their own place, the benefit is mutual. Both for them as well as for us, because you get a license to operate, people admire the organization and the local administration also admires the organization*".

Even in the cases of more established technologies, societal acceptance is a major driver for competitive advantage, since societal acceptance will determine the existence of a market for the results of the research and innovation processes. Inclusion and responsiveness practices help to market the results of research and innovation by determining, early in the process, whether the resulting technology, product or service is acceptable for the final user or consumer, and helping the organization being more responsive to such changes. Inclusion of a wide variety of stakeholders beyond the final consumer will help with the fit across the value chain, hence increasing efficiencies. However, the drive of social desirability might sometimes conflict with ethical acceptability (Kuzma & Roberts, 2018; Weckert et al., 2016).

3.1.2.3. Incorporating stakeholder needs and tapping on new markets

At the micro level, RRI-like practices have a direct effect on competitive advantage, since they build on principles of collaboration, inclusion and responsiveness that allow for incorporating stakeholder needs better into the innovation process (Auer & Jarmai, 2018). As a consequence of the incorporation of such stakeholder needs, businesses not only address societal needs, but also develop innovations based on a demand pull, which are more likely to find a market. Indeed, developing research and innovations based on technology push often makes the marketing of the product or service harder (Ceicyte & Petraite, 2018; Chatfield, Iatridis, et al., 2017; van de Poel et al., 2017). Although technology pushed innovations may also be successful, responding to an identified need ensures there is an audience for the result of the innovation. Competitive advantage built on RRI-like practices is sustained by a strategy of differentiation and superior quality, based on being responsive to customer demand (Lees & Lees, 2018). Moreover, RRI-like practices may be adapted locally to reflect societal values, further increasing the connection with stakeholders and the tailoring to local societies, as proposed by (Hilmi, 2018) for the case of the Islamic banking sector.

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Engaging in RRI not only helps to tailor research and innovations towards previously identified markets. Engaging a diverse range of stakeholders may help to tap into new markets, through the identification of new consumer markets that were not identified before and tailoring products to those needs. Good examples of this are innovations that incorporate the gender perspective, or are addressed to disadvantaged groups (for example, bottom-of-the-pyramid strategies, or accessible technologies) (Botha et al., 2016). Identifying particular needs for use helps to develop technologies that are closer to actual needs, as it is the case of frugal innovations (Peša, 2018), particularly in the Indian context (Pacifico Silva et al., 2018; Pansera & Owen, 2018). Anticipatory measures may also be useful in identifying new markets; for example, through regulatory or technology vigilance, it may be observed whether new markets will be created. A good example of this is found in the case of Company G, in Uruguay, which, by being attentive to upcoming regulation and the technological developments in energy efficiency, identified a new market opportunity:

> "*We saw an opportunity in the market and sometime later it was actually generated, that is, there were only some indicators of the government. The environment that started to favour a lot of people appeared much later, in fact, at first, when we started, we didn't even know that we were an energy service company. Then, we realized that this already existed elsewhere in the world and that there were several companies that were dedicated to this very thing, but we really started in a very particular niche*".

3.1.2.4. Efficiency of innovation

Efficiency is not limited to a better fit in the value chain. From a macro perspective, the fact that research and innovation performing organizations (such as research centres, universities and businesses) incorporate stakeholder needs, increase openness in the process and incorporate ethical and sustainability assessments, helps to make the innovation process is made more efficient (Ligardo-Herrera et al., 2018). During the innovation process, "control checkpoints" are introduced to ensure that the innovation process runs as smoothly as possible, often through so-called stage-gate models that build in evaluation moments in the research process. These checks serve to decide whether to continue with the innovation effort, based on ability of the technology to prosper at the technical or marketing levels. The earlier the innovation process is halted it if it is unlikely to prosper, the more savings for the research performing organization, and to that extent, business engage in reflective, participatory processes, such as Company C, in Malawi:

> "*We also have discussions with our clients to do with data ethics or ethics in general, how to handle private and personal data or data that is sensitive. Ethics is also part of our values. We got for that. I think integrity is also one of them*".

Such efficiency at the micro level has impacts at the macro level. Of course, this might be introduced in policy for publicly funded projects, integrating ethical and social stage gates in the process in order to halt programmes for which there is no market, or if the product is not going to be socially desired

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or ethically acceptable. In the case of countries with highly planned or very centralized research and innovation programmes, this might be particularly significant at the macro level, as indicated for the case of China (Yang & Han, 2017). However, this idea of efficiency of innovation has another side to the coin: reductions of serendipity, and hence probability of innovation, as explored in the subsection on barriers.

3.1.2.5. Reputational effects

At the micro level, engagement in RRI might enhance reputation and, consequently, the public trust in the company. Beyond the social licence to operate discussed above, which allows for good operating relationship between the company and its community, engagement in RRI-like practices allows for the company to be perceived as a 'good company', a reputational effect on which brand strategies might be developed (Martinuzzi et al., 2018). Public engagement, transparency and open communication with stakeholders also allow for increased brand / company awareness (Gurzawska et al., 2017). This is the case of Company E, which practices open science and, in words of its CEO, derives a sense of achievement from such social recognition, even when it means being copied:

> "*If you create something where the people from all around the world wanted to come, to see, to share, and where we are feeling well, then I think that it is the success. Or if you create something what is ready to be copied in any spot on the world, and if there is a sense to copy that, then it means that you're successful*".

As a consequence, companies enjoy these reputational effects based on engagement in RRI-like practices both directly and indirectly in relation to competitive advantage: directly, as it builds on brand, resulting increased customer loyalty, but also indirectly, by providing access to more and better collaborations with stakeholders and the ability to set contracts along the value chain (Gurzawska et al., 2017). Engaging in RRI opens the possibility for more meaningful collaboration along the value chain, which aids in the innovation process (Auer & Jarmai, 2018). Moreover, these reputational effects extend to the ability to attract talent, also in different contexts, as noted by the CEO of Company G, who noted how their sustainable energy orientation helped to bring in and keep employees:

> "*This area has something… Working in the area of renewables has sort of a romantic aspect that people value -- especially the people in science, who respect it a lot- and that […] provides advantages in terms of people wanting to work here*".

3.1.3. RRI as a barrier of competitive advantage

Despite the identified drivers, RRI-like practices might also pose a barrier to competitive advantage. These are not so often discussed in the literature; partly because the normative nature of a great amount of the existing work, which aims to advocate RRI. In addition, while drivers of competitive

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advantage were identified both at the micro and macro level, the barriers to competitive advantage identified are mostly concentrated on business actors. The acknowledgement of such barriers helps to examine the characterisation of RRI-like practices in competitive environments, setting the groundwork to provide tailored recommendations. Four main barriers to competitive advantage based on RRI-like practices were identified, as developed in the next sub-sections.

3.1.3.1. Obstacles in the innovation process

Engaging in RRI-like practices poses certain obstacles to the development of competitive research and innovation, particularly in later stages of commercial innovation where time-to-market is crucial for the development of a first mover advantage. Engaging in participatory and reflective actions lengthen the innovation process, which might mean losing out the race to other competitors (Auer & Jarmai, 2018). Although such actions also present rewards to competitive advantage, as illustrated in the previous section, these actions also lengthen time-to-market and have an uncertain effect on profits (Chatfield, Iatridis, et al., 2017), while also needing to cope with the differing interests among stakeholders. This is reflected in the words of the interviewee of Company A, in India:

> "*We are more interested in whether it will actually generate revenue and whether it will actually be a successful project. Which requires engineering to come out, equipment to be installed in place, to have them checked and run properly. That's the lengthy process as of now. Then we face hurdles. Some of the projects get delayed or even shelved off because that requisite support from the academia and the engineering communities are not there. I wish that [support] was available so that some more projects could go through, but it's okay. It's how things are*".

In addition, incorporating RRI concerns in the research and innovation process calls for the development of additional capabilities and sometimes personnel, which implies a large organizational change and financial effort, particularly in small organizations (Auer & Jarmai, 2018). In addition, as discussed above, the introduction of further checkpoints and social and ethical criteria by which the research and innovation processes might be stopped, reduces the probability of innovation, because of reduced serendipity and anticipatory processes that cannot account for full information – this is particularly true for small organizations with limited funding, as noted by the start-up Company F:

> "*We're a small company so we don't have limitless money to do limitless research so we have to think properly about what kind of controls we can take. If you do research you have to have an experimental group and a control group, for instance*".

As a consequence, fewer options will be explored in a fully fleshed-out innovation processes, resulting in potential losses not only for industry actors – as noted by Company A-, but also for countries (Yang & Han, 2017), or research performing organizations and policy-makers, which might shut programmes

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in response to the concerns of civil society, if fully compliant with RRI principles (Paredes-Frigolett, 2016).

3.1.3.2. Intellectual property issues

Engagement in participatory processes during research and innovation work means bringing in and being transparent with stakeholders about the work being done. However, competitive advantage is often built on information asymmetries; therefore, the risk of information leakage is threatening for company strategy (Blok & Lemmens, 2015). Beyond these risks during the innovation process, intellectual property rights and their management pose many questions in relation to RRI-like practices for research-performing organizations and businesses (Inzelt & Csonka, 2017; Yu, 2016). For example, how is the value created -and the rights over the innovation outcome- equitable shared among the participating stakeholders? As noted by Auer & Jarmai (2018) openness restricts access to the profits derived from innovation; because of the imbalance between the private responsibility for investment and public rewards for such investment.

Open science and existing frameworks of intellectual property protection present seemingly contradictory objectives. While opening science and innovation processes would imply a significant progress (as it has been paradigmatically signified in the scientific response to COVID-19), the incentives for innovation lie on the development of proprietary technologies; hence being fully transparent about research and innovation processes and outcomes implies a trade-off between the private and public good. However, keeping research processes closed is sometimes even built in regulatory frameworks, as noted for the case of biotechnology by Company F:

> "*I just can tell from our experience that, of course, with competitors we cannot even legally often share all our information, which would be in a way will be better because then at least we don't do the double amount of work*".

As suggested by Yu (2016) the implementation of adequate governance mechanisms in which the public good is more clearly operationalized, should have a positive impact on the resistance based on intellectual property rights.

3.1.3.3. Lack of consumer awareness

While by integrating stakeholder needs, RRI-like practices drive a competitive advantage and sustain reputational effects, the lack of consumer awareness of RRI-like practices and their impact on society limits market demand for innovations developed under these principles. First, consumers do not always have sufficient knowledge of what RRI-like practices entail; and second, even when they do, organizations lack the resources to communicate what they are doing in this direction. Regarding consumer awareness, Company E, in Serbia, highlighted the difficulty to market their organic products:

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> "*Here the awareness about the organic and good food and everything is much lower than in the West. All that makes our life really, extremely difficult*".

Even outside consumer markets, when customers are more educated about the topic, the lack of appropriate incentives prevents the development of a competitive advantage based on RRI, as noted by Company D in relation to public procurement in Malawi:

> "*Meaning we'll not be making money through [previous service] anymore. I foresee that there might be resistance to it. Because the incentives within the political economy is that when we do mapping, we make money. That's the incentive. That is only one challenge that every innovation has to face* ".

To this extent, certification and the use of standards have been proposed as incentives for engagement and public awareness (Gurzawska et al., 2017).

3.1.3.4. Barriers derived from the institutional environment

Some additional barriers are related to the institutional environment that businesses operate in. access to workforce in order to adhere to RRI-like practices sometimes poses a barrier to competitive advantage, as a consequence of not being able to hire the most readily available workforce. This varies from region to region; for example, the lack of sufficient qualified female research and innovation workers was noted as a significant barrier for SMEs in the European health industry (Auer & Jarmai, 2018), while in the case of Company A, based in India, their choice to hire locals to support development in rural areas implied additional investments in training of their workforce:

> "*The local community may not be - may not find the right talent, we may not find the right fit for the organization and what kind of engineers, what kind of managers we require. But we are ready to take that. What should I say? Take that baton. Through community development programs which are at various levels, we start inducting people, develop them over the years. We pay on the short-term, we pay for that*".

An underlying issue derived from the institutional environment is that, beyond and within the RRI discourse, at macro level, evaluations of 'success' are still made in economic terms (for instance, gross domestic product), which does not account for or reward trade-offs between the protection of the public good and economic gain in policy-making (Saille, 2015) or the inclusion of non-economic objectives in business (Inzelt & Csonka, 2017). In addition, local regulatory frameworks and policies often interfere with the development of competitive advantage based on RRI-like practices, as noted for the case of ICT governance in Malawi by Company C:

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> "*ICT is not prioritized here in Malawi as a country. We are yet to do a lot of things or we are yet to compete like internationally in terms of our IT or ICT governance issues. Unless if all those are put in place and well implemented and we prioritize the ICT sector, things might not improve in Malawi*".

These issues in institutional environment show the importance of developing measures that include competitive advantage in the development of RRI.

3.1.4. Summary and implications

In trying to find out what drives or hinders the development of competitive advantage based on RRI-like practices, five main drivers that were applicable both at the macro and micro levels were identified: avoiding uncompetitive regulation, social acceptance, incorporating stakeholder needs and tapping onto new markets, increasing the efficiency of the innovation process, and reputational effects. At the micro level, it was observed that these drivers are sustained by both direct and indirect effects on sales and performance, since some of them are directly related to bringing an improved product to the market (hence directly impacting on sales) while others are mediated by reputational effects or by gaining wider acceptability of the product or service (which will only on a second instance impact on the sales and the economic performance of the company). At the macro level, contextual aspects gained more importance, such as avoiding uncompetitive regulation (which would affect a whole domain in the territory where the legislation is applicable) or increasing societal acceptance and reducing public outcry. These drivers affect whole markets, and players other than the economic actors can play an important and relevant role in developing this background conditions.

When it comes to barriers, it was found that some of them are related to the innovation process itself, and therefore are mainly considered at the micro level of competitive advantage. For instance, the obstacles found in terms of lengthening the innovation process or intellectual property issues, which might affect some sectors more than others (in particular, those who rely heavily on the protection of intellectual property, such as pharmaceutical companies). In contrast, other domains that have more frequently engaged in open innovation processes (such as ICT) would be less affected by these. The effect of the institutional environment played a very relevant role, indicating how contextual factors might be a driver or barrier for competitive advantage based on RRI-like practices. This is particularly relevant in the analysis of RRI-like practices in regions other than Europe, since the traditional RRI frameworks are embedded in the European context, with an established baseline of protection of individual rights, democratic principles and a market economy that are not necessarily found in other regions.

Indeed, certain factors can play as both drivers and obstacles. For instance, social awareness of socio-ethical issues on a certain topic may reflect positively on the reputation of actors that act to adequately manage these concerns, which is relevant in the case of widely discussed technologies that take a central role in the public debate. However, the lack of consumer awareness and the lack of involvement of the public plays against actors who have engaged further in participatory or reflective process (hence lengthening the time to market) while not obtaining an improved customer or market performance. This is also the case about the possibility of improving the efficiency of the innovation

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process, by halting research and innovation processes that won't reach a good degree of social acceptance (and market share) early on in the process. This also reduces serendipity and the possibility of developing innovation based on technologies originally designed for other purposes which could also have beneficial effects for society and for the development of a competitive advantage. These show that drivers and barriers vary based on domain and local context and need to be analysed taking into consideration the existing institutional frameworks and local societal concerns in order to adapt practices for the development of a competitive advantage.

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3.2. Survey on RRI attitudes and engagement and their relationship to competitive advantage

The survey had a two-fold objective by design: first, to gain a view of the state-of-the-art in different regions, and understand which RRI-like practices were considered to be of utmost importance in each of the regions for different stakeholders; and second, to assess whether RRI-like practices lead to competitive advantage. These two issues are presented sequentially below.

3.2.1. RRI-like practices: attitudes and engagement in different regions

First, the results of the survey regarding the practice of RRI and RRI-like activities are presented. Two general trends may be observed: first, while attitudes towards underlying values are mostly uncontested (with the majority of respondents agreeing, albeit to different extents, to the reference statements), there is a significant attitude-behaviour gap. That is, agreeing to the value does not immediately mean that it is taken into actual RRI-like practices. Second, although there are some differences among regions – which are discussed in detail in the following subsections – there isn't great variation from one region to another.

For each of the practices, both attitude and activity were measured, following the next scheme: 1) attitude (importance of underlying value of the RRI-like practice in research and innovation); 2) engagement in the RRI-like practices; and 3) selection of RRI-like practices responding to each of the values. The results are offered for the whole sample and disaggregated by region.

3.2.1.1. Diversity

The first RRI-like practice evaluated was the inclusion of diverse perspectives in the research and innovation process. For the whole sample, 95 % of the respondents agreed, to a different extent, that including diverse perspectives is important in research and innovation, as illustrated in Figure 8.

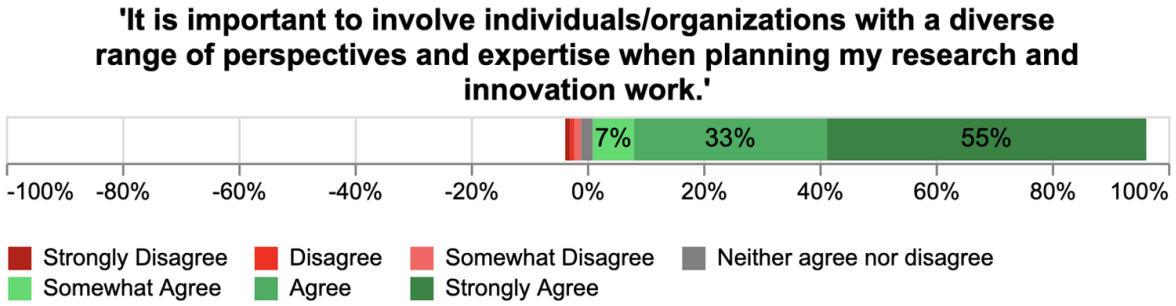

Figure 8. Attitudes towards diversity in research and innovation, for all regions

As observed in Table 9, this is the general trend for all regions; however, some regions place more emphasis on diversity as a value in research and innovation. For instance, in Sub-Saharan Africa 70.2%

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strongly agreed with the statement, in contrast with the lower levels of strong agreement in the other regions. For the rest, high levels of agreement are widespread in all regions, with the lowest level of agreement in Asia and the Pacific.

Table 9. Attitudes towards diversity in research and innovation, disaggregated by region

	All regions	**Arab States**	**Asia & the Pacific**	**Europe & North America**	**Latin America & the Caribbean**	**Sub-Saharan Africa**
Strongly Disagree	0.9%	0.0%	1.1%	0.4%	3.2%	1.9%
Disagree	0.7%	0.0%	0.0%	0.8%	0.0%	0.0%
Somewhat Disagree	1.1%	0.0%	1.1%	1.2%	0.0%	1.0%
Neither agree nor disagree	2.0%	0.0%	5.7%	1.2%	0.0%	1.0%
Somewhat Agree	7.0%	6.8%	8.0%	7.5%	6.5%	2.9%
Agree	33.2%	43.2%	35.2%	35.3%	38.7%	23.1%
Strongly Agree	55.0%	50.0%	48.9%	53.5%	51.6%	70.2%

When it comes to engagement in practices leading to the inclusion of diverse perspectives in research and innovation, we observe a significant attitude-behaviour gap: while 95% of respondents agreed to their importance, only 56% of the respondents engaged with these practices regularly (frequently, usually or always), while 42% engaged in such practices occasionally or sometimes (see Figure 9).

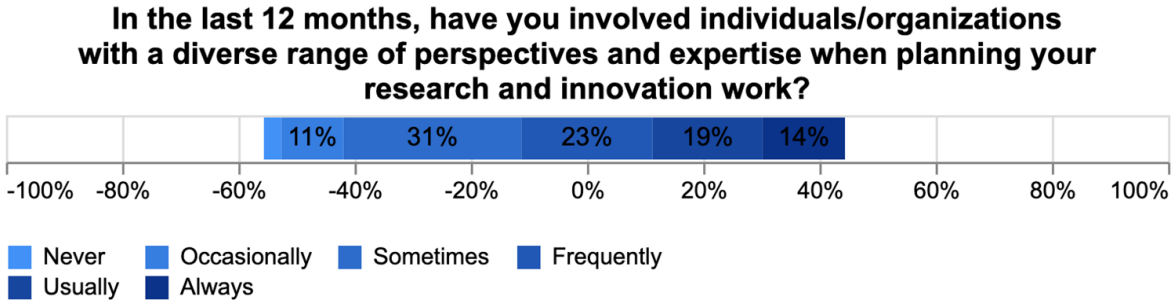

Figure 9. Frequency of engagement in diversity related RRI-like practices, for all regions

The attitude-behaviour gap, as observed in Table 10, is particularly pronounced for Sub-Saharan Africa, and the least for Latin America & the Caribbean (where all the respondents reported to involve diverse perspectives at least occasionally, as in the Arab States). The most frequent response for all regions was that they involved diverse perspectives 'sometimes', despite placing strong importance for diversity in research perspective at the level of attitudes.

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Table 10. Frequency of engagement in diversity related RRI-like practices, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Never	3.0%	0.0%	1.1%	3.8%	0.0%	2.8%
Occasionally	10.7%	4.3%	11.5%	9.7%	11.8%	14.2%
Sometimes	30.6%	34.0%	37.9%	23.6%	23.5%	24.5%
Frequently	22.6%	25.5%	25.3%	22.8%	23.5%	24.5%
Usually	18.9%	21.3%	12.6%	23.2%	17.6%	15.1%
Always	14.2%	14.9%	11.5%	16.9%	23.5%	18.9%

Among those who engaged in diversity oriented RRI-like practices, at the global level, working with individuals or organizations with similar values was the most frequent practice, while consulting individuals or organizations for idea development or during the research and innovation processes were also frequently applied (Figure 10). As a significant note, despite the importance placed on the inclusion of diverse perspectives collaboration or consultation with individuals or organization with opposing values seldom occurs; hence the dialogue space remains fairly limited across regions.

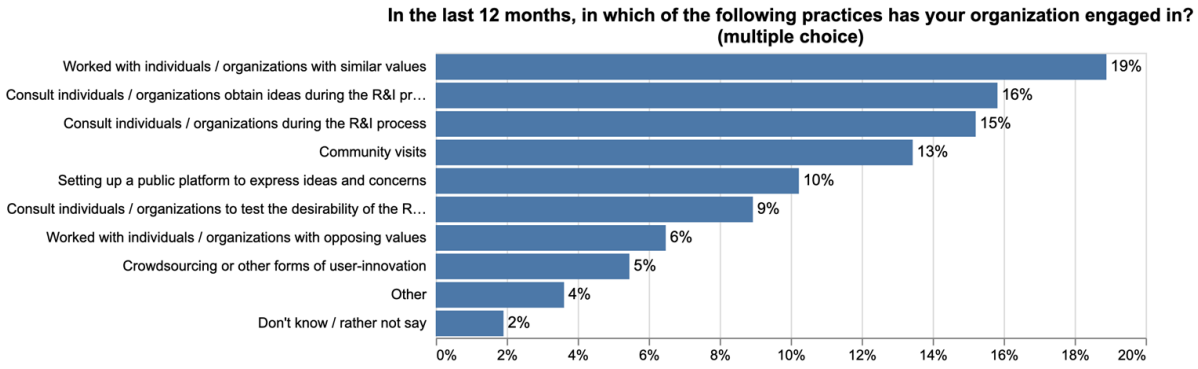

Figure 10. Detail of engagement in RRI-like practices towards diversity, for all regions

However, the choice of practices towards the inclusion of the diversity in the research and innovation process varies significantly across regions: although diversity is an important value in all regions at the attitude level, the actual practices to reflect that in the research and innovation process vary, as noted in Table 11. For example, community visits are a frequent practice in Latin America & the Caribbean and Sub-Saharan Africa, while ranking only fourth in Asia & the Pacific, the Arab States and Europe and North America. This shows more focus placed on the community, rather than the consultation of individuals or organizations that is more prevalent in other regions. Although crowdsourcing is not a widespread practice in any of the regions, the degree of engagement in this practice almost doubles is Latin America & the Caribbean, as compared to other regions.

Table 11. Detail of engagement in RRI-like practices towards diversity, disaggregated by region

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 788503.

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Worked with individuals / organizations with similar values	18.9%	20.1%	18.0%	18.7%	19.8%	17.1%
Consult individuals / organizations obtain ideas during the R&I process	15.8%	15.2%	14.5%	16.9%	15.7%	14.0%
Consult individuals / organizations during the R&I process	15.2%	15.2%	16.7%	15.4%	9.1%	14.2%
Community visits	13.4%	11.6%	14.1%	11.5%	14.9%	16.1%
Setting up a public platform to express ideas and concerns	10.2%	11.0%	12.2%	8.3%	9.1%	14.2%
Consult individuals / organizations to test the desirability of the R&I results	8.9%	8.5%	8.7%	9.3%	8.3%	9.6%
Worked with individuals / organizations with opposing values	6.5%	6.7%	5.1%	7.3%	5.8%	5.8%
Crowdsourcing or other forms of user-innovation	5.5%	6.7%	5.5%	6.0%	10.7%	5.8%
Other	3.6%	3.0%	3.2%	4.5%	3.3%	1.9%
Don't know / rather not say	1.9%	1.8%	1.9%	2.2%	3.3%	1.2%

3.2.1.2. Gender equality

While the levels of agreement are very high at the attitude level for the promotion of gender equality (88%, to different extents), they are not as high as for the inclusion of diverse perspectives, in general (see Figure 11). A significant percentage (10%) is in the grey area of neither agreement nor disagreement, the second highest percentage at this level at the attitude level for any of the values analysed (only after the inclusion of ethnic minorities, another aspect of diversity).

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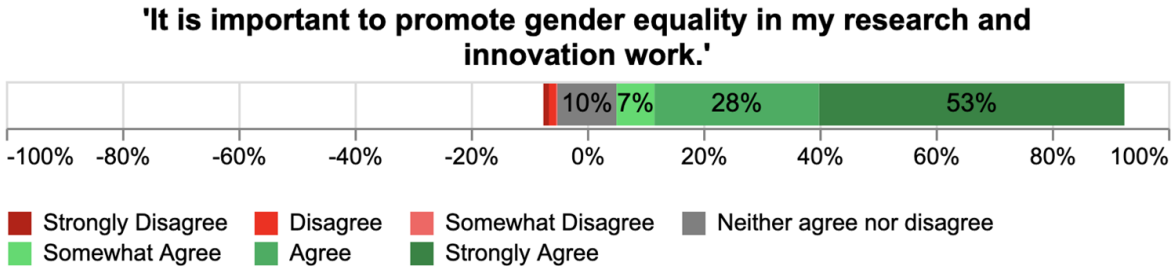

Figure 11. Attitudes towards the promotion of gender equality, for all regions

When analysed region by region, as for diversity, Sub-Saharan Africa stands out for the high level of strong agreement (70%) and agreement to different extents (95%). The levels of disagreement are generally low (although 5 % the respondents of Asia & the Pacific expressed disagreement of the promotion of gender equality in their research and innovation work as compared to 0% in Sub-Saharan Africa). The levels of indifference towards the promotion of gender equality in research and innovation work are also quite varied, ranging from 5% in Sub-Saharan Africa to 16.7% in the Arab States (see Table 12).

Table 12. Attitudes towards the promotion of gender equality, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Strongly Disagree	1.0%	2.4%	2.4%	0.9%	0.0%	0.0%
Disagree	1.2%	0.0%	1.2%	1.3%	2.8%	0.0%
Somewhat Disagree	0.2%	0.0%	1.2%	0.0%	0.0%	0.0%
Neither agree nor disagree	10.2%	16.7%	7.1%	12.8%	11.1%	5.0%
Somewhat Agree	6.5%	4.8%	7.1%	7.5%	0.0%	2.0%
Agree	28.3%	26.2%	35.7%	25.6%	30.6%	23.0%
Strongly Agree	52.5%	50.0%	45.2%	52.0%	55.6%	70.0%

The attitude-behaviour gap is not as prominent for the promotion of gender equality as it is for diversity, with 60% of respondents having taken steps in this regard during the last year (Figure 12).

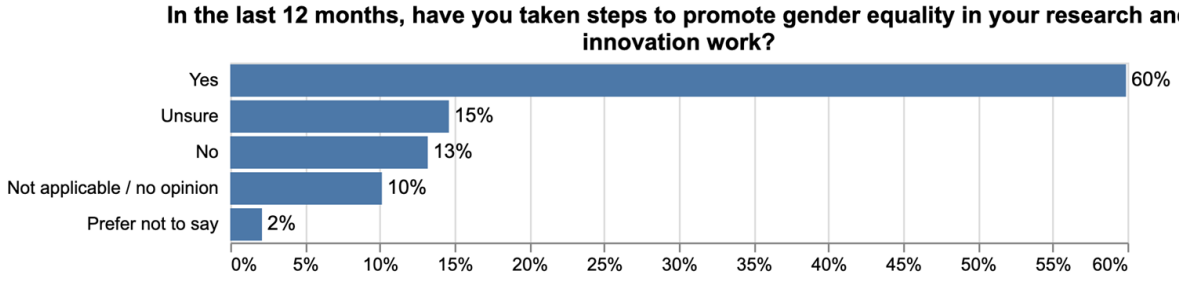

Figure 12. Engagement in the promotion of gender equality in research and innovation work, for all regions

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However, regional differences may also be appreciated when examining actual engagement in the promotion of gender equality. As expected, considering the strong levels of agreement at the attitudinal level, engagement in Sub-Saharan Africa is the highest (76.2%), with a significant difference with the other regions, with the second region with the highest level of engagement being Europe and North America (57%). The largest attitude-behaviour gap is found in Latin America & the Caribbean, where despite high levels of agreement on the importance of the promotion of gender equality (86.2%), only 47.2% of respondents engaged in it in practice. Detail per region may be found in Table 13.

Table 13.Engagement in the promotion of gender equality in research and innovation, disaggregated by region

	All regions	**Arab States**	**Asia & the Pacific**	**Europe & North America**	**Latin America & the Caribbean**	**Sub-Saharan Africa**
Yes	59.9%	55.6%	56.6%	57.0%	47.2%	76.2%
Unsure	14.6%	22.2%	19.3%	14.5%	27.8%	8.9%
No	13.2%	13.3%	10.8%	14.5%	11.1%	6.9%
Not applicable / no opinion	10.1%	8.9%	10.8%	12.3%	13.9%	5.9%
Prefer not to say	2.1%	0.0%	2.4%	1.7%	0.0%	2.0%

Regarding further detail on practices, only a small number of respondents had achieved gender equality on research and innovation teams or decision-making teams (9%), although aiming for such equality were the most frequent actions (21% and 18%, respectively). As illustrated in Figure 13, integrating the gender perspective at the process (17%) and outcome (14%) dimensions were also identified as frequent practices.

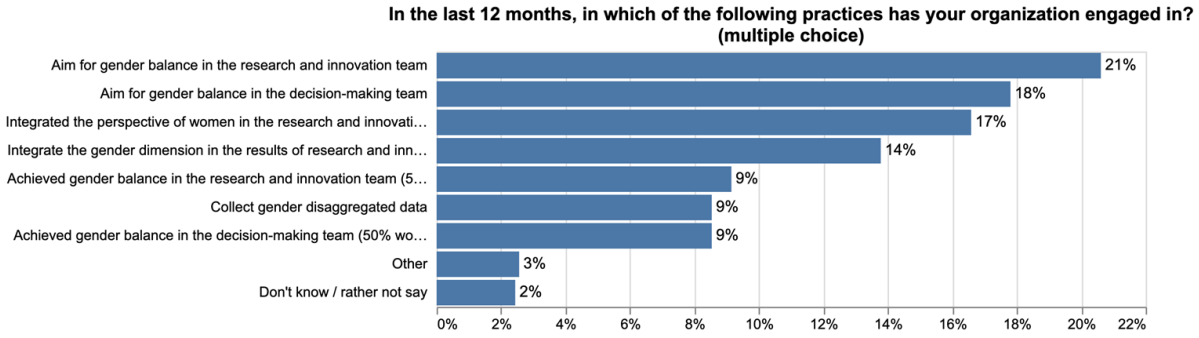

Figure 13. Detail of practices for the promotion of gender equality in research and innovation, for all regions

Disaggregating these results by region shows some differences, collected in Table 14. For example, Europe & North America is the region that ranks the highest in terms of achieving gender equality in

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decision-making teams: 8.9%, vs. 5.4% in the lowest ranked region for this practice, Latin America & the Caribbean. Interestingly, Latin America & the Caribbean is the region where most respondents reported having achieved gender equality in research and innovation teams (12.5%). This seeming contradiction might reflect underlying issues that call for further investigation, such as the fact that access to STEM careers does not determine access to culturally-determined power roles.

Table 14. Detail of practices for the promotion of gender equality in research and innovation, disaggregated by region

	All regions	**Arab States**	**Asia & the Pacific**	**Europe & North America**	**Latin America & the Caribbean**	**Sub-Saharan Africa**
Aim for gender balance in the research and innovation team	20.6%	21.4%	21.4%	20.0%	19.6%	20.3%
Aim for gender balance in the decision-making team	17.8%	17.9%	17.9%	17.6%	14.3%	18.6%
Integrated the perspective of women in the research and innovation process	16.6%	16.7%	19.3%	15.2%	19.6%	17.9%
Integrate the gender dimension in the results of research and innovation	13.8%	16.7%	12.4%	13.0%	14.3%	15.0%
Achieved gender balance in the research and innovation team (50% women or more)	9.1%	10.7%	10.3%	10.4%	12.5%	7.3%
Collect gender disaggregated data	8.5%	7.1%	8.3%	7.7%	8.9%	10.0%
Achieved gender balance in the decision-making team (50% women or more)	8.5%	7.1%	6.2%	8.9%	5.4%	8.6%
Other	2.6%	2.4%	2.1%	3.6%	1.8%	2.0%
Don't know / rather not say	2.4%	0.0%	2.1%	3.6%	3.6%	0.3%

3.2.1.3. Ethnic minorities

Another aspect of diversity worthy of further investigation is the inclusion of ethnic minorities in research and innovation. Although, once again, the levels of agreement with the importance of inclusion of ethnic minorities are high (81%), they are the lowest among the studied value dimensions, and the levels of indifference (neither agree nor disagree) are the highest (15%), as noted in Figure 14.

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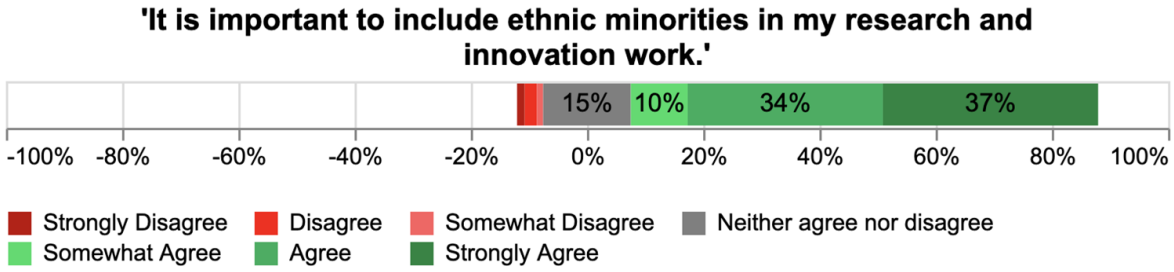

Figure 14. Attitudes towards the inclusion of ethnic minorities in research and innovation, for all regions

Some regional differences may be observed by region (see Table 15). Inclusion of ethnic minorities is given great importance in Latin America & the Caribbean, with 100% of respondents agreeing to its relevance to a varying extent. While the levels of disagreement were almost negligible for other values, they are notable for Asia and the Pacific (5.6%), and the levels of indifference are relatively high, particularly in Europe & North America (17.5%) and, to some extent, in the Arab States (13.5%). The prevalence of ethnic dominant majorities in these regions may explain these levels.

Table 15. Attitudes towards the inclusion of ethnic minorities in research and innovation, disaggregated by region.

	All regions	**Arab States**	**Asia & the Pacific**	**Europe & North America**	**Latin America & the Caribbean**	**Sub-Saharan Africa**
Strongly Disagree	1.3%	2.7%	2.8%	0.5%	0.0%	1.1%
Disagree	2.1%	0.0%	1.4%	1.9%	0.0%	3.3%
Somewhat Disagree	1.1%	0.0%	1.4%	1.4%	0.0%	0.0%
Neither agree nor disagree	15.1%	13.5%	9.9%	17.5%	0.0%	9.8%
Somewhat Agree	9.8%	10.8%	8.5%	10.0%	3.6%	8.7%
Agree	33.6%	35.1%	46.5%	31.3%	60.7%	28.3%
Strongly Agree	37.0%	37.8%	29.6%	37.4%	35.7%	48.9%

Such high levels of indifference towards the inclusion of ethnic minorities is reflected in the levels of actual engagement in practices to include ethnic minorities in research and innovation work, since this category presents the largest attitude-behaviour gap, with only 32% of the respondents having engaged in such practices in the last year (Figure 15).

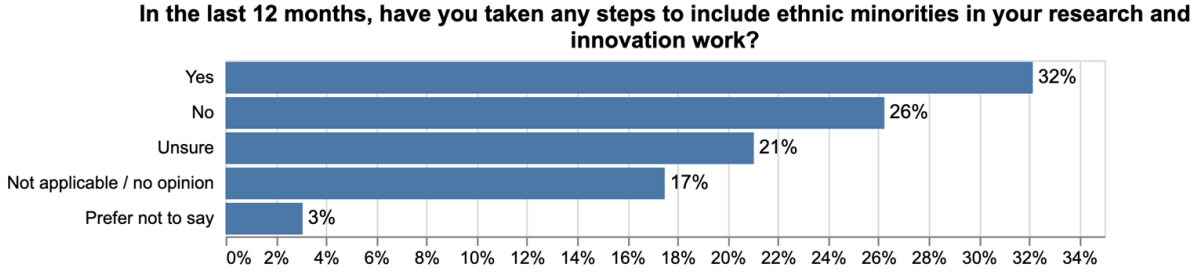

Figure 15. Engagement in practices of inclusion of ethnic minorities in research and innovation, for all regions

When examined by region (see Table 16), there are significant different differences in the level of engagement. While 45.5% of Sub-Saharan respondents had engaged in practices of inclusion of ethnic

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minorities in the past year, just 27.9% of European and North American respondents reported doing so, which is consistent with the reported levels of importance given to the underlying value. A high attitude behaviour gap is identified in Latin America & the Caribbean, where, despite the high levels of importance reported at the attitudinal level, only 38.2% had engaged in practices towards the inclusion of ethnic minorities.

Table 16. Engagement in practices to include ethnic minorities and research and innovation, disaggregated by region

	All regions	**Arab States**	**Asia & the Pacific**	**Europe & North America**	**Latin America & the Caribbean**	**Sub-Saharan Africa**
Yes	32.2%	31.1%	40.2%	27.9%	38.2%	45.5%
No	26.2%	20.0%	15.9	30.5%	20.6%	21.2%
Unsure	21.0%	26.7%	23.2%	20.2%	23.5%	21.2%
Not applicable / no opinion	17.5%	15.6%	15.9%	19.3%	14.7%	10.1%
Prefer not to say	3.1%	6.7%	4.9%	2.1%	2.9%	2.0%

In detailing the practices of inclusion of ethnic minorities in research teams, all the identified practices (see Figure 16) where reported to be practiced to a significant extent.

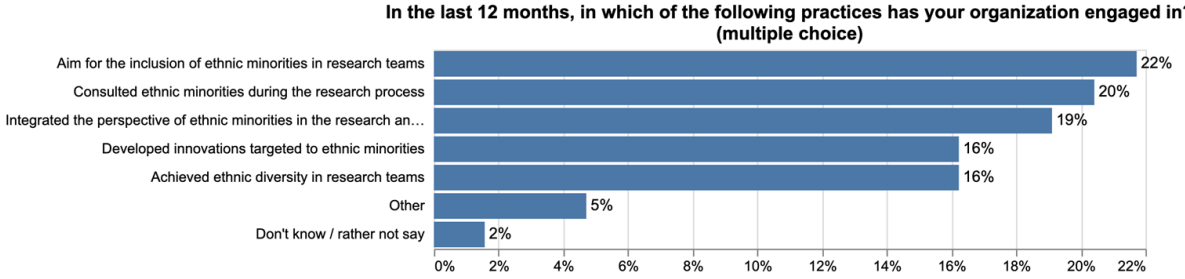

Figure 16. Detail of practices of inclusion of ethnic minorities in research and innovation, for all regions

Also, as noted in Table 17, there was little difference when analysed per region. The focus in the Arab states seems to be placed on the development of inclusion practices in research teams. In Asia and the Pacific, while inclusion in teams is quite developed, the consultation and integration of perspectives is quite relevant as well. In Europe and North America, the focus is placed again on the consultation, integration and inclusion of ethnic minorities, and, significantly, in Sub-Saharan Africa the development of innovations targeted to ethnic minorities is further developed as compared to the other regions. The Arab states and Latin America & the Caribbean were the regions that reported the highest levels of achieved ethnic diversity in research teams.

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Table 17. Detail of practices of inclusion of ethnic minorities in research and innovation, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Aim for the inclusion of ethnic minorities in research teams	21.7%	25.0%	20.5%	22.6%	23.3%	22.6%
Consulted ethnic minorities during the research process	20.4%	20.8%	20.5%	22.0%	18.6%	18.9%
Integrated the perspective of ethnic minorities in the research and innovation process	19.1%	20.8%	20.5%	19.0%	18.6%	19.5%
Developed innovations targeted to ethnic minorities	16.2%	14.6%	15.9%	13.7%	14.0%	18.3%
Achieved ethnic diversity in research teams	16.2%	18.8%	15.9%	14.9%	18.6%	17.1%
Other	4.7%	0.0%	4.5%	6.5%	2.3%	3.7%
Don't know / rather not say	1.6%	0.0%	2.3%	1.2%	4.7%	0.0%

3.2.1.4. Societal risk management

The next two categories are more related to the relationship between research and innovation work and society. The first one, societal benefit, takes a precautionary, risk management approach through which the possible unanticipated consequences of research and innovation for society are taken into consideration. The second one, that is, societal needs, relates to the development of research and innovation work that addresses a societal need or demand.

When it comes to societal benefit (see Figure 17), we can appreciate that the great majority (85%) agree with the importance of ensuring that research and innovation does not cause concern for society. The levels of indifference are low (4.8%); however, it must be noted not this category presents a higher level of disagreement with the reference statement (9.7%) than other dimensions. A possible reason for this is the approach to science and innovation that favors progress knowledge and discoveries over the precautionary principle (van Hove & Wickson, 2017) or social acceptance of research and innovation.

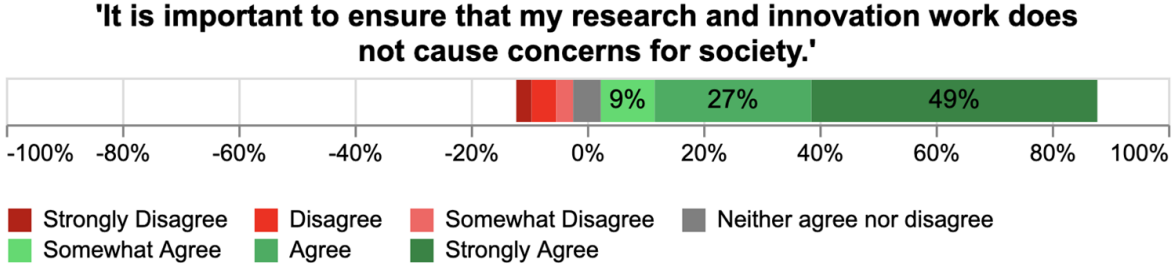

Figure 17. Attitudes towards social risk management in research and innovation, for all regions

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The differences across regions regarding attitudes towards the need for research and innovation to not cause harm for society are visible across regions. Latin America & the Caribbean is the region where the importance of such precautionary approach is more highlighted, with only 3.3% of respondents disagreeing about their relevance, and 3.3% respondents indicating indifference. On the other side of the spectrum, 18.2% of respondents either disagree to various extents or neither agree or disagree in the Arab States, same as about 15% of respondents in Asia & the Pacific and Europe and North America (Table 18).

Table 18. Attitudes towards social risk management in research and innovation, disaggregated by region

	All regions	**Arab States**	**Asia & the Pacific**	**Europe & North America**	**Latin America & the Caribbean**	**Sub-Saharan Africa**
Strongly Disagree	2.6%	3.0%	2.7%	2.9%	0.0%	3.2%
Disagree	4.2%	6.1%	4.1%	2.9%	0.0%	6.4%
Somewhat Disagree	2.9%	3.0%	2.7%	4.3%	3.3%	2.1%
Neither agree nor disagree	4.8%	6.1%	5.5%	4.8%	3.3%	2.1%
Somewhat Agree	9.3%	0.0%	8.2%	12.0%	3.3%	6.4%
Agree	27.0%	24.2%	27.4%	27.8%	26.7%	20.2%
Strongly Agree	49.2%	57.6%	49.3%	45.5%	63.3%	59.6%

When it comes to engagement in practices aiming to prevent causing concerns for society, 60% of respondents confirmed having taken steps in that direction in the past year, which shows a lower attitude-behaviour gap as compared with other values (see Figure 18).

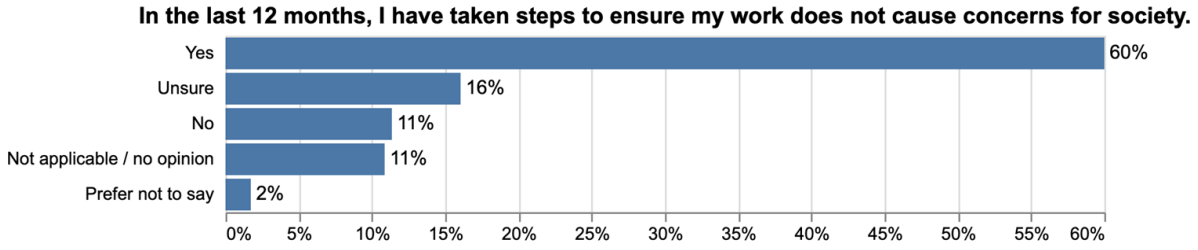

Figure 18. Engagement in practices to avoid societal concerns, for all regions

When examined by region, engagement in such practices is the highest in Latin America & the Caribbean, which is consistent with the high importance given to avoiding societal concerns at the attitude level. The levels of engagement are also relatively high in the Arab States, Asia & the Pacific and Sub-Saharan Africa, showing a lower attitude-behaviour gap. The case of the comparatively low engagement in such practices in Europe & North America is interesting, since it is highest scoring region despite the European Union having strongly promoted RRI and associated practices of management of risks and unanticipated consequences of research and innovation.

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Table 19. Engagement in practices to avoid societal concerns, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Yes	60.0%	61.4%	66.7%	54.3%	67.6%	62.9%
Unsure	16.0%	4.5%	16.0%	17.9%	17.6%	17.5%
No	11.4%	11.4%	6.2%	11.2%	2.9%	13.4%
Not applicable / no opinion	10.9%	18.2%	9.9%	13.9%	11.8%	6.2%
Prefer not to say	1.7%	4.5%	1.2%	2.7%	0.0%	0.0%

Regarding the actual practices in which the respondents engaged (see Figure 19), at the global level anticipatory measures were made, mostly based on designing with social desirability in mind (35%), forecasting through innovation roadmaps (32%) and preventing or mitigating negative impacts (25%).

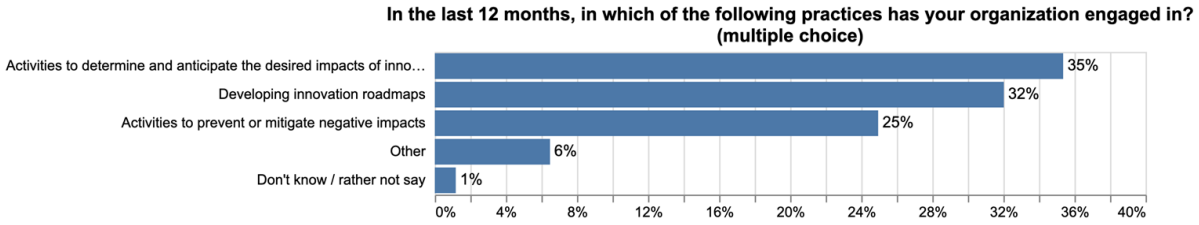

Figure 19. Detail of practices to avoid societal concern, for all regions

As observed in the regional disaggregation in Table 20, there are only small differences in the distribution of these practices across regions, the most visible being the focus in the Arab States and Latin America & the Caribbean on practices related to anticipation, rather than activities to prevent or mitigate the identified negative impacts.

Table 20. Detail of practices to avoid societal concern, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Activities to determine and anticipate the desired impacts of innovation	35.4%	39.9%	35.0%	33.8%	38.5%	34.6%
Developing innovation roadmaps	32.0%	37.5%	32.0%	32.0%	33.3%	33.1%
Activities to prevent or mitigate negative impacts	25.0%	17.9%	22.3%	27.9%	15.4%	23.5%
Other	6.5%	3.6%	9.7%	5.9%	7.7%	8.1%
Don't know / rather not say	1.2%	1.8%	1.0%	0.4%	5.1%	0.7%

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3.2.1.5. Societal needs

This outcome oriented dimension of RRI-like practices refers to the orientation of research and innovation practices towards addressing societal needs. The importance of such objective was almost undisputed among the respondents, with almost 96% agreeing, to different degrees (Figure 20).

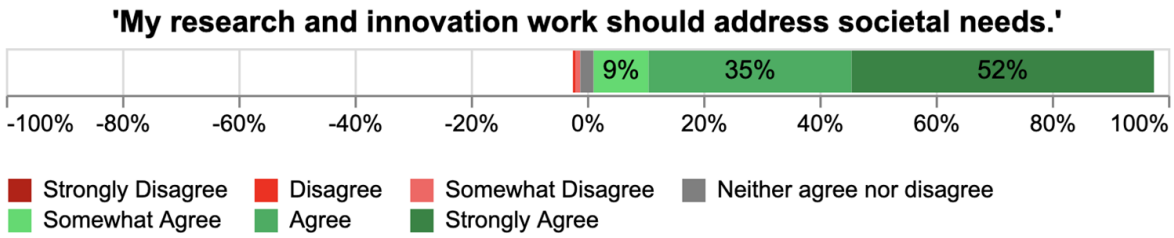

Figure 20. Attitudes towards orienting research and innovation towards societal needs, for all regions

This degree of agreement on the importance is, overall, shared across regions (see Table 21); however, the strength of the importance given to this is Sub-Saharan Africa should be stressed, with 69.2% of respondents strongly agreeing to the reference statement. A very low degree of disagreement could be identified in Asia & the Pacific and Europe & North America, to almost negligible percentages, but notable when compared with the 0% disagreement in the Arab States, Latin America & the Caribbean and Sub-Saharan Africa.

Table 21. Attitudes towards orienting research and innovation towards societal needs, disaggregated by region

	All regions	**Arab States**	**Asia & the Pacific**	**Europe & North America**	**Latin America & the Caribbean**	**Sub-Saharan Africa**
Strongly Disagree	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Disagree	0.5%	0.0%	1.4%	0.5%	0.0%	0.0%
Somewhat Disagree	0.8%	0.0%	1.4%	1.4%	0.0%	0.0%
Neither agree nor disagree	2.3%	4.7%	2.7%	2.7%	6.5%	0.0%
Somewhat Agree	9.4%	4.7%	6.8%	10.0%	6.5%	5.5%
Agree	34.9%	32.6%	35.1%	39.4%	45.2%	25.3%
Strongly Agree	52.0%	58.1%	52.7%	46.2%	41.9%	69.2%

When it comes to engagement in practices to ensure that research and innovation work addresses societal needs, 78% of respondents worldwide reported having taken steps in the last year (see Figure 21), showing a low attitude-behaviour gap. It is notable, based on such degree of engagement, that outcome-oriented frameworks (such sustainability-oriented innovation, inclusive innovation and others) have permeated research and innovation globally to a greater extent that frameworks combining procedural and outcome dimensions such as RRI (Adams et al., 2016; Timmermans, 2017).

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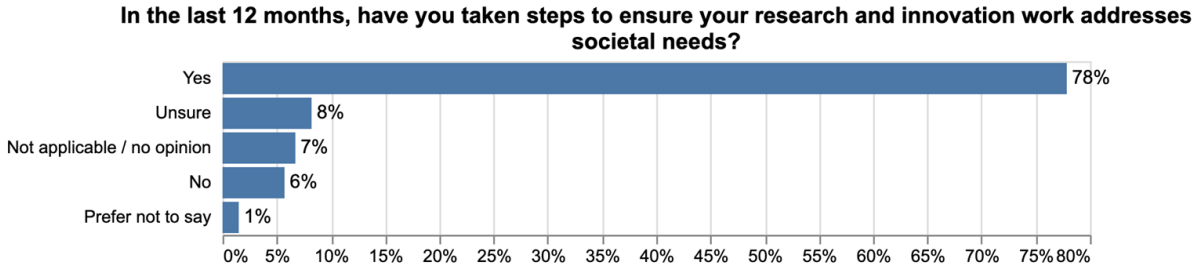

Figure 21. Engagement in practices oriented to addressing societal needs through research and innovation, for all regions

The examination of the data in a regionally disaggregated manner reveals how, despite engagement in practices towards addressing societal needs is high across regions, regions with more countries in development show higher levels of engagement in such outcome oriented measures; particularly in the case of the Arab States and Sub-Saharan Africa (see Table 22). In those areas, research and innovation efforts seem to be more strategically placed towards addressing societal needs.

Table 22. Engagement in practices towards addressing societal needs in research and innovation, disaggregated by region

	All regions	**Arab States**	**Asia & the Pacific**	**Europe & North America**	**Latin America & the Caribbean**	**Sub-Saharan Africa**
Yes	77.9%	86.7%	79.2%	73.5%	78.1%	86.2%
Unsure	8.2%	2.2%	6.5%	10.2%	6.2%	7.4%
Not applicable / no opinion	6.7%	4.4%	7.8%	8.4%	6.2%	3.2%
No	5.7%	6.7%	6.5%	7.1%	6.2%	1.1%
Prefer not to say	1.5%	0.0%	0.0%	0.9%	3.1%	2.1%

Looking at the detail of such practices, addressing social (27%), environmental (27%) or economic (24%) problems are the most widespread practices worldwide, while the development of research and innovation practices that directly benefit disadvantaged groups is also a relevant practice (Figure 22).

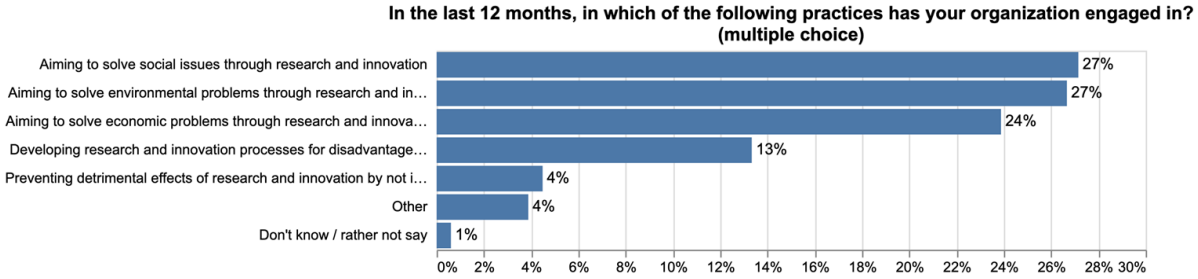

Figure 22. Detail of practices oriented to addressing societal needs through research and innovation, for all regions

By region, changes in societal priorities led to favouring certain practices over others: while aiming to addressing environmental problems is the most applied practice in the Arab States and Latin America & the Caribbean, social issues are the focus in Europe & North America. The development of research

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and innovation processes targeted at disadvantaged groups is more frequent in Sub-Saharan Africa and Latin America & the Caribbean.

Table 23. Detail of practices oriented to addressing societal needs through research and innovation, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Aiming to solve social issues through research and innovation	27.2%	24.7%	24.2%	28.3%	22.6%	26.5%
Aiming to solve environmental problems through research and innovation	26.7%	30.1%	26.1%	26.5%	32.3%	25.7%
Aiming to solve economic problems through research and innovation	23.9%	24.7%	25.5%	23.5%	21.0%	24.1%
Developing research and innovation processes for disadvantaged groups	13.3%	10.8%	13.0%	13.8%	14.5%	15.7%
Preventing detrimental effects of research and innovation by not introducing it to the market	4.5%	5.4%	4.3%	3.4%	4.8%	5.6%
Other	3.9%	3.2%	0.0%	4.3%	4.8%	1.6%
Don't know / rather not say	0.6%	1.1%	0.6%	0.2%	0.0%	0.8%

3.2.1.6. Open and transparent methods and processes

Along with the outcome dimensions, the engagement in open and transparent methods and processes was also evaluated as a procedural dimension. The importance of the development of research and innovation processes under these principles, again, was almost uncontested (Figure 23).

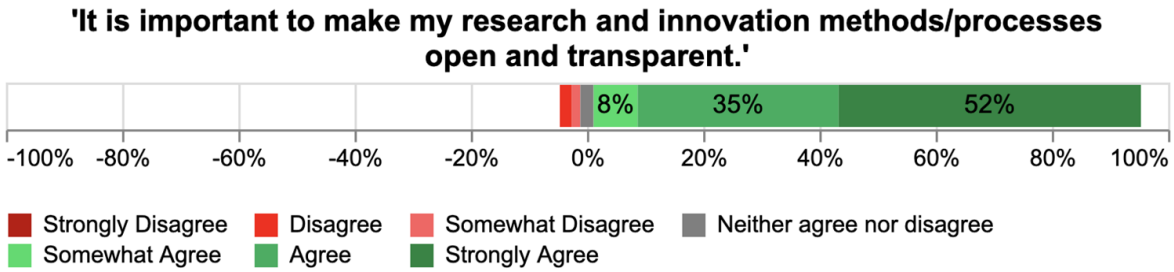

Figure 23. Attitudes towards open and transparent research and innovation methods and processes, for all regions

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Overall, there are no major differences across regions, except for Sub-Saharan Africa, which stands out on the importance provided to openness and transparency in Sub-Saharan Africa, alongside, to a lesser extent, Latin America & the Caribbean.

Table 24. Attitudes towards open and transparent research and innovation methods and processes, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Strongly Disagree	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Disagree	2.0%	2.4%	2.7%	1.8%	0.0%	2.2%
Somewhat Disagree	1.5%	0.0%	1.4%	1.8%	0.0%	1.1%
Neither agree nor disagree	2.3%	0.0%	2.7%	2.3%	3.4%	2.2%
Somewhat Agree	7.6%	11.9%	6.8%	6.8%	0.0%	6.5%
Agree	34.6%	40.5%	38.4%	37.9%	41.4%	28.0%
Strongly Agree	52.0%	45.2%	47.9%	49.3%	55.2%	60.2%

In the case of open and transparent methods and processes, the attitude behaviour gap does exist, but is not as large as for other dimensions, with 72% of respondents worldwide having engaged in such practices in the previous year (Figure 24).

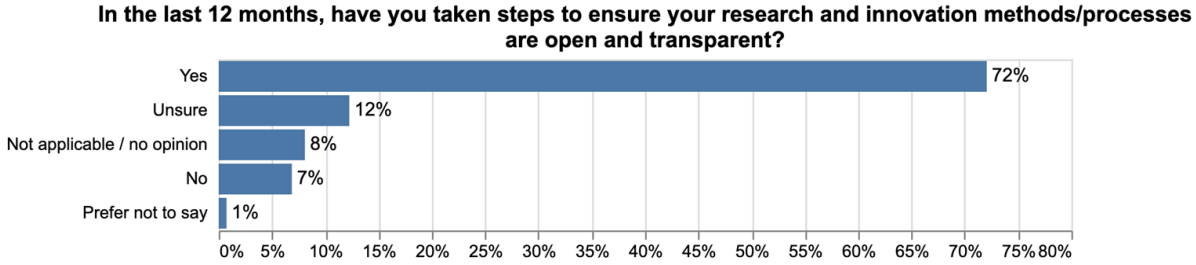

Figure 24. Engagement in openness and transparency methods and processes, for all regions

As observed in Table 25, the degree of engagement across regions varies, though. The attitude-behaviour gap widens or narrows depending on the region. Latin America & the Caribbean and the Arab States stand out for their high levels of engagement in practices leading to open and transparent methods and processes in research and innovation, with over 80%, with Sub-Saharan Africa coming close. Europe & North America and Asia & the Pacific rank the lowest; which might have to do with customary practices in intellectual proprietary rights (the top 10% patent offices (in terms of number of patents) are either in Asia & the Pacific, or Europe and North America).

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Table 25. Engagement in openness and transparency methods and processes, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Yes	72.1%	80.0%	72.7%	70.7%	81.2%	76.3%
Unsure	12.3%	8.9%	14.3%	12.9%	6.2%	9.3%
Not applicable / no opinion	8.1%	6.7%	6.5%	10.7%	9.4%	3.1%
No	6.9%	2.2%	6.5%	4.9%	3.1%	11.3%
Prefer not to say	0.7%	2.2%	0.0%	0.9%	0.0%	0.0%

Looking further into detailed practices, as observed in Figure 25, information exchange and dissemination related practices are the most applied globally in terms of ensuring open and transparent methods and practices. More collaborative approaches such as co-creation, open code and crowdsourcing are deployed less often.

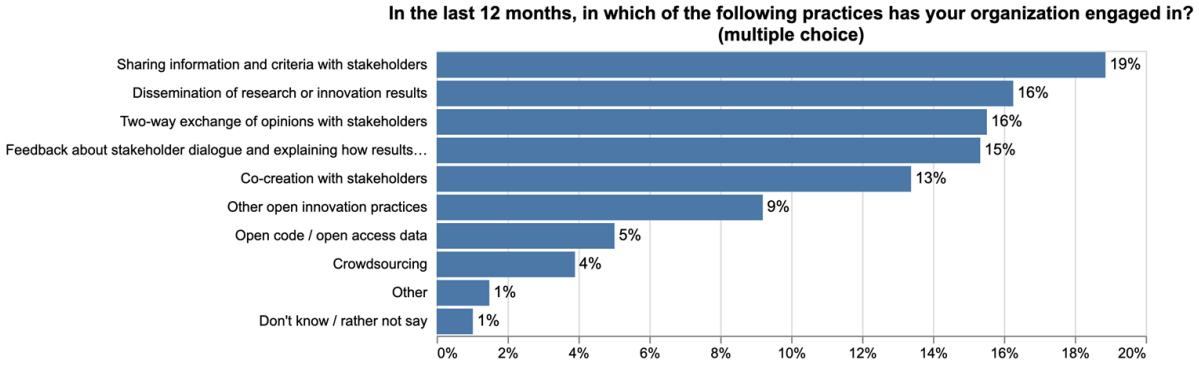

Figure 25. Detail of practices towards open and transparent methods and processes, for all regions

The observation of these practices in detail by region shows interesting results (see Table 26). Although the number of organizations involved in open and transparent methods and processes is lower in Europe and North America, the collaboration practices are deeper, with co-creation, andsharing of information and criteria with stakeholders being more prevalent than in other regions. Open code and open data are more prevalent in Latin America & the Caribbean, at a rate of double the global average.

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Table 26. Detail of practices towards open and transparent methods and processes, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Sharing information and criteria with stakeholders	18.9%	19.0%	17.6%	18.9%	15.7%	17.9%
Dissemination of research or innovation results	16.3%	15.5%	16.1%	16.3%	16.9%	15.2%
Two-way exchange of opinions with stakeholders	15.5%	17.2%	17.1%	14.6%	12.4%	15.5%
Feedback about stakeholder dialogue and explaining how results are integrated in research or innovation	15.3%	16.4%	14.6%	15.0%	12.4%	15.2%
Co-creation with stakeholders	13.4%	12.1%	12.6%	14.1%	13.5%	13.4%
Other open innovation practices	9.2%	8.6%	10.1%	9.4%	11.2%	10.0%
Open code / open access data	5.0%	6.0%	5.5%	5.7%	10.1%	4.8%
Crowdsourcing	3.9%	4.3%	3.5%	3.3%	3.4%	6.2%
Other	1.5%	0.9%	1.5%	1.5%	3.4%	1.0%
Don't know / rather not say	1.0%	0.0%	1.5%	1.2%	1.1%	0.7%

3.2.1.7. Ethics

The last of the categories analysed is related to the inclusion of ethical principles in research and innovation. As noted in Figure 26, 95% of the respondents globally agreed, to a varying extent, that ethical principles guide their research and innovation work (which is a cross-cutting dimension).

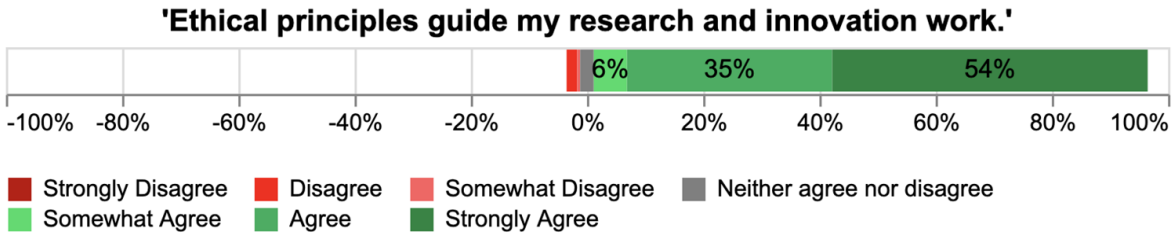

Figure 26. Attitudes towards ethics in research and innovation, for all regions

While very high levels of agreement with the reference statement are common across regions, the degree of agreement is stronger in Latin America & the Caribbean and Sub-Saharan Africa (see Table 27).

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Table 27. Attitudes towards ethics in research and innovation, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Strongly Disagree	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Disagree	1.8%	0.0%	4.1%	0.9%	0.0%	2.2%
Somewhat Disagree	0.5%	0.0%	0.0%	0.9%	0.0%	0.0%
Neither agree nor disagree	2.3%	0.0%	4.1%	3.3%	0.0%	0.0%
Somewhat Agree	5.7%	17.9%	5.5%	4.7%	7.1%	3.4%
Agree	35.3%	35.9%	38.4%	38.1%	28.6%	25.8%
Strongly Agree	54.3%	46.2%	47.9%	52.1%	64.3%	68.5%

As collected in Figure 27, the attitude-behaviour gap for the ethical dimension was not wide compared to other analysed dimensions, with 75% of respondents worldwide reporting having taken steps in that direction in the last year (and 7% reporting they did not).

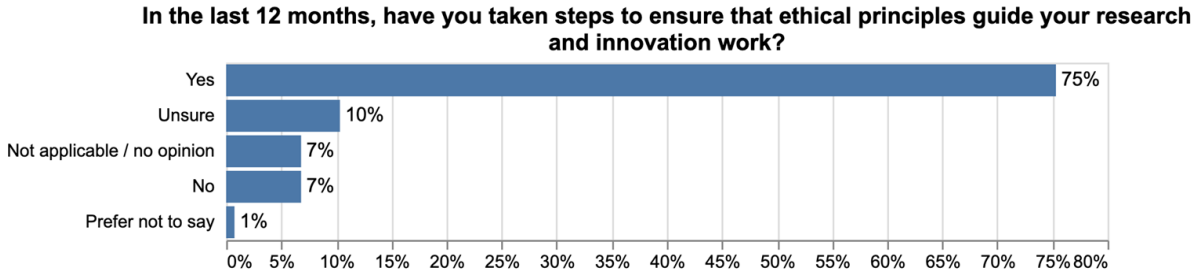

Figure 27. Engagement in practices to introduced ethical principles in research and innovation, for all regions

When analysed by region, Table 28 shows that the Sub-Saharan Africa stands out for degree of engagement in practices leading to the inclusion of ethical principles in research and innovation, but other than this, there were not many differences, with these percentages ranging from 70.5% in the Arab States and 77.4% in Latin America & the Caribbean.

Table 28. Engagement in practices to introduced ethical principles in research and innovation, disaggregated by region

	All regions	Arab States	Asia & the Pacific	Europe & North America	Latin America & the Caribbean	Sub-Saharan Africa
Yes	75.3%	70.5%	75.3%	73.1%	77.4%	87.2%
Unsure	10.3%	11.4%	11.7%	10.8%	9.7%	2.1%
Not applicable / no opinion	6.8%	13.6%	5.2%	9.4%	9.7%	5.3%
No	6.8%	2.3%	7.8%	6.3%	3.2%	5.3%
Prefer not to say	0.8%	2.3%	0.0%	0.4%	0.0%	0.0%

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Looking in detail at the practices reported on including ethical principles in research and innovation work, there is wide variation, from own personal evaluation and reflection, to including formal evaluations at the organizational level and becoming aware of biases and the function and role of the individual and the organization in society, as illustrated in Figure 28.

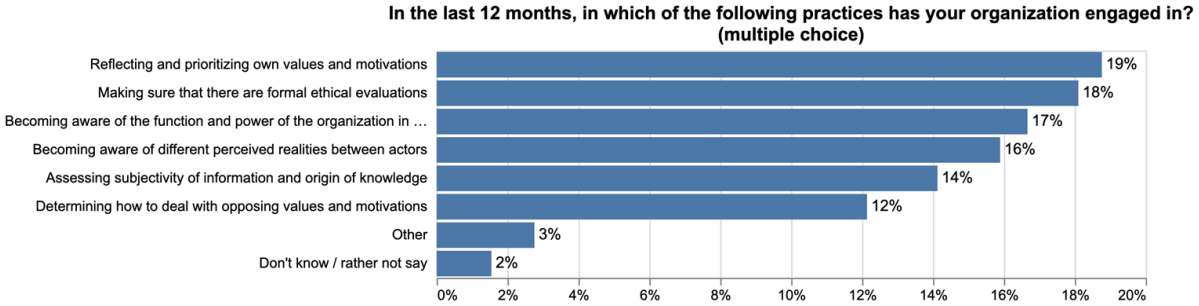

Figure 28. Detail of practices to introduced ethical principles in research and innovation, for all regions

Some regional differences may also be observed (see Table 29), although the results are fairly similar across regions. Some notable differences are the fact thatrelational reflexivity practice is more prevalent in Latin American & the Caribbean, while becoming aware of the function and power of the organization in society, more related to reflecting about power balances, is more prevalent in the Arab States and Sub-Saharan Africa.

Table 29. Detail of practices to introduced ethical principles in research and innovation, disaggregated by region

	All regions	**Arab States**	**Asia & the Pacific**	**Europe & North America**	**Latin America & the Caribbean**	**Sub-Saharan Africa**
Reflecting and prioritizing own values and motivations	18.8%	20.8%	18.5%	21.2%	14.1%	14.9%
Making sure that there are formal ethical evaluations	18.1%	18.2%	17.4%	17.5%	19.4%	19.8%
Becoming aware of the function and power of the organization in society	16.7%	19.5%	15.7%	14.3%	16.1%	19.1%
Becoming aware of different perceived realities between actors	15.9%	13.0%	16.9%	16.6%	19.4%	16.0%
Assessing subjectivity of information and origin of knowledge	14.1%	13.0%	15.2%	13.9%	11.3%	13.2%
Determining how to deal with opposing values and motivations	12.1%	14.3%	11.8%	11.4%	9.7%	14.9%
Other	2.8%	0.0%	1.7%	3.3%	3.2%	1.7%
Don't know / rather not say	1.5%	1.3%	2.8%	1.7%	6.5%	1.0%

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3.2.2. Analysing relationships between RRI-like practices and competitive advantage

An analysis of the correlations between the RRI-like practices and the competitive advantage compound variables was carried out. Because of the cross-sectional nature of the survey and the fact that the disaggregated sample for businesses and policymakers -the stakeholders for which data on competitive advantage was collected - was not sufficiently large, causality relationships could not be established. Consequently, correlation tests and t-tests of independent samples were carried out to examine the patterns found in the data.

3.2.2.1. The case of businesses

First the analysis off attitudes towards the integration of RRI-like practices in research and innovation work showed significant positive correlations between practices of diversity, avoiding societal concerns, addressing societal needs and engaging in open and transparent methods and processes, and customer performance, as noted in Table 30. As for the overall attitudes towards RRI-like practices, the index variable also showed a significant correlation with customer performance. No significant correlations were found for market or financial performance, suggesting that the relationship between RRI-like practices end competitive advantage may be mediated by indirect factors; such us brand recognition reputation in customer loyalty. This kind of mediated relationships have been observed outside the innovation realm for CSR and performance (Surroca et al., 2010).

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Table 30. Correlations between attitudes to RRI-like practices and competitive advantage variables, for businesses

		Market performance	Financial performance	Customer performance
Attitudes to diversity in research and innovation	Pearson Correlation	0.197	0.175	**.273****
	Sig. (2-tailed)	0.108	0.154	**0.026**
	N	68	68	67
Attitudes to inclusion of gender aspects in research and innovation	Pearson Correlation	-0.005	0.090	0.137
	Sig. (2-tailed)	0.968	0.470	0.271
	N	67	67	66
Attitudes to inclusion of ethnic minorities aspects in research and innovation	Pearson Correlation	0.148	0.143	0.088
	Sig. (2-tailed)	0.247	0.263	0.497
	N	63	63	62
Attitudes to avoiding societal concerns in research and innovation	Pearson Correlation	0.105	0.065	**0.211***
	Sig. (2-tailed)	0.393	0.598	**0.086**
	N	68	68	67
Attitudes to addressing societal needs in research and innovation	Pearson Correlation	0.105	0.048	**.265****
	Sig. (2-tailed)	0.392	0.695	**0.030**
	N	68	68	67
Attitudes to open and transparent methods and processes in research and innovation	Pearson Correlation	0.141	0.106	**0.209***
	Sig. (2-tailed)	0.250	0.390	**0.089**
	N	68	68	67
Attitudes to ethics guiding research and innovation work	Pearson Correlation	0.011	-0.143	0.191
	Sig. (2-tailed)	0.928	0.253	0.128
	N	66	66	65
Attitudes to RRI-like practices (index variable)	Pearson Correlation	0.103	0.057	**.257****
	Sig. (2-tailed)	0.432	0.663	**0.049**
	N	60	60	59

**. Correlation is significant at the 0.05 level (2-tailed).

*. Correlation is significant at the 0.1 level (2-tailed).

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In order to examine actual engagement in RRI-like practices in relation to competitive advantage, T-tests were carried out for two independent samples: one with businesses that had engaged in such practices in the previous year, and one composed of businesses who had not engaged in such practices in the previous year. Only the results for those RRI-like practices that were significant are presented, which shows that for most of the practices no significant differences were found.

On the one hand, as Table 31 and Table 32 show, there is a statistically significant difference in the financial performance of companies that engaged in practices of gender equality and inclusion of ethnic minorities. While this sample is too small to extract definitive conclusions, this difference in which companies that did not engage in these diversity related practices exhibit higher financial performance might indicate that such practices of inclusion imply a slight loss of competitive advantage in the short term, although not necessarily in the long term. This is consistent with statements made in the exploratory interviews by some businesses who expressed difficulties in attracting and hiring talent based on these criteria, and it might also be related to practices related to participatory processes, which require financial resources and make the research and innovation process slightly lengthier.

Table 31. Results of T-tests for engagement in gender quality practices and performance variables, for business

		Market performance	**Financial performance**	**Customer performance**
Engagement in gender equality practices	Mean	5.68	5.43	5.90
	N	40.00	40.00	39.00
	Std. Deviation	1.47	1.48	1.35
No engagement in gender equality practices	Mean	6.55	6.45	5.45
	N	11.00	11.00	11.00
	Std. Deviation	1.29	1.69	1.21
Significance (two-tailed)		0.72	**0.09***	0.31

*. Significant at the 0.1 level (2-tailed).

Table 32. Results of T-tests for engagement in inclusion of ethnic minorities practices and performance variables, for business

		Market performance	**Financial performance**	**Customer performance**
Engagement in inclusion of ethnic minorities practices	Mean	5.8125	5.1875	5.6875
	N	16	16	16
	Std. Deviation	1.04682	0.91059	1.57982
No engagement in inclusion of ethnic minorities practices	Mean	6.1739	6.0870	5.5000
	N	23	23	22
	Std. Deviation	1.46636	1.78155	1.10195
Significance (two-tailed)		0.403	**0.072***	0.669

*. Significant at the 0.1 level (2-tailed).

On the other hand, as Table 33 shows, practices related to addressing societal needs through research and innovation show that companies who do so perform slightly better in terms of customers than

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companies who do not address societal needs through research and innovation. These results might be explained because this outcome dimension has further visibility with consumers, also responding to market needs better by looking at societal concerns. The reason while this might not be reflected in market and financial performance is that these questions were asked for the previous year and these effects on customer loyalty and brand recognition might take slightly longer to pay off financially or through an increased share of the market, since these are mediated by the indirect reputational effect of customer performance.

Table 33. Results of T-tests for engagement in practices to address societal needs and performance variables, for business

		Market performance	**Financial performance**	**Customer performance**
Engagement in practices to address societal needs in research and innovation	Mean	5.7917	5.5208	6.0213
	N	48	48	47
	Std. Deviation	1.51529	1.47301	1.27670
No engagement in practices to address societal needs in research and innovation	Mean	5.8889	6.1111	5.0000
	N	9	9	9
	Std. Deviation	1.61589	2.08833	1.22474
Significance (two-tailed)		0.870	0.307	**0.043****

**. Significant at the 0.05 level (2-tailed).

3.2.2.2. The case of policymakers

As shown in Table 34, in the case of policymaking organizations only two aspects dimensions of RRI like practices were correlated to impact or sustainability performance. Giving high importance to avoiding societal concerns in research and innovation was shown to be positively correlated to both impact performance and sustainability performance of the organization. In addition, having an open and transparent approach to methods and process was positively correlated to both measures of performance. Engaging in open and transparent methods and processes has also been explored in relation to competitive advantage through concepts like open innovation, also in relation to innovation systems, which might explain an increased local performance of the region (see, for example, (Brem & Radziwon, 2017).

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Table 34. Correlations between attitudes to RRI-like practices and competitive advantage variables, for policymakers

		Impact performance	Sustainability performance
Attitudes to diversity in research and innovation	Pearson Correlation	-0.071	-0.148
	Sig. (2-tailed)	0.674	0.375
	N	38	38
Attitudes to inclusion of gender aspects in research and innovation	Pearson Correlation	0.038	-0.029
	Sig. (2-tailed)	0.824	0.863
	N	37	37
Attitudes to inclusion of ethnic minorities aspects in research and innovation	Pearson Correlation	-0.009	-0.001
	Sig. (2-tailed)	0.960	0.994
	N	32	32
Attitudes to avoiding societal concerns in research and innovation	Pearson Correlation	**.340****	**.395****
	Sig. (2-tailed)	**0.049**	**0.021**
	N	34	34
Attitudes to addressing societal needs in research and innovation	Pearson Correlation	0.095	0.156
	Sig. (2-tailed)	0.572	0.349
	N	38	38
Attitudes to open and transparent methods and processes in research and innovation	Pearson Correlation	**.402****	**0.320***
	Sig. (2-tailed)	**0.012**	**0.050**
	N	38	38
Attitudes to ethics guiding research and innovation work	Pearson Correlation	0.173	0.018
	Sig. (2-tailed)	0.327	0.918
	N	34	34
Attitudes to RRI-like practices (index variable)	Pearson Correlation	0.170	0.022
	Sig. (2-tailed)	0.406	0.917
	N	26	26

**. Correlation is significant at the 0.05 level (2-tailed).

*. Correlation is significant at the 0.1 level (2-tailed).

However, it was not possible to examine to obtain results in the examination of actual engagement in practices. The T-tests of independent samples for policymakers did not show any significant results.

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3.2.3. Summary and implications

The survey on attitudes and engagement in RRI-like practices worldwide showed that there are not so many differences in terms of the dimensions to which importance is given across regions, despite some differences, in particular regarding how these dimensions are implemented in practice. Notably, the degree of variation in terms of attitudes (rather than actual engagement) was smaller, but when it comes to the practices that reflect that engagement there were definite differences. This shows that, despite giving importance to similar issues when it comes to RRI and socio-ethical dimensions in research and innovation work, organizations need to adapt to their particular context when engaging in RRI-like practices; hence the differences between percentages in engagement in detailed practices.

In terms of the relationship with competitive advantage at the micro level, it is notable that, when it comes to attitudes it was mostly the outcome dimensions that had a clear positive relationship with competitive advantage; more specifically on customer performance. The reason for this might be that the outcome dimensions are the ones that are more directly visible by customers and consumers; hence reflecting directly in customer performance. This would have a secondary effect on market and financial performance, by increasing the loyalty and satisfaction of consumers. In addition, certifications that could give more visibility to the work that is done at the procedural level could be an incentive for organisations to engage in RRI-like practices (Gurzawska et al., 2017; York et al., 2017). This would add another instrumental layer to the motivations behind the participation in RRI-like practices, since these would enhance the reputational effects impacting on customer performance and, in the longer term, in market and financial performance. It is relevant to note, in any case, that in terms of the index variable on attitudes to RRI-like practices, it is positively related to customer performance.

When it comes to actual engagement in RRI-like practices and the relationship to competitive advantage in business, it was observed there weren't significant relationships between groups based on engagement in RRI-like practices for many of the dimensions. However, it was notable that companies who engage in practices of inclusion (diversity and gender equality) had a slightly lower average financial performance. This might be explained (particularly in the context of this worldwide sample) that companies' actions in this field are not visible for the consumers and imply a short-term cost in terms of difficulties in recruiting qualified candidates. This was noted in the exploratory interviews (Company A) in the case of India, where inclusive hiring practices resulted in additional training costs. It might have to do with the need to lengthen the research and innovation process to some extent in order to have a participatory approach. However, it was noted that in terms of the outcome dimensions (addressing societal needs) through research and innovation work, engaged companies showed a significantly higher customer performance than the ones who did not engage in these practices. This reinforces the hypothesis (which would need to be tested through further longitudinal studies) that RRI-like practices, and in particular outcome dimensions, have an impact on customer performance, which would mediate on market and financial performance. However, only longitudinal studies captured performance over a period of years would be able to reveal such causal relationships.

It was not possible to identify significant relationships between engagement in RRI-like practices and competitive advantage dimensions for the case of policymakers. However, in terms of attitudes to RRI-like practices, both having open and transparent approaches to research and innovation and avoiding societal concerns showed a positive relationship with both sustainability and impact

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performance. This suggests that having a public engagement approach for policymakers, and the application of a precautionary principle, is related to a better performance; nevertheless, more research is needed on the topic through longitudinal studies.

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3.3. Case studies

In order to closely examine how socio-ethical issues are managed through RRI-like practices in different regions in relation to competitive advantage, two case studies were conducted; one in the bio-economy domain, and one in the ICT domain. The first case analyzed delved into the socio-ethical and economic implications of GMOs and the impact of new techniques in gene editing, such as CRISPR-CAS. The second case focuses on the impact of artificial intelligence and deep learning for biometrics on society, and its relationship to competitive advantage. These two case studies allowed a close examination not only of how these issues are managed by the focal stakeholders in competitive advantage, that is, businesses and policymakers (and how the adequate management of these issues allows or hinders the development of competitive advantage); but also how all the supporting actors that are part of a responsible research and innovation process interact in such processes.

For this reason, for the case studies interviews with not only representatives from the focal stakeholders were conducted, but rather, representatives from other actors in the research and innovation systems that would illustrate the management of these issues from a diverse range of perspectives. In addition to the social-ethical issues identified as part of each of the domains and topics, gender equality and diversity considerations were examined as a transversal topic in the cases. This is because gender equality and diversity are cross-cutting aspects in RRI-like practices, considered at the European and global levels: it is one of the European six policy keys, but also one of the SDGs, which shows agreement on its relevance for development not only from a Eurocentric perspective but also globally.

The following subsections introduce the case studies following a structure in which first the research context is presented, then the main findings on what the issues are how the stakeholders react to them through RRI-like practices and lastly, how they relate to competitive advantage. The final additional section focuses on gender equality.

3.3.1. Bioeconomy case: socio-ethical implications of gene editing

In the field of the bioeconomy, one of the most controversial topics has been that of GMOs. Genetic modification might be done with different purposes, medical and agricultural production uses being the most common. Medical genetic modification may be done either directly modifying the genome of humans, which is still in a research phase and generally not permitted by regulation, or in order to obtain medicines or products for human use: as an example, most of the insulin used for the treatment of diabetes is genetically engineered and has been for many years, since this was one of the first products that saw techniques of genetic modification broadly applied (Campbell, 2017). While modification of human genome is highly controversial, the utilization of other genetic modification techniques is not so widely contested.

In terms of public discussion and effect on regulation, the use of GMOs for agriculture has been one of the most controversial issues, because of concerns of safety (both for nature and human consumption) and threats to biodiversity (Splitter, 2019). This clashes with the ability of GMO technologies to produce higher yields and adapt to changing environments and pressures (e.g., because of climate change, population increase). Hence, the debate pivots between the ability of these technologies to sustain socio-economic development and foster a competitive advantage at the

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micro and macro levels, and safety and legitimacy concerns. In the context of the European Union, public outcry led to regulation banning the use of GMOs for agricultural purposes for several decades, while it was widely used in other world regions under strict global agreements on safety (such as the Cartagena Protocol on Biosafety). New techniques in gene-editing, such as CRISPR-CAS, have recently reignited the discussion on GMOs. Gene-editing techniques are simpler that traditional genetic modification techniques, since they imply modification in the species' own genome through the introduction or removal of existing genes in a particular genetic sequence, by using a nuclease as a "genetic scissor". This technique does not imply cross-species alternation of the genome. Such techniques have been quickly been applied successfully because the relatively simple modification, within species, is cheap and does not require as much laboratory resources as traditional GMOs, which opened up the market for smaller players, which has added another layer of discussion in relation to competitive advantage (and sharing the profits across more actors in the system).

However, a recent ruling of the European Court of justice declared that gene-editing techniques were to be considered, for regulatory purposes, under the same scope as traditional genetic manipulation techniques, leading to further controls and bureaucracy in order to use them. This prompted a strong reaction from European researchers against this ruling (Christiansen et al., 2019). While this has not been the case in other regions, this news triggered a renewed discussion on GMOs and CRISPR-CAS, bringing back the attention of civil society, policymakers, researchers, industry and all players in the research and innovation system (Synthego, 2019). This made for an interesting case for further study on the unfolding of RRI-like practices in the management of socio-ethical issues and competitive advantage, particularly in terms of how already engaged organizations are responding to this new challenge. The next section provides a brief introduction to the research context, both globally and in different regions.

3.3.1.1. Research context

The following sub-sections provide a short overview about the regulations, status quo and spread of GMO technologies across different world regions, in order to provide the backdrop and help to interpret the results of the interviews in each of the areas.

3.3.1.1.1. Global standards and issues

At a global scale; the Convention on Biological Diversity was started in 1992, as a multilateral treaty convention. It was developed as part of the Rio Earth Summit that also marked the beginning of the international discussion on sustainable development (CBD, 2020). Notoriously, the discussion of these issues as part of sustainable development inextricably linked socio-economic development to the use of natural resources, and thus linking issues of biological diversity and GMOs to economic development and competitive advantage (Boisvert & Vivien, 2012). The Cartagena protocol on living modified organisms was then signed in 2003 as a way to protect biodiversity specifically from the techniques of genetic modification that had been developed in the previous decades. In essence, the Cartagena protocol called for the application of a precautionary principle in the development of GMOs

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and allowed countries to set limitations on the imports of GMOs or GMO-based products if it was considered that the scientific evidence what's not strong enough to ensure biosafety.

As part of the Convention on Biological Diversity the Nagoya Protocol focused on the access of indigenous communities to the profits and benefits derived from genetic diversity. Some areas in which indigenous communities live count amongst the most biodiverse in the world and, in exploring biological solutions, it has been common to investigate genetic diversity in such areas to find new active principles, leading to conflicts in the ownership of intellectual property (Downes, 1993). The consequences of this for the local communities are twofold: on the one hand, there is a threat to biodiversity, particularly if genetically modified products are developed based on the existing biodiversity (hence posing possible threats to the traditional cultivars and the existing wild flora and fauna). On the other hand, corporations and countries benefiting from exploiting such genetic resources often did not share this with the indigenous communities from which the knowledge or genetic resource was extracted. The Nagoya protocol aims to both protect biodiversity in these areas and ensure an equitable access to the profits derived from traditional knowledge and indigenous genetic resources when combined with modern scientific and commercial innovation.

Beyond regulatory practices, the GMO the debate has been ongoing for several decades and despite almost complete scientific agreement on the safety of such products and their potential contribution to sustainable development a large part of the public is still resistant to the introduction of GMOs in foodstuffs (Splitter, 2019). Building on this resistance, the inclusion of non-GMO labels in products has been commonly used as a marketing technique for foodstuffs and sometimes textiles, as a way to communicate with this section of the public (Phillips & Isaac, 1998). However, these branding practices have been heavily criticized by some other actors in the system, arguing that they are built on unscientific claims (Weighardt, 2006).

Others argue that GMOs are essential to contribute to sustainable development, by providing sufficient food for a growing global population, adapting to climate change in areas in economic development that have been particularly punished by more frequent extreme climate events, or providing more nutritious food in areas in need (Alberts et al., 2013; Zilberman et al., 2018). In that sense, a North South debate on the use of GMOs has emerged, with most developing countries advocating for faster development of GMOs that might help to address local needs such as producing drought resistant seeds, cheaper medical products or addressing nutritional shortages, although the lobbying divide is more complex, with opposing views also present between Northern (e.g. US and EU) and between Southern countries (e.g. Argentina and Bolivia) (Falkner & Gupta, 2009; Ostry, 2002).

Although this debate has been going on in the public sphere in relation to all GMOs already from the 80s, there have been technological developments in the field of GMOs that have not been sufficiently accounted for in the public debate, despite the very different characteristics of the techniques and resulting products used in genetic modification (Splitter, 2019). While early GMOs were based on transgenesis (which involves the modification of the genome through the introduction of sequences of DNA from other species), the latest techniques of gene editing use the species' own genome and introduce duplicates or double recessives or remove genes, as in is the case, for instance, of genetically edited wheat with no gluten (Jouanin et al., 2018). Because of the variety of techniques and possible uses of GMO the scope of the debate has also been diverse in different regions, as illustrated below. North and South America contains 85% of global genetically modified agricultural production (Paull & Hennig, 2019), an effect of the very different approaches in each region.

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3.3.1.1.2. Africa

Africa, along with the European Union is the region that has set most the most stringent regulations against the use of GMOs in agriculture. Only a few countries in Africa allow for the use of GMOs, mostly Bt cotton, which is an industrial crop, not a food crop, and with only two countries allowing more than one crop. Most African countries have decided to rule against GM owes because a large amount of their agricultural products are exported to the European Union, which disallowed imports of GMOs or GMO-based products (Grunstein et al., 2019). Therefore regulation in Africa is mostly driven by the developments in the European Union, because, although it would be possible to deploy them under the Cartagena protocol (which calls for the application of the precautionary principle the developments in GMOs), since the latest decades of use have shown no scientifically-proven danger to bio safety derived from the use of GMOs, the EU's continued ban on imports outweighs local benefits to their adoption. The case of the non-use of GMOs in Africa is particularly notable, considering the development of GMOs that could help tackle some of the issues the continent has been severely affected by, such as climate change, and that the ban on its use is mostly based on political economy reasons (Grunstein et al., 2019).

South Africa and Sudan have been the countries at the forefront in the use of GMOs in Africa. During this time, South Africa has almost doubled its agricultural production and small farmers have been able to produce for export rather than use for home consumption, driving economic development in the region (Agaba, 2019). GMO driven development in South Africa has been supported by the political authorities and has been paired with stronger collaboration institutions, which are being created throughout the continent to support the introduction of GMOs such as the Open Forum on Agricultural Biotechnology in Africa (OFAB). In the context of these developing countries, the debate is mostly driven by increases in productivity and better stress management in the case of extreme weather events (often produced by climate change) and the use of scientific evidence to support the development of less strict regulations that ensure safety but do not hinder development and economic growth, better addressing the local needs in African countries (Bothma et al., 2010). The debate also includes the use of techniques such as CRISPR-CAS, which could help not only to develop more productive agricultural yields, but also in the control of diseases like malaria by introducing modifications to the mosquito genome (Ogaugwu et al., 2019). However, science education and empowerment of the locals have been highlighted as factors of success of such techniques in the African context.

3.3.1.1.3. Arab States

In the Arab States, the effect of European legislation and the application of the precautionary principle following the Cartagena Protocol has led to stringent regulations on GMOs. Their use is not widespread and, although not completely banned in many countries, states such as Saudi Arabia or the UAE require positive labelling in their commercialization, with an explicit indication in Arabic and English expressing that the product contains GMOs (FAO, 2020). Developments in the area of GMOs are often put on hold because of the public and political debate, despite researchers highlighting the need for use of GMOs, particularly in relation to drought-resistant crops (El-Galil, 2017) and to promote socio-economic development (DaSilva, 2001). Labelling practices, along the resistance of Arab consumers to GMOs under health concerns (Bakr & Ayinde, 2014) make commercialization of GMO-based foodstuffs difficult in the Arab context.

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However, the resistance to GMOs and gene editing is not acute in the context of medical uses, where several developments are thriving in the Arab States. Although research in this area is not particularly advanced in the region, Qatar has been spearheading research, dissemination and promotion in the region (Vogel, 2018).

3.3.1.1.4. Asia & the Pacific

The attitudes and practices in relation to GMOs are quite different across Asia & the Pacific. The examples of some larger countries are presented here to represent the contrast between different areas.

India has resisted the use of GMOs, with have been banned for agricultural purposes (except for Bt Cotton) (Ahuja, 2018). However, the civil society response has been varied and controversial. Very recently, in 2019, 1500 farmers planted GMO seeds as a response to the ban of the government, aiming to show how important these crops would be for development in the region and their own development as farmers. (Alliance for Science, 2019). Nevertheless, there are also other civil society movements that aim exactly for the opposite; hence the debate on their use is still heated In India, with farmers advocating on GMOs for socio-economic development, but many NGOs successfully advocating for GMO-free agriculture (Paarlberg, 2014).

In the case of Japan, the planting of GMO crops within the territory is not allowed; however, the country is one of the largest importers of GMO-based products in the world (Umeda, 2014). The general public shows some degree of resistance to GMO-based foods because of health concerns (Evenson & Santaniello, 2004), and a label that expressly indicates that there are GMO-based contents in the product needs to be on the package. In relation to gene editing techniques, products that have been modified in this way are allowed in the market without the label, since they are not considered in the same way as traditional GMOs, as there is no transposition of genes from other species (Japan Times, 2019). This has resulted in a certain degree of concern among the population, who are still resistant to any kind of technique of genetic modification for foodstuffs.

In Australia, three different GMO crops are accepted (cotton, canola and safflower) and other are in the research and experimentation phases (Department of Health of the Australian Government, 2019). China also allows for certain genetically modified crops, which are subjected to government approval (Zhang, 2014). Australia and China have shown a more open approach to GMOs that contrasts with other countries in the Asia-Pacific region, which has largely piggybacked on European regulation and the Cartagena protocol. This shows a variety of approaches within the region both at the regulation and civil society levels. Controversies about the tradesoff between health and biodiversity protection versus social wellbeing and economic growth remain.

3.3.1.1.5. Europe & North America

Similar to the Asia & the Pacific region, when it comes to GMOs the Europe & North America region is deeply divided. The European Union has amongst the most stringent regulations regarding GMOs, regulations that have been highly influential in Africa, the Arab states and certain parts of Asia & the

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Pacific, while North America leads the pro-GMO block in international negotiations and has influenced policy in regions that have decided to go forward with GMOs, particularly Latin America & the Caribbean (Falkner & Gupta, 2009; NELSON, 2001). Therefore, these two blocks require separate considerations.

Europe, and specially the European Union has responded quite strongly to public concern on GMOs. European NGOs, civil society and consumers have shown a strong reaction against GMOs, with many consumers still resisting the use of such products in foodstuffs, which led to a total ban of GMOs production and imports for several years (Tamma, 2017). At the moment consumer resistance is still very high, including for foods based on gene-editing (Shew et al., 2018), and the non-GMO label is still used for marketing purposes to make sure that consumers that are conscious about GMO content have access to what they perceive us safer product. In North America, on the other hand, there has been a liberal approach to GMOs, following safety considerations (NELSON, 2001), but with a much earlier introduction of GMOs and GMO-driven agricultural growth, especially in crops like cotton, maize or soy which are not only used for human consumption, but also for animal feed.

3.3.1.1.6. Latin America & the Caribbean

In Latin American countries there have been no strong objections to the use of GMOs, particularly because of their potential for economic development. Argentina and Brazil are among the big four producers of GMOs and have experienced strong economic growth and local development based on the use of GMOs (Traxler, 2006), although other countries such as Ecuador, Bolivia and Peru have set strong limitations. .

Apart from issues of socio-economic development, there are major implications from the use of GMOs in areas linked to indigenous communities (e.g. Leguizamón, (2016)). The need to protect biodiversity in traditional ways derives from indigenous communities in these areas regarding humanity's relationship with nature as something that goes well beyond perceptions of organisms as natural resources and disputes the legitimacy of the right of humans to modify nature: the use of GMOs comes along with many cultural and management implications that are not always in accordance with traditional practices, beyond the purely technical considerations (Mereles & Florencio, 2012). Consultation mechanisms have been built into legislation in some countries, but with different degrees of success (Salazar & Torres-Mazuera, 2018).

3.3.1.2. RRI-like practices in response to issues in GMOs, and relation with competitive advantage

As illustrated above, the understandings and ethical questions raised around GMOs varies from region to region. It is commonly understood that the handling of GMO should be done in a responsible way that ensures safety in their development and use. However, what such safety entails varies across regions and the way in which this should be protected also changes over time. Interviewees across regions agreed on the need for responsible handling and safety checks for development, as illustrated by the point made by Interviewee S, a professor and member of policy-making organization in Japan:

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> "*We do thorough safety evaluations, so I think genetically modified foods are actually the safest. That is to say, which is the safer between these (checked genetically modified foods) and organically cultivated foods which have not been checked?*"

Nevertheless, views on the extent to and methods through which this should be protected vary. Some interviewees perceived low risks in GMOs and gene-editing, while others expressed concern about uncertainty of alternative methods. According to researchers in the biotechnology field, risks are either minimal, as illustrated by the views on CRISPR of a professor in the Netherlands (Interview O):

> "*Now, they consider, according to the European rules, the one [traditional tomato] that is now in the supermarket with all those changes made [through cross-breeding], where we did not know at all what we were doing, that was not at all checked, but they say, "Okay, well, this has a long history of safe use." This whole process is accepted and that is not called GMO. If you now compared it to CRISPR, where they say, "Okay, well, this is a new process and we don't know what will happen." Of course, it's a new process, but we know exactly what happens because we can determine the sequence, so we know the outcome. If something happens that we don't like, because sometimes that happens, but in many cases, it's exactly as we want it, then we say, "Okay, what can be wrong with that?*"

or the views of another university professor in Colombia (Interviewee K), who argued for a principle of familiarity for GMOs, considering the fact that they have been in circulation with no apparent harmful effects for long years:

> "*I agree that you have to be careful, you have to analyse. In the case of transgenics, we have been marketing for more than 25 years, we are going for 30 years, without any harmful effect on health or the environment. I believe that we must turn to familiarity and we cannot forget that spontaneous mutations occur every day*".

However, the controversy remains, and not all stakeholders agree with this point, despite having a scientific background. For instance, the bioethicist in China (Interview L), wondered:

> "*Maybe we can change the mind to think about why cannot we use another way? That way is not such high risk. Are there any other ways, not so risky, but also can have people to get food? I don't think using this kind of risky technology is the only way we can solve this problem [providing food for the while planet]*"

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Similarly, Interviewee P, with a background in Biology and member of a civil society platform, raised moral concerns about gene-editing techniques, the lack of thorough knowledge on the topic and the ability of the economic system to ensure a safe use of the technology:

> "*I think there's still a lot of knowledge missing. I do wonder, from a moral point of view, if we should explore it further, because I do have moral concerns about it. I'm fascinated by the technology, let's say, but yes, I have moral concerns, and I wonder if at the moment the system is capable of handling it well. And with system, I mean we have a very profit-driven system. I wonder if this technology will end up in the right hands, and that it will be morally and ethically used for the right purpose*".

Beyond the perceived risks to biodiversity, another interesting point that rose in the Latin America & the Caribbean region is the relationship between the protection of indigenous communities and the use of GMOs. On the one hand, there is a need to protect the communities and their area's biodiversity (including their use of traditional seeds); their way of life and beliefs, including an understanding of nature beyond 'natural resources'; and their access to the profits made on traditional seeds and knowledge and local biodiversity. This has led to several layers of protection through regulation, which, in several countries, bans the use of GMO seeds within the indigenous reserves and international regulations such as the Nagoya Protocol. However, because of the economic development that comes along with the use of GMOs, difficulties in finding an appropriate balance between their rights as a community and rights to development were mentioned by Interviewee K:

> "*Throughout Latin America, we have many indigenous communities, we have Afro-descendant communities, we have a whole range of cultural diversity. The rich biological diversity we have is not only from plants, animals and microorganisms but also from cultures. All that is what one must learn to respect and live with it. Yes, there is a situation and it is that these small communities do not really have large crop fields, they do not have very large extensions. They have their own productive systems. In Colombia, for example, various biotech crops have been approved but for indigenous reserves they are not approved, it is forbidden. Each of these indigenous communities cannot sow there, although, interestingly, there are already some complaints from some indigenous people who say they are being denied access to technology*".

The responses about how to manage these risks varies. However, there are two main approaches: regulatory responses and second-order reflexivity, and science education and engagement. Through regulatory responses, the responsibility is to set governance structures, boundaries to technology and its commercialization and establish the limits to possible trade-offs between not causing concern for society and competitive advantage, as noted by Interviewee S for the case of Japan:

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> "*The Food Safety Commission is supposed to make judgements only from the viewpoint of science, so there is no need to make such trades. However, considering the circumstances of other countries and such things, we must regularly consider the issue of whether we can continue to use the screening system created 10 years ago to evaluate foods made with new technologies. In this case, I always thinking that in order not to put Japanese companies at a significant disadvantage, we need to match the situations in other countries*".

Second-order reflexivity approaches were also suggested; for instance, by Interviewee P, who proposed rules to be developed by research performing organizations or the government to avoid placing full responsibility on individual researchers:

> "*If there are no set rules by either the government or universities themselves, then you're asking the researchers themselves to do this moral unethical assessment, which I find tricky. Of course, we all have our own definitions and values*".

Interviewee K, who participates in international bioethics committees, highlighted the role of the Convention for on Biological Diversity and its protocols to protect underlying socio-ethical values:

> "*In all countries where GM crops are present, there are instituted regulatory systems, some better established than others, but in all of them there are protocols, international standards, which embrace the Cartagena Protocol on Biosafety. In fact, we have helped a lot at the horizontal level for training and capacity building, but in all cases, there are designated competent authorities that are strong in this and remain updated, because it is a topic that evolves very rapidly*".

However, most European stakeholders in research and innovation, who are affected by the most stringent regulations and the recent ruling on CRISPR-CAS, disagreed with the regulatory responses, since they have limited the scope of action and the possibility to develop a competitive advantage too much:

> *"[…] In Europe, we can't perform science to do business based on gene editing, to develop final products. It's very complicated and it's not considering them as gene editing but as GMO, which we know is not so positively accepted by the society. This problem now to my knowledge is discussed in the very top European level, but still, the legislation is there and then the interpretation is standby or decisions are really hard to change things back to where they were, at the same time, US and Japan and other countries are moving forward*" (Interviewee Q, Industry, Lithuania).

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Regulation might also lead to unintended consequences in the balance of power, as noted by Interviewee O, who pointed out that the European court decision on CRISPR would affect the competitiveness of small businesses, largely leaving big biotech companies – who can still develop this technology in alternative headquarters – unaffected:

> "*Based on power, that is only in the interest of the big biotech companies. Also, I know that when the decision was made by the European Court, it was partly timed for Greenpeace, but what they did not realize is that this decision doesn't really affect the big companies. It does affect the smaller companies. That is exactly what they should have realized and then maybe they wouldn't have a party because of this decision*".

However, second-order reflexivity also comes in placed in such cases, as noted by the Chief Technology Officer of an international company headquartered in The Netherlands (Interview N), who stressed the importance of company rules in relation to complying with regulations and ethical codes:

> "*As an internationally operating company, we have one standard that we follow. I often hear that if gene editing is not allowed in Western Europe, you can do it in any other country. I strongly disagree with that. I strongly disagree with that, because I know and I also tell that the results of gene editing, to take that as an example, cannot be traced. So if we would say, "Well, we do this in China," then our customers in Europe, they expect us to, of course, operate within the law, and if gene editing is not allowed then we can't get away with, "We didn't do this in Europe, we did it somewhere else." It's one company, one policy, irrespective of where we are*".

The second widespread response relates to public engagement and science education. Many of the respondents highlighted how GMOs and gene-editing generally has a bad reputation with the public which led to the regulations perceived as inappropriate indicated above. However, the lack of popularity of the GMO's is considered by some to be due to a lack of knowledge of the science behind them and their potential benefits as well as the lobbying efforts of environmental NGOs, as noted by Interviewee R, who represents a non-for-profit association promoting the use of GMOs in Colombia:

> "*There are campaigns where they [NGOs or leaders who are against the issue] have put in their heads that their Creole corn is going to run out because of GM corn, something that is not true and something that is manageable. The risk exists, but it can be managed. We are also open to speak with them in this way, sincerely and clearly, on the subject, but there are also certain groups that are up to this, who have put them against us to make campaigns, that they don't want or need us*".

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In order to respond to this, the need for participatory anticipatory and reflective practices was highlighted, as illustrated by the need for "common decisions" expressed by Interviewee Q, in Lithuania:

> "*Researchers are always exploring new areas, and probably sometimes they can find technology that could be very useful, but if they're used for bad purposes, they can kill people. We try to explain at least from government or the society, that all of us are involved into that and we should decide on the technologies that are used, but not decide on the scientist or the companies that are doing novel science. You can make these kinds of decisions at all. It has to be common decision*".

The need to discuss methods, since common goals – safe food for all – were shared by all the involved stakeholders, was highlighted by Interviewee O:

> "*I think the goal is to make sure that we will be able to provide enough food for the growing population, not only now but also in the future, and not only here but also on the rest of this planet. I think that's the same goal. They want to do that most likely in an organic way. Well, there's nothing wrong with doing it or using an organic strategy, but I think it won't be enough. I think if we can find a combination that partly organic and maybe partly by using these techniques like CRISPR to help evolution to speed up and to lead to the production of crops that do a better job or that can feed the whole world, I think if we can reach or if we can find such a compromise, that will be a major step and that is what we should aim for, I would say*".

This dialogue approach to deliberation, reaching compromises, was noted by a member of civil society, who was not strongly against the use of gene-editing, but viewed these techniques as mechanisms of last resort once the underlying problems of global food security and distribution are solved (Interview P):

> *"In certain African countries, why are people there suffering a lot, and how is it possible that other people have access to food in a very excessive way? Well, maybe there's a flaw in the current system, because we would have now already enough food to feed the world, it's just allocated in a questionable way. I see gene editing sometimes in this context as if putting a band-aid on it versus looking at the route where's the problem coming from, even though the band-aid helps, of course. It's still like, okay, there's something before that's causing it, to begin with*".

Beyond engagement in anticipatory practices, inclusive practices built on public engagement and science education to increase the social acceptance of GMOs and promote their safe use among farmers was highlighted across regions. In the Latin American context, public engagement was

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considered of major importance both of the micro and macro levels: at the micro level it was considered so important to engage in dissemination practices that an industry association has been developed to increase awareness on and engage with the through training programs and dissemination events. The impact of such engagement is far reaching, across several stakeholders, as noted by Interviewee R:

> *"We work with the farmers to show them the seeds are not magic, and have to be handled in a responsible way, also trying to avoid that the good impact or the benefits that the farmers receive from the technology today do not go away or decrease or they will end. We work with many universities, colleges, giving training. We work with the government giving training and working in the regulatory frameworks. You know, science is going faster than regulation, trying to adapt the regulatory frameworks to this evolution of knowledge, the technological advancement of innovative products, we work with media that for us are a multiplier of the message, and if journalists are trained and they know about the subject, they can inform in a better way about the subject. We work with the food industry and the textile industry who are the users of the technology".*

These kinds of practices show companies taking responsibility for the safety in use of GMO beyond them just developing and selling the technology, with a two-fold intention, to increase social acceptability, but also to promote safe use and avoid social concern. This was also the case of a Nigerian researcher, who highlighted the need for engagement with the farmers to ensure safe use and the acceptability of new technologies (Interview M):

> "*There is resistance at first, the areas that we covered they were being occupied by local people and especially farmers that were not very familiar with this technology and the potential risks that may come with it. In the beginning, we go around to educate them and to further enlighten them on these technologies and more especially how they can become useful in their farming and agricultural activities. There is this stage, in the beginning, to make them become familiar with what we are doing*".

However, this dialogue and engagement is not always easy, which sometimes leads to dead-ends in some instances, particularly when the responsibility is placed not at the industry level, but on individual organizations, as noted by Interviewee N, in the Netherlands:

> `*The general trend is that production needs to become more animal welfare friendly. Explaining that to the public is not trivial, because the debate is polarized in "We should become vegan." Although I recognize the opportunities to reduce the amount of animal proteins, it's not as simple as that, because certainly in Western Europe and North America, everyone could reduce the amount of animal proteins in their diet. That's without any risk, speaking in average terms. But that's not the only solution, because there will remain a part of animal proteins that needs to be produced in a sustainable manner. But*

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it's very difficult to get a good discussion on that. Everything we do is in an environment where the discussion is polarized`.

However, despite disagreement, the need for open discussion to ensure social acceptability of the technologies was agreed on by all stakeholders, despite identified difficulties, either to ensure safety and transparency in the development process, or to ensure that acceptability and regulatory issues were not standing in the way of the capacity of GMOs to enhance socio-economic development and the development of a competitive advantage. The key, as noted by Interviewee K, is to find the right balance between safety, sustainability and economic development through the promotion of safe use practices through adaptation to the local environment:

"*Monoculture can be dangerous, it is risky. Those who use this have to be aware and have to, although they earn a lot of money with a crop, look and do crop rotation; that is, make am adequate handling. But again, it depends on each case. Of the most interesting cases that one finds in Latin America is Argentina, […], who had a boom with all this from the use of biotech crops, mainly soy and corn. Their economy at this time depends on that, but they have already realized that they cannot continue exporting commodities, that is, the raw material; hence they are developing their own bioeconomy. They are adding value and processing or semi-processing all these harvests from their biotech crops. They are also trying to do more rotation, to increase agrobiodiversity, but it depends on each region and the leaders of each region. Therefore, everything depends on the situation and circumstances*".

3.3.1.3. Summary and implications

The case study on the use of GMOs and gene editing technologies showed significant differences in approaches to RRI-like practices in relation to competitive advantage, but also significant commonalities that show that domain related contextual factors are as important as geographical and economic factors when understanding approaches to RRI-like practices.

Three main contextual factors affected the development of RRI-like practices in this domain: the regulatory framework, public acceptance of the technology, and the degree of socio-economic development. The first, regulation, was very relevant because the degree of discretionary approaches and own reflexivity that research and innovation workers could apply varied significantly depending on the extent to which safety concerns had been regulated. In those countries that had established regulations based on the precautionary principle established in the Cartagena protocol, but no further, researchers were happy to oblige with the procedures established by law, even taking a step further; however, in more stringent contexts the regulatory approaches were perceived to be a significant barrier in the development of competitive advantage, both for smaller companies and for the region as a whole, since research capability could not be developed.

Regarding the second factor, public acceptance of the technology, across regions it was perceived -to varying degrees- that science communication and public engagement were needed to obtain public acceptance and develop a competitive advantage based on wide public support. For instance, in the context of Latin America & the Caribbean the use of GMOs is more widespread, and there is not much

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public resistance; therefore, public communication and information for the farmers were deemed sufficient to achieve social acceptance. In the European context, where the opposing stakeholders are more vocal and have achieved more relevance in terms of their contribution to legislation, a more engaged dialogue was needed; however, because of the polarisation of the debate, this dialogue could not proceed.

A third relevant contextual factor was the degree of socio-economic development. Avoiding the use of GMOs was perceived as a "luxury" that not all countries could afford; consequently, those countries that were more reliant on their use and had agriculture as their main economic driver seemed to be more positive toward their use and therefore require different RRI-like approaches. This showed the importance of having a balanced approach to RRI-like practices that integrates both moral and instrumental motives, and balances ethical and economic considerations, particularly in the context of development.

Nevertheless, there were some commonalities across regions; mainly, that the RRI-like responses in order to ensure a competitive advantage were related to public communication and science engagement, and the development of standards (either by the government either or by the research and innovation networks). This suggests that, when it comes to ensuring competitive advantage in the context of emerging socio-ethical issues, domain specificities might be more relevant than geographical considerations, since the emerging issues from the use of that technology are not singular to one region. However, it was notable that in the case of the Latin America & the Caribbean region, where cultural diversity of indigenous people and the existence of protected reserves where the use of GMOs were banned, had led to an additional layer of complexity in RRI-like responses and the competitive advantage and access to tools for development of smaller communities.

3.3.2. ICT case: deep learning and biometric recognition

In order to examine the case of deep learning in the context of biometrics, first, some research context is provided in the global and regional contexts, in order to understand better the contextual factors playing into the development of competitive advantage in each of the regions based on the results of the interviews. The section closes with an overview of implications.

3.3.2.1. Research context

Biometric identification can be a useful tool, but it can also be easily misused or abused. The rise of real-world usable AI (deep learning, particularly) in recent years has allowed the development of forms of biometric identification that were previously impossible. In particular, this includes forms of processing of visual information for biometric analysis such as facial recognition, iris recognition, gait recognition. These identification techniques can link individuals between contexts without needing an existing identity and/or can be linked to some existing identity data set. An example of this is the face recognition applied to all photos uploaded to Facebook. In addition to cross-linking photos which appear to contain the same person according to the visual analysis algorithms, manual tagging of photos by Facebook users with other users' account handles, or even with just the names/other system identifiers of those appearing in them provides the link to an identity. Uploading of personal

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ID photos by users themselves on systems such as Facebook, LinkedIn etc. adds to this linked set of data. Formal government creation of such datasets has been ongoing for many years, in particular the inclusion of digital photographs into passports and associated databases, and their use in electronic immigration gates, provides governments with a linked photo and identity, to which other visual biometric analyses may be linked.

Many positive uses of these systems exist (the quicker and cheaper immigration process for regular legitimate travellers, for example). However, as seen in Hong Kong, these systems can also be easily abused. Their misuse, and in particular their uses in circumstances where false positive or false negative identification can lead to significant consequences for the person, leads to public concern about private and public development and deployment of the technology. In this climate, the attitude of those developing underlying technologies, and full systems for real-world deployment, may find it is in their best interests to take such concerns into account or face wasted effort in developing systems which are socially unacceptable, leading to either resistance to their use (potentially degrading their utility to the point of abandonment) or not matching legal requirements for deployment. The following subsections provide an overview of the regulatory context as a backdrop for the empirical section.

3.3.2.1.1. *Global standards and issues*

From a global perspective biometrics and deep learning have been met with conflicted positions and it is indeed one of the most pressing issues in ethics of emerging technologies, particularly when in use in combination with artificial intelligence to identify patterns (Joshi, 2019). The OECD recently published have their principles for artificial intelligence recognizing the potential the risks of a potential misuse of this technology and aiming to hedge such risks. These principles are the following (OECD, 2020):

- *AI should benefit people and the planet by driving inclusive growth, sustainable development and well-being.*
- *AI systems should be designed in a way that respects the rule of law, human rights, democratic values and diversity, and they should include appropriate safeguards – for example, enabling human intervention where necessary – to ensure a fair and just society.*
- *There should be transparency and responsible disclosure around AI systems to ensure that people understand AI-based outcomes and can challenge them.*
- *AI systems must function in a robust, secure and safe way throughout their life cycles and potential risks should be continually assessed and managed.*
- *Organisations and individuals developing, deploying or operating AI systems should be held accountable for their proper functioning in line with the above principles*.

Their focus is placed on the development of trustworthy artificial intelligence. In the field of biometrics, this means not only to improve the technologies to avoid misrecognition and racial bias, but also protecting privacy in the context of surveillance capitalism and authoritarian approaches to the use of the biometric data (as for the case of control of minority groups, such as the case of the alleged application of the these technologies to control Muslims in the Chinese region of Urumqi). The risk of data breaches and of the potential use of biometrics and AI have against diversity and human rights are noted in the spirit of these principles. However, they can also be useful tools for

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development; for instance, to access certain public services, such as the health and pension systems, for previously isolated communities. In fact, these technologies also have the potential to drive sustainable growth across regions; therefore, they have been explored widely both in research and practice.

However, the experience has been diverse and has given rise to different concerns across regions. The speed at which the technology is developing has also called for the development of international standards. Such standards, in the fashion of ISO and others, are focused on technical interoperability (which is paramount in the case of biometrics and deep learning, for uses as for example border control). Unlike previous standards for technologies, most countries have agreed to participate in the negotiations, bringing in both the United States and China – the countries where biometric recognition and use by the government are more widespread (Cihon, 2019).

3.3.2.1.2. Africa

Biometric identification has been signalled as a significant tool for development in the African context, and, more particularly, in ensuring an adequate distribution of wealth and access to public services for the whole population (ID4-Africa, 2020). However, in certain contexts the lack of strong institutions and regulations might lead to privacy breaches, as noted for the voter biometric identification in Tanzania (Makulilo, 2017). For this reason, efforts in the region are being directed in two directions; first, strengthening the supporting institutions to ensure that the technologies are used in a responsible manner, and second, improving access to the technology.

In terms of the first goal, ID4Africa is a pan-African NGO that aims to bring together governments, development agencies/charities and commercial service providers to create an individual ability to demonstrate one's identity, while maintaining security and privacy (ID4-Africa, 2020). This is currently one of the major players in the region and focuses on the development of knowledge on the topic relevant to the region and issuing of guides and recommendations for governments, who are both procurers and regulators of the technology. The organization has also issued a code of ethics, that recognizes the need to protect human rights and transparency in biometrics driven development in Africa (ID4-Africa, 2016).

In terms of access to the technology, governments have been the major drivers of identification technologies. In some cases, biometric identification is being used for the unification of health records, enabling access to state services or promoting e-commerce (Burt, 2020). In addition, it is increasingly used for voter identification in the region, an advanced use that is not available in many other regions, but that raises concerns on privacy and use of the data by the government in the absence of appropriate institutions and regulation (Makulilo, 2017). In the private sector, banking (which is prominent in the region for its innovative uses of technology to enable access to services in remote rural areas) has also welcomed and supported biometric identification. For example, the e-zwich system implemented by the Ghanaian Central Bank, which is set to take off also in other countries, provides an additional layer of identification upon use of credit cards, preventing from the use of stolen or lost cards by anyone other than the cardholder (Breckenridge, 2010).

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3.3.2.1.3. Arab States

In the Arab States, similarly to Africa, some concerns have been raised regarding the fitness of the institutional environment to support the good management of data, such as the case, for instance, of biometric voter data in Iraq (Sayadi, 2018). The implementation of biometrics in the region has been driven by border control and security, and banking; however, the region is a hub for knowledge and implementation of the technology (Mayhew, 2020).

Arab States have adapted the choice of technologies to cultural and religious sensitivities. While fingerprint and facial recognition are the most used technologies in other regions, iris recognition is the most widespread in Arab States, since it allows contactless identification (unlike fingerprints) and the identification of women wearing the niqab (unlike facial recognition) (Gelb & Decker, 2012). Therefore, the border identification system in several countries in the region is based on iris recognition (Jain et al., 2016).

3.3.2.1.4. Asia & the Pacific

As identified in the bioeconomy case, the issues and standards are varied across Asia & the Pacific, a very large region with a wide diversity of cultures and standards when it comes to biometrics. Two countries have been selected to introduce the issues in this region: Japan and India.

The Japanese government identification systems and databases/numbers have a long and controversial history in the country. The current MyNumber system allocates every citizen and resident a single government identification number. Although initially introduced with a very specifically limited set of allowed usages, the possible usage has expanded over time and was even foreseen in the original proposal, despite government assurances that the use of the system would be very limited. These ties into public concern about high profile government data breaches (such as a major one at the national pension scheme in 2015 in which 1.25m people's details were exposed). The Japanese government has been pushing forward recently with various facial recognition schemes being rolled out (airport immigration gates) or proposed (self-enrolment in facial recognition systems for health insurance identification at health care providers, promoted as both convenient for patients and a preventive measure for insurance fraud). The Tokyo Olympics were expected to see a large-scale use of facial recognition to prevent re-selling of tickets to popular events by tying each ticket to a facial biometric ID. If successfully used at this one-off event both the technology and the public awareness/acceptance could be leveraged into broader acceptance (Bennett & Haggerty, 2012). The Japanese government's general approach to biometric ID technology is to promote development via university research grants and support for industrial development of real-world systems, to promote use of these systems within Japan and then to leverage their use in Japan to promote Japanese technology exports to other countries. As such, social acceptance of the technologies in Japan is considered a necessary element of this security-industrial complex (Mills, 2004). Achieving that acceptance, however, is more usually achieved by promoting or creating a local maximum of convenience (by requiring ID where none was needed before or by making other identification routes more awkward) than by public engagement and socio-technical testing.

In India, the Aadhaar system has been highly controversial. Based on fingerprints, iris scans and digital photos, the system is particularly aimed at basic benefits (particularly free or subsidised food)

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claimants in rural regions. Its reliance on technological processes for checking ID, which require electricity and an Internet connection not always available (at all in some areas, reliably in others) has led to criticism. The fingerprint scanning system can fail with people who have hard manual labour backgrounds and/or current jobs. Iris scanning has fewer (but not no) problems but requires more expensive equipment (Frayer & Khan, 2018). Such concerns have been raised by the UN's Special Rapporteur on Extreme Poverty and Human Rights in his recent report (available in draft at the time of writing) as a warning to other governments in developing economies (and developed economies) that such technology may exacerbate rather than help solve, problems with poverty (Dixon, 2017). In 2017, India's Supreme Court ruled privacy to be a fundamental right in relation to a case involving Aadhaar; hence raising the degree of protection provided to the right to privacy.

3.3.2.1.5. Europe & North America

The approaches in Europe and North America have slightly differed; particularly in terms of data protection and adequate data management. The focus is placed on the European Union and the United States.

The European Union has developed a strong regulatory framework regarding data protection, the GDPR, which unifies data collection and management regulation throughout the Union, which includes the right to be forgotten, the need for affirmative and explicit consent for the collection of data, and severe consequences for non-compliance. This includes biometric data which, except under exceptional circumstances (e.g., issues of public health or is critical for legal claims or use of public services) cannot be collected without the subject's consent. Moreover, because the GDPR applies to organizations collecting data on EU citizens or residents, it has wider international impact. Although the GDPR has set strict procedures whereby many organizations needed to change their approach to privacy and data management, debates about the balance between privacy, security and democracy remain (Freitas et al., 2017; Liberatore, 2007), with limitations to the biometric driven security measures being taken elsewhere in the world (Rommetveit, 2016).

In the US, there is no single federal law on data protection, despite the more widespread use of biometrics. California introduced a comprehensive law (CCPA) in 2018, which, along with the introduction of the GDPR, creates pressure for further federal regulation (Gemalto, 2020). However, at the moment, self-regulation is still the norm, and many large businesses have independent agreements with the federal government (Benson, 2018). For instance, under its agreement, Facebook needs affirmative, express consent of the user to recognize her face in uploaded photos. However, it is possible to use biometrics to identify individuals without consent when data is obtained in public spaces (e.g., through street cameras) (Gemalto, 2020). Calls for the protection of privacy, considering the permanence and uniqueness of biometric data have been made (Benson, 2018); however, the US is increasing its use of biometric recognition for public security and surveillance (Burt, 2019a).

3.3.2.1.6. Latin America & the Caribbean

Although there are regulations on the use of biometric data and their consideration of sensitive data in Peru or Colombia, most Latin American countries have not yet developed solid regulations to

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support the safe management of data and prevent pervasive uses (Garrido Iglesias et al., 2017). However, social acceptance of biometrics for commercial purposes is relatively high, and it is a growing market, particularly in the banking and insurance industries, where biometric identification provides another layer of security (Burt, 2019b).

Despite the lack of supporting regulations (Garrido Iglesias et al., 2017), the case of facial recognition in Chile has been recently brought to attention, due to plans to use facial recognition to identify the leaders of the ongoing social revolt (Delgado, 2020). However, technologies of facial recognition in crowds are still emerging; hence the use of sensitive and potentially inaccurate data to support criminal claims was brought into question. Other countries, such as Peru, have developed legislation to use such technologies for non-commercial purposes; for instance, voter identification, but have not implemented such systems for the moment.

3.3.2.2. RRI-like practices in response to issues in deep learning and biometrics, and relation with competitive advantage

Notably, the socio-ethical concerns and degree of regulatory development vary across regions, which results in different RRI-like responses. However, there are certain similarities and further convergence on social reactions. Some of the major concerns that were shared across regions involve the use (and potential misuse) of data; the uncertainty and ambivalence of new technologies, and the lack of truly informed consent. Problems of gender and racial bias in the technology were also identified.

The possible misuse of data was highlighted by several respondents across regions. One of the major questions was who was going to have access to the data. The issue of access to and use of the sensitive data obtained by biometrics was highlighted across regions, as illustrated by the following quotes, pertaining to university professors in Peru and Lithuania:

> "*I think it basically depends on the use of technology. At the end, artificial intelligence is a technology. I believe that the challenges mostly come from the area in which they are used, and the use given to this technology. I believe that the ethical questions come mostly from which people will use it. [For biometrics], I think it is about information security, the protection of people's private information*". (Interview J)

> "*We have automated systems that can do something to identify, classify or recognize, based on data, a disease, a bacterium, a person, a voice, etc. How this should be ethically handled is the same question of whether you may be tracked by some agent, whether she has the right to do that*". (Interview D)

In that regard, trust in the stakeholders involved in the collection, management and use of data is essential for the correct development of safe systems; in order to make sure that there are no data breaches and only adequate agents are responsible for using the data for the intended purposes. These aspects of trust were highlighted by an engineer working on the development of deep learning networks (Interview A), in relation to anonymization and transfer of data across stakeholders:

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> "*One way to bring the data out is to anonymize them in-situ and then you post them to the cloud, encrypt them. Yet again, for these technologies, trust is the key word here. The trust of the infrastructure is of paramount importance. Everybody's working towards making the infrastructure trusted because it has to be shared with other […] workloads that belong to different persons, different stakeholders. Breaches between those co-located workloads would allow somebody that is not right to have access to this data*". (Interviewe A)

In the case of biometrics, the privacy concerns are amplified by how deep learning could be used to go through biometric data to examine to find patterns that could not be evidently identified before (for example, this it would be the case for gait recognition, which can be linked to other personal data and easily collected through street cameras). This aspect was noted by Interviewee H, from a research organization and think-tank in Germany:

> "*One, of course, being privacy and the fact that through better artificial intelligence systems, you can now connect data and you can actually find patterns that allow you to identify sensitive information in cases where there wasn't really sensitive information provided. I think this can really lead to new breaches of privacy that we haven't had before*".

As noted in the quote above, the emergent nature of artificial intelligence opens the gate to unwanted uses and new kinds of data breaches that legislation could not have anticipated. This is related to the ambivalence of new technologies, which was highlighted in several regions, since the effects and uses of the new technologies is not fully known yet. This was highlighted by Interviewee E whose company provides biometric identification systems in Germany:

> "*Biometrics as such, is not good and it's not bad. It's like a knife. It's a tool. You can use biometric technology to verify the identity of people, and after having done this identification or authentication, you can open a door, you can switch on the light, you can let the appropriate type of coffee coming out of the coffee machine, you can start the engine of a car*".

In this regard, the protection of data was seen as a responsibility of the company for Interviewee C, whose non-for-profit organization works mostly in regions in development (Sub-Saharan Africa, South East Asia). While their use of biometrics for development provides access to many services (such as unified health records) in rural areas, the need to protect populations that are particularly vulnerable was placed on the company itself, rather than the organizations (NGOs or governments) that acquired the technologies:

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> "*An overarching challenge is the piece around data privacy and security. It's something that we take very seriously. I think there's a huge responsibility if you're providing technology for some of the world's most vulnerable people. You can't afford to get anything wrong in this area. It's something that we have at the forefronts really of what we're doing*".

In the case of artificial intelligence, Interviewee D noted how it could be compared to the ambivalence of nuclear energy and nuclear weapons, highlighting, in this case, how public awareness could help to drive the direction of development of the technology:

> "*I guess there are a lot of people that believe that this weapon stopped the World War II and started new type of energy, nuclear power. Maybe, artificial intelligence is also going to be a very powerful weapon and it starts to be used. Everyone will aware are about capabilities of such type of artificial intelligence, maybe. Then, they will start to apply it more carefully*".

However, the current lack of knowledge or public activism was noted as a difficulty to support the inclusion of privacy issues as a major ethical gatekeeper in the use and development of deep learning and biometrics technologies. Interviewee H, who managed a project on the development of rules for artificial intelligence systems, noted the existence of a 'privacy paradox' in the behaviour of consumers (hence disincentivizing the inclusion of further privacy requirements). This might be based on a lack of knowledge of the data collection procedures and uses, and noted the co-responsibility of consumers:

> "*With B2C (business-to-consumer) we know about the problems like the privacy paradox; and so people say they care about privacy, but then when it comes to buying safer technology, they don't act like they care. I think, to some extent, this paradox is because privacy is not explained well or the impact that the technology has on people is not explained well and that stands in the way of people acting responsibly*".

When it comes to racial and gender biased, this was perceived as a problem in technology development, but their severity origins were perceived differently across regions and stakeholders. In the case of Latin America, two main issues were identified, as noted by the professor in Peru (Interviewee J): mainly, a technological one – systems are not trained for Latin America's racial diversity – and a development one, the fact that most of the companies operating in the region are not local (and hence train their models based on other traits):

> "*Obviously the models that are made to make some kind of recognition, depend a lot on the type of information they collect, and for that I think it would be necessary to make an analysis, what type of data they use... […] Because generally there are no companies in*

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> *Peru that develop their own applications, they are usually applications that come from abroad. It could be, for example, thus a very typical case, facial recognition, as an example. These models have been trained with data that are external, and if I want to make a recognition similar to the people I use current models, but generally those have not been trained with people from here, from this environment*".

On the contrary, racial bias was not perceived as a major issue in Asia, as noted by Interviewee I, who worked in a multinational company based in Japan, precisely because of societies not being so diverse:

> "*The problem of racial bias is not so significant in Japan. But in the United States and Europe, racial bias is quite a problem. In China, however, there is not much problem at present. This is because there is little ethnic variation with respect to population*".

In the case of businesses in other regions where more diversity and recognition bias were identified as an issue, different approaches were taken in response. For example, for Interviewee C, whose company is not-for-profit and operates in several African and South East Asian countries, the need to make biometrics accessible as a tool of development, led to the adoption of the technologies by local beneficiaries:

> "*Racial bias and gender bias as well. We find that a lot of the existing algorithms work very well for white men and not very well for the majority of our beneficiaries who are women of color basically. That is a technological challenge that we're really looking to address as we moved more towards developing the modalities, facial recognition. It will only work as well as data that you put into it. We're working on creating our own data sets and really making sure that we don't develop a product that works well but not for our target beneficiaries*".

However, adapting the model to racial diversity was noted as a significant barrier to access to certain markets; hence, resource-limited SMEs, such as the one in which Interviewee F, from Spain, find severe limitations in new markets. As a consequence, they focus their efforts in training the models for the markets that are sufficiently large to be able to provide a return on investment:

> "*If we tried to sell in Africa right now, it could be, but it would cost us a lot more because we don't have people for it. We would have to grow in every possible way [including technically, number of employees]. […] Nor is it that we have limited ourselves in any case; it is simply that we have to choose where to make that effort*".

This need to keep a good return on investment and sustain the competitive advantage of the company is understandable at the micro-level; but it also provides further insight at the macro-level: in order to

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develop a national competitive advantage, it is necessary to overcome this bias by providing tools for development also for local research and innovation actors, as noted by Interviewee J, from Peru:

> "*The use of technology gives you a differential, that does not need much thought. The point is that in third world countries like ours [Peru], we don't have the trained people who know how to implement this whole situation, all this technology. We are generally using technology as canned packages that come from abroad, and we do not know our own so that they can be used*".

When it comes to responding to these issues while developing a competitive advantage, the responses vary across regions. The emergent nature of the technology and the ongoing breakthroughs called for anticipatory measures aiming to avoid the identified risks of privacy and misuse of data. Interviewee H noted how such measures (such as technological impact assessment) are and should be included in standards for the development of deep learning software, particularly in a participatory and responsive way:

> "*Something that is actually part of […] a lot of principles out there is the demand for a mandatory technological impact assessment before the use of the technology. I think for particularly for government use of AI software, this is really key to really think of possible unintended consequences because we know so many cases where I'm pretty sure if this would have done before and if people who are later affected by the use of technology would have been involved in this assessment, they would have anticipated a lot of the bad things that happened much later. So, such a technological impact assessment should not only lay out the risk but also should entail measures that are taken to avoid that these risks come true*".

When it comes to application of such measures in businesses, in the European context these are guided by regulation (such as the GDPR), since the law already provides many guidelines about data management, although additional anticipatory measures are embedded in the vision of responsibility, as noted by the company providing biometric identification services in Germany (Interview E):

> "*We are extremely careful before we do anything, and all potential impacts are considered in advance. This is for sure. In that sense, we act responsibly, and our owner wants us to act responsibly, but this is all embedded, so to say in the legal context*".

Such measures are adopted across regions; however, the regulatory context sets the rules of the game; hence allowing businesses and the countries to develop a competitive advantage based on the adoption of precautionary measures. The importance of such regulatory sensitivity, along communication and education on the technological advances for policymakers and the general public

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were highlighted for the case of Peru (Interview J), noting their relevance for competitive advantage and socio-economic development:

> "*From a technological point of view, there is no longer any hope, but I know that this technology can be used for the benefit of society, can be exploited, widely used and improve society itself, give a better quality of life to people. I know that that can be done, but that depends a lot on the population also being prepared for all of this, but unfortunately in third world countries like ours, starting from the authorities, there is no such awareness. My fear is that if no action is taken, this may even lead to a wider gap*".

As noted for the case of Peru, public awareness and acceptance of the technologies is key, and the ways and needs to achieve such acceptance also varies across regions. The strict legal compliance and impact assessment found in Europe, was not of direct application in other regions, where different cultural and religious understandings come in place when providing biometric data. These aspects were also highlighted by the company operating mostly in Sub-Saharan Africa and South East Asia (Interview C), for which inclusive anticipation was key for achieving social acceptance:

> "*Other communities may have religious sensitivities or cultural sensitivities. If you look in your facial recognition, for example, there are very varying ideas about taking an image of someone's face and how appropriate that is. It's something we have to be very aware of*".

In addition, reflective measures were seen as important to deliberate on the possible outcomes of the technology and their social acceptance, particularly in Europe. The need to find formulas that allowed for deliberation without excessively lengthening the research and innovation process were noted, since the first mover advantage would be key for competitiveness, as noted by Interviewee E:

> "*You have to be careful with that what you do, and you have to have a close cooperation among the partners, that you can discuss issues. That all partners know that as soon as there is some technological status reached, where the result could be somehow sensible, that we would have to talk about that. I think you cannot prevent technological progress. If we don't do this, someone else will do this. If we do this and are among the first adopters into this responsively, then we set technologies. If we walk behind, then the train is gone*".

The idea of common reflective measures for the industry, perhaps developing second-order reflexivity measures, such as standards that incorporate socio-ethical concerns, was highlighted by businesses, as illustrated above. This would imply developing such standards at a pre-competitive stage, while not sharing information at a later stage, since competitive advantage may be sustained by such information asymmetries. In order to level the field at the competitive stage, an expert working on

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the development of standards supported the idea of procurement requirements to be introduced to provide companies engaged in RRI-like practices with a competitive edge (Interview H):

> "*Another thing is when we talk about B2B or B2G, B to governments apps, it depends a lot on procurement standards. I am a big believer in the power of procurement standards. I really want to push actually for a revision of procurement standards of the German public sector when it comes to AI technology because I think here you can really move a market and, for example, demanding that providers of AI technology to government agencies allow for some type of scrutiny should definitely be a part of procurement. Once this happens, then, of course, it becomes a big advantage*".

The idea of introducing these socio-ethical assessments in the research and innovation process is, however, difficult, first, because of the interactions with competitive advantage noted above – which called for second-order reflectivity measures; and second, because it is difficult for research and innovation workers to step out of their positions and engage directly in such processes. Having to do so requires training and the inclusion of external experts in the reflective process was suggested by a policymaking agency to ensure the balance between economic and training efforts and the need for socio-ethical assessments (Interview G):

> "*Bring in the people you need to bring in that have that [ethical assessments]. If you have somebody who was stuck inside in a lab developing new sockets or whatever, they're thinking about the technology. They're not necessarily thinking about the bigger picture. It's important that it is covered somewhere*".

Beyond the inclusion of experts in the innovation process, the inclusion of the general public in the development of standards was suggested to improve not only the ethical standing of such standards, but also the social acceptability of the resulting technologies. However, as noted by Interviewee H, this often implied resistance because of the need to protect business secrets:

> "*All of this can be avoided if we think about these problems in the process of building the system. If we make sure we have balanced data sets, if we involve people affected or organizations representing them in the development process, if we test these systems regularly, then we can deal with these issues. However, oftentimes because there's new, for example, the governments feel there's new private sector stakeholders involved, business secrets can become a big hurdle for this type of accountability. We've seen this in so many cases, unfortunately*".

Beyond these procedural concerns, practices of inclusion were considered to be key in the development of biometric technologies across regions, although the way and motives for which these should be incorporated vary across regions. While in the case of Europe & America, as noted above,

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the focus is placed on accountability, in regions in development it is not only about social acceptance, but also the need to adapt technologies to local conditions of operation (temperature, humidity, access to electricity, local uses…). This was noted by Interviewee C for the case of South East Asia:

> "*When we designed our very first fingerprint scanner, which is now one of our core products, this was co-created in consultation with frontline healthcare workers in Bangladesh. The design of it, the way it works, how it plugged into their work, that was all done really in collaboration with the people who would actually be using it. That was a key principle really of how we designed that innovation process*". (Int C)

However, the approach in Japan was also closer to the European approach, concentrated on the social acceptability of outcomes and business accountability, as noted during Interview I:

> "*We are very concerned about that point, and our company considers social acceptance as a keyword. We call it social acceptance (Note: English transliterated phrase). In terms of social acceptability, it is very much respected and a top priority to which we pay attention, so things which are connected to privacy and human rights, even if they are technically possible to do, if they are not going to be socially acceptable, our way of thinking is not to go ahead with such things*".

In the case of Latin America, inclusive processes were directed towards public engagement and science education, aiming to increase the levels of awareness and education on the technologies, allowing to develop a national competitive advantage and closing the technological -and economic- gap, as noted by Interviewee J:

> "*At the Latin American level, taking out some countries such as, perhaps, Brazil, a bit Argentina, and now a bit Colombia, that have deployed quite a lot what is research... The other countries, we are very delayed, Chile may change a bit. We are very late. For me it is a matter of education, there is no other way out. If your people are not well educated, obviously they will be permanently relegated*".

However, in order to be able not only to create but also sustain a competitive advantage, across regions, it was shown that companies need to stay close to the realities of their users, being responsive to their demands and adapting the research and innovation processes and outcomes. For example, Interviewee C, whose company works in Sub-Saharan Africa and South East Asia, highlighted the need to adapt and respond through other identification systems in those cases when users would not consent to providing biometric data, in order to still be able to consistently deliver the service:

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> "*People should always be free to say, "Actually, I don't want to give out my biometrics. Let's use another method." That's something that we work really closely on*".

This also implies following new user and technological trends, as in the case of 'explainable AI' raise for the case of Lithuania by Interviewee B, which would be particularly important as awareness on the technology increases:

> "*We have now a new trend coming. It's called explainable AI. The truth, especially for the medical things, medical care, it should be explained how the algorithm made a decision for the clinic*".

3.3.2.3. Summary and implications

In the case of deep learning and biometrics and how to handle the socio-ethical issues that emerge from their use, it was observed that different regulatory responses had been developed across regions, and also that the uses allowed for such technologies were different across regions. However, a concern shared worldwide was (particularly in the case of companies and researchers involved in the development of such technologies) the development of trustworthy structures that wouldn't allow for misuse of the technologies. Sometimes this was translated into the development of industry standards: interestingly, these second order reflexivity approaches were favoured by many of the participants in the interviews in relation to competitive advantage. Particularly at the macro level, these standards were shown to close the gap of technological development between developing and developed countries; but also at the micro level, they levelled the field for smaller businesses that could not design standards for trustworthy infrastructures at such high level by themselves.

Focusing on biometrics, the inclusion of racial bias racial and gender bias issues were a very significant problem to be addressed through RRI-like practices, and a major driver of competitive advantage in some regions. For instance, in the case of Latin America it was noted that models for biometrics are mostly trained with people who are not local; therefore local companies that could train models through inclusive principles would have a competitive edge in ensuring better recognition, which was a very important requirement for the banking and insurance companies that were the most relevant clients for the technology providers. In the context of Africa or South East Asia, or areas whose population includes very diverse ethnic backgrounds, inclusivity was shown to be even more relevant in terms of making a good technology that will work in that context. However, this concern was not widely shared; for instance, ethnic diversity was not perceived as needed to be included in the models in Japan, and it was not something that was widely acknowledged also in the European context. For SMEs acknowledging these limitations meant not accessing certain markets because technology was not sufficiently adapted to the local ethnic diversity.

In any case, anticipating and being responsive to the emergent issues was shown to be very relevant in the development of competitive advantage in the domain because of the speed at which the technology is developing and the increasing number of breakthroughs that are rapidly being commercialised. The approach in this domain revealed two trends in the field that where consistent

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with RRI-like responses in relation to competitive advantage. The first one is standardization and internationalization; that is, adopting a global approach and having secure structures and an ethical baseline across countries. This would allow for uses that respect human rights and sustainable development issues (in line with the OECD principles for AI), but at the same time, there was need to adapt technologies to ensure that there is no racial bias or no gender bias, and that the technology can actually be used in contexts for which it was not originally designed. This showed a level of international understanding relevant for the domain and basic normative anchors like human rights or the SDGs, but at the same time, a need to adapt to local environments. This was also shown by some companies in the bioeconomy case, who suggested that it was necessary to have one ethical policy for the whole company despite then needing to adapt local strategies to gain a competitive advantage.

3.3.3. Gender equality issues across cases

In addition to observing how different actors respond to socio-ethical issues through RRI-like practices while balancing competitive advantage considerations in their industries, we also noted aspects of gender equality for both cases. Since gender equality is a transversal issue that is part of the six policy keys and the SDGs, it allows for the observation of both procedural and outcome dimensions, and it provides a good perspective on the development of matters not directly related to the studied domains. Wider diversity considerations were also included. Four main dimensions were assessed in relation to gender, RRI-like practices and competitive advantage: gender equality in research and innovation processes, gender and diversity in research and innovation, sustaining formal equality programmes and representation, and the development of a competitive advantage through diversity.

3.3.3.1. Gender in research and innovation processes

In terms of the inclusion of gender and diversity aspects in research and innovation processes, not only the regional cultures and institutions, but also domain and organizational culture played a very important role. Domain-related considerations were considered to be very important; mostly because of the availability of qualified researchers to be hired by the organization. Within the same region, Europe and North America, significant differences were found between domains: as illustrated by Interviewee Q, from Lithuania, gender equality was met for CRISPR (even if not for research work, in general):

> "*What we really observe that still in the research community, is that men are the major players in the market and there are not so many women. In the CRISPR technology field however, I will say two of the main founders of this technology from US and from Europe, they are women professors. Other two are men, so it's like equal*".

However, in the case of biometric recognition, the representative of the company headquartered in Spain, noted that there was a gender imbalance because of the lack of sufficient graduates wanting to work in the topic; hence reducing the pool of female candidates (Interview F):

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> "*I have not been discriminated at any time for being a woman, but […] it is very difficult for us to find the profiles. In fact, we will now publish job offers, because we are growing a lot and we need people right now. It is not that we look for more men or more women. Anyone who fulfils the requirements that are requested is sought for and well-received. Another thing is that yes, in the end it turns out that we see by graduates of the university, and the majority of computer or phone [engineers] are men. In companies, most were men. In another sector, most of them are women*".

The culture in the research team -often pivoting around the CEO, particularly in SMEs, was also a very relevant aspect, as noted by the CEO of a company when asked about why there were more women in her team (Interview B):

> "*Because I like working with women. [laughs] They listen. Men don't listen. They have their own perspective. They want to do like this, and that's it. They (think they) know better. Every time, we have a fight*".

Another interesting aspect of the inclusion of gender aspects in the research processes, beyond balances in the workforce, is related to inclusive practices, and who and how to include in the research process. To this extent, local cultures and gender roles were very important. This was highlighted by a researcher in Nigeria, who noted that the possibilities of inclusion of women were scarce because of the traditional division of labour (Interview M):

> "*The way our system works here it is such that men are the ones that are very active on the farms. The female amongst them are mainly their wives or members of their family. Often times they are not there except during harvest. Each time we see them during harvest it's an opportunity to once again try to explain the project to them and let them understand how useful this could be to their agricultural activities. But it's their men that we meet in the beginning of the sensitization of the program. It's actually their men that we often take to the bar and sit with them over a few drinks and then chat about the projects and how much role we would like them to play on the project*".

However, it must be noted that, across regions, the inclusion of women and other minorities to incorporate a diverse perspective that would inform the research and innovation process was considered to be a source of competitive advantage. This was also the case of a biometric technology provider, based in Europe but operating mostly in Africa and South East Asia (Interview C), which highlighted the value of diversity to anticipate and resolve a wider range of challenges earlier in the process:

> "*It's the right thing, but also we find that if you're developing technology, having as diverse a number of view policy as possible leads to better innovation. If you have a mix of genders*

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> *and mix of backgrounds, a mix of cultural backgrounds, national backgrounds, you end up identifying potential challenges much earlier, you'll end up not getting into the situation of taking something for field testing that is completely wrong for the context. You will have identified more challenges, more potential pitfalls much earlier in the process*".

In the case of Latin America & the Caribbean, the focus was placed on meritocracy and being able to attract the best, and most diverse talent, as illustrated by a university professor in Peru (Interview J):

> "*Particularly we stimulate a lot that within our research projects, for example, as part of the team, many women from different regions of the country participate, that is what we try to do. We have no question that-- Whoever knows, knows, be it a woman or a man. We handle it that way. […] There is no restriction on that*".

However, in the case of Japan, interviewees noted that most of researchers were men and that, despite the willingness of teams to hire women (and providing equality programmes, see below), it did not necessarily mean to wider diversity of opinion, as noted by the representative of a Japanese company (Interview I):

> "*Of course, there are women and men at the [department]. In that sense, we don't only take men and we don't only take women. In this sense, they are treated fairly. Our group of course includes female staff. I don't think I'm particularly conscious that women have different opinions because they are women*".

3.3.3.2. Gender in research and innovation outcomes

Another aspect to be considered is how gender is incorporated into innovation outcomes. For the technologies and domains in the study, some differences could be observed. For instance, in the case of CRISPR, this was not considered to be a major issue to be considered in designing the possible outcomes. This was noted was by the CEO of a company in Lithuania (Interview Q), who highlighted that medical problems were not necessarily gendered, although trials on both men and women were necessary:

> "*I would say that most of the diseases they are equally important for men and women. We might say that women sometimes have one kind of disease more than other, but having in mind rare diseases, having in mind major cancer variance, there is no gender issue. I know that when our partners if they reach the stage when they start the clinical trials, they have to do it equally with men and women because well, society is both men and women equally. I know that some other companies are even working in the field of personalized medicine for children which that it's even less important if it's a boy or a girl. It's a common problem for everyone*".

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Nevertheless, when speaking about uses of CRISPR techniques for foods, rather than medical uses, safety issues need to be considered for different groups, as noted by an expert in Japan (Interview S), who stressed that safety considerations might vary for different groups:

> "*We must remember that certain foods may not be safe for pregnant people, small children or those with special conditions*".

However, when it comes to biometric recognition, the racial bias acknowledged in the sector (due to the models being trained mostly with white males) extended to gender, as noted by the innovation manager of a provider in Japan (Interview I):

> "*There is a similarity to racial bias. A gender perspective relates to, for example "a woman", does it not? If women cannot be recognized or if men cannot be recognized… our technology is required to overcome various differences according to gender in terms of inability (to recognize), so in that sense gender, as with race, the point is whether correct recognition is possible. That's the gender perspective for us, I think*".

In order to incorporate such outcome considerations, adjustments in the research process are necessary. However, this might mean just acknowledge these outcome issues in reflective processes, focusing then, on the outcome dimension; or aiming to have more diversity in the research process to help in anticipating these outcomes, but with a procedural emphasis. However, deciding which path to go, particularly in standardization processes, is not an easy task, as noted by Interviewee H:

> "*This goes right into the discussion of product versus principles standards because, of course, when you say, "Our standard will be that the accuracy of the AI system needs to be this and this," you have a guarantee that it will be that once you've tested it. When your principal is something that talks about the process, like please involve people who are affected or please involve a diverse group of people, we believe that this will also positively impact the outcome of the technology, but we don't know for sure*".

3.3.3.3. Equality programmes and representation

In addition to the research and innovation process and outcome dimensions, organizations also engage in equality programmes (providing equality of opportunities to work and thrive in the organization) and representation (having more diversity at the decision-making level). These aspects are important for research and innovation as well, since they provide the structure on which research and innovation processes will be carried out.

Differences per region might be observed. In Latin America & the Caribbean, similarly to considerations of gender in the research and innovation process, meritocratic principles guided

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policies; hence focusing on equality of outcome, rather than equality of opportunity, as noted by a researcher in Colombia (Interview K):

> "*Fortunately, things have turned out well for me, and I think it is not for being a woman but for having done things, showing results*".

This also translated in equality of outcome focused communication strategies, in terms of science education (Interview R):

> "*The truth is not, we have not made any discrimination or programs focused on women or men, but it is a general program for all, and the communication strategy is the same*".

In Japan, the focus was placed on avoiding discrimination at the time of hiring, but also, on the provision of services that allow both sexes to find a balance between work and personal life, with family friendly arrangements, as noted by Interviewee I. This is particularly important in this context because of the very little available holiday and long working hours that characterise traditional working arrangements:

> "*We have a flexible working arranging, with family-friendly time off arrangements. These include maternity leave, family member illness leave, and childcare leave. Childcare leave relates to women in particular. They can. So, both genders can equally take such leave. Parental, or other, leave does not necessarily deal with "the problems faced by women*".

In Europe and North America, the approach is mostly based on principles of equality of opportunity, which translates in hiring practices that aim to eliminate any kind bias, as illustrated by the hiring practices in this enterprise (Interview C):

> "*We're really trying to be at the forefront of hiring practices, for example, in our most recent round of hiring, we had a completely blind assessment process. The hiring manager wasn't given a name or any identifiable information. They were given an assessment for the task. They assessed that and then only once they decided right here are the people that we want to invite to interview, only at that point were they given any information about, for example, the gender or their nationality. We found this was really useful, in terms of really trying to stand apart of that unconscious bias, {…] it's much better than training people on unconscious bias, it's much better to actually just remove the chance of bias as far as you can*".

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However, one of the companies (Interview F), who discussed their difficulty to achieve gender balance in the teams because of lack of diversity among the qualified candidates, and the need to implement practices earlier to ensure that girls are not discouraged from STEM careers from a young age:

> "*Maybe it is that discrimination is in the primary education; that you are going to like one thing, or that you are going to like another, and you don't give everyone the same chance. Maybe you have to go much further back*".

In fact, these domain-related considerations were also noted by Interviewee C not only in terms of achieving equal numbers in research and innovation teams, but also in terms of representation at the decision-making levels. Having representation at the top level resulted in further commitment to gender equality and diversity in the organization.

> "*We take it very seriously as an organization to try and make sure that we hire a very diverse team. One of the founders of the organization is female and sadly, it's not actually that common for a tech company to have a female founder. That's really important for us and something that we want to make sure that we continue as the organization develops*".

For this reason, at the policy-making level, representation (rather than absolute numbers of gender balance) is gaining relevance in Europe & North America, as illustrated by a representative of a public agency providing support to SMEs in Ireland (Interview G):

> "*We don't say that has to be a female CEO, but there have to be females in senior management somewhere. One of the things that we have found looking back historically over companies is, we've always had a low number of female CEOs. Then when we look further into that, it's we don't have that many females in senior management roles. If they're not in senior management role, they don't end up in CEO positions*".

3.3.3.4. Value creation through diversity

Across regions, the value of incorporating diversity concerns in research and innovation process and outcomes was acknowledged as an important tool for value creation; hence driving the development of a competitive advantage. This value was mostly acknowledged in industry, both in the case of large and small enterprises, in both domains. This was, perhaps, the stakeholder that had a stronger emphasis on value and competitive advantage; therefore, it was not so often acknowledged by other actors. However, the value creation aspects were illustrated by the representative of a large multinational enterprise working on biometrics and deep learning (Interview A):

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> "*I think everybody has something to bring, and just expanding the ability to get everyone on board, just don't have filters that are not-- don't have silos or anything about anyone or any different cultures. It's super fine and it brings value to the business. If you take [company], it is full of different nationalities, full of different people. It's been working very well for many years*".

However, this was also noted by a smaller company (Interview C), who highlighted the role of having a diverse team in increasing the efficiency of the research and innovation process:

> "*It's the right thing, but also we find that if you're developing technology, having as diverse a number of view policy as possible leads to better innovation. If you have a mix of genders and mix of backgrounds, a mix of cultural backgrounds, national backgrounds, you end up identifying potential challenges much earlier, you'll end up not getting into the situation of taking something for field testing that is completely wrong for the context. You will have identified more challenges, more potential pitfalls much earlier in the process. Absolutely, there's huge value I think for any technology company in having a very diverse workforce designing it*".

In addition, the value of diversity in other research organizations was also highlighted; particularly in academic research (Interview D), since diversity increased the chance of coming up with novel ideas, and minimized risks for the whole research and innovation system:

> "*It is a contribution if people from somewhere else with slightly different ideas come in, at least at the academic level, when you look at those articles, publications, what algorithms accomplish, differences are in fact an advantage because they bring diversity, as you say, they bring diversity and it is beneficial for everyone, because everything is still evolutionary, if a lot of things happen, there is little chance that they might be better than the classic ones. That being said, we can jump from one pit to another in optimization, in the sense of minimization, that is, we get better in the sense that if we minimize something, we can get to the next maximum that is more comfortable and better for us. The more diverse the systems, the better*".

3.3.3.5. Summary and implications

In terms of gender and wider diversity, they are transversal for research and innovation, since they involve both procedural and outcomes dimensions. Differences between the domains were not so significant in this case, it was the organisational and local cultures that drove the implementations of RRI-like practices in different areas. However, it must be noted that the only references to value creation through diversity were made by organizations based in the Europe and North American context, although indirect quotes in this regard were made across regions. Nevertheless, the fact that

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the recognition of such a direct relationship was only noted in this region might be linked to the results in the survey, where gender and ethnic diversity inclusion practices were negatively related to the development of our competitive advantage. This could be linked to understandings about how equality concerns are built in the organization.

For instance, in the case of Japan, equality was mostly perceived as programs that were introduced in the organization such as family care programs that allowed both sexes to have adequate maternity opportunity leave. However, when approached in this manner, this could have an additional cost (despite improving employee engagement) rather than being a direct driver of competitive advantage. In other regions, this relationship was perceived as strategic, and therefore it was included for both process and outcome dimensions. When it comes to the process dimensions, it was understood that having a more diverse team would help with anticipatory and reflective measures; therefore, avoiding problems that could not otherwise be anticipated. It could also be helpful to tap into new markets that hadn't been explored before because of an oversight of the realities of minorities; however, this was also introduced as an outcome dimension. In this regard, the local cultural practices were more determinant of whether these outcome dimensions were included; for example, when it comes to dissemination of results or engagement of women in the research process it was not always possible to engage them because they weren't working in the same contexts as men. In some regions, the approach to equality was based on equality of outcome, while others focused on equality of opportunity. Different approaches would also result in different considerations for competitive advantage, to the extent to which diversity was a moral need ("the right thing to do") or also a strategic consideration that might bring added value to the company.

In a nutshell, it was perceived that a strategic approach to gender, focused more on equality of opportunity, would better drive competitive advantage based on such inclusion practices, while programs based on equality of outcome or percentages of minorities (regardless of representation) would not have such a great impact on the development of a competitive advantage, as noted also by the results of the survey.

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4. General conclusions

4.1. Limitations of the study

The study presents several methodological limitations, which opens avenues for further research, but advises some caution in interpreting the results. The desktop research showed that the existing literature on RRI-like practices and competitive advantage is mostly Eurocentric and normative. While this study aims to address these limitations and learn from other world regions from a bottom-up perspective, this must be taken into consideration, since the desktop research informed the development of the research instruments.

On the qualitative research strand, it is notable that no access to organizations in the Arab States was obtained, and very limited empirical access to regions other than Europe and North America were obtained. While this was partially supplemented by secondary data, the fact that the study did not reach a fully even coverage must be acknowledged. Further research with local researchers and in the native language is recommended. While it is not possible to generalize the data obtained through the cases, there is sufficient analytical generalizability to observe trends in similar fashion in other contexts.

When it comes to the quantitative strand, the response rate of the survey was very low. While this was considered enough to proceed with this first study, this is indeed a major limitation to the representativeness of the study. It is hoped that the dissemination efforts carried out as part of the RRING project through UNESCO and the RRING partners will yield further awareness and interest in RRI outside the European Union, which would favour higher response rates in these regions in future studies. Besides, the cross-sectional nature of the survey presents limitations in terms of drawing causality in relationships (Bryman, 2012).

4.2. Discussion of contributions and future research

This is the first worldwide study on RRI-like practices in relation to competitive advantage. It adopted a constructivist approach to examine such practices, how they may create drivers or barriers to competitive advantage and attitudes and engagement of research and innovation professionals in different regions in RRI-like practices in relation to competitive advantage. It also examined the cases of RRI-like practices in action through the cases of GMOs and gene-editing techniques, and deep learning and biometrics. Through this research the question about how competitive advantage based on RRI-like practices can be developed and sustained was observed, which resulted in a list of practical recommendations for different stakeholders. It also provides insight into this relationship for future research, through the illustration of how RRI-like practices are influenced by domain, geography, and stakeholder, and how competitive advantage considerations also determine to what extent and in which manner organizations will engage in the management of socio-ethical concerns.

However, the limitations posed by the timeframe and resources for this research open interesting avenues for future research. First, in terms of the survey, this first quantitative approximation could not provide full insight on causal relationships, which calls for further longitudinal studies in the future. This would be very useful not only to understand more widely, with a larger sample, how these issues

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have developed, but also to try to examine mediating relationships between attitudes, engagement, and different types of performance. Also, in relation to policymakers it would be ideal to obtain data for a wider sample, and to obtain macroeconomic data to assess whether the practices carried out by local policymakers are influencing performance at the country level. The implementation of macroeconomic indicators of development based on the management of socio-ethical issues would need to be developed beyond the classical macroeconomic indicators such as GDP growth, have including the indicators based on the SDGs to account for outcome dimensions of RRI-like practices accounted for in macroeconomic data.

Moreover, the results of the case studies suggest that there might not be that many differences in terms of the dimensions that are important for the management of socio-ethical issues across regions. However, it was shown that regional differences are highly influential in the choice of particular practices; therefore in order to be able to develop frameworks for RRI that truly adapt to local circumstances (in the way that they have been developed for the Europe and North American context) further research from a bottom up perspective, focused on the interplay between different actors in these particular regions would be needed this would provide further insight into the practices that are being carried out beyond the two particular domains that were examined in this study. It was not possible to access primary qualitative data for the Arab States, which calls for more research on the specificities of that region.

Nevertheless, this study makes a significant contribution to existing research on RRI-like practices and competitive advantage and adds to the literature on company practices for RRI that has been flourishing despite the traditional outlook of actors in competitive environments in relation to RRI. It is noted that further research that includes competitive advantage considerations and the instrumental motives that coexist with moral motives in organizations performing in competitive environments should be further developed, in order to acknowledge the increasing role of businesses in research, science and innovation, and their subsequent potential contributions to science in and for society.

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5. Recommendations: developing a competitive advantage through RRI-like practices

Based on the empirical insight gained through the survey and case studies, recommendations for different stakeholders about how to develop RRI-like practices while deriving a competitive advantage are provided below. First, recommendations for industry, which is the principal actor of competitive advantage at the micro level, are provided. These are followed by recommendations for the main actors of competitive advantage at the macro level: policymakers. Then, recommendations for supporting stakeholders that help to create the context in which RRI-like practices are developed are provided, with the aim of supporting their role in accompanying the principal actors in competitive advantage concerns, allowing for sustainable socio-economic development. These are recommendations for research performing organisations, research funding organisations, investors, civil society, and NGOs and association bodies.

5.1. Recommendations for industry

Industry (both SMEs and large enterprises) has been largely ignored in the RRI literature; therefore, competitiveness considerations have not been well incorporated into many of the frameworks. Some of the tenets of RRI, such as transparency or mutual responsiveness, pose limitations in a business context because of the need to develop and protect a competitive advantage. The recommendations below aim to provide some guidelines about how to engage in RRI-like practices in a way that nurtures the competitive edge of the company.

1. ***Be responsive to context***

While integrating RRI-like practices into your research and innovation process, it is important to adapt to and understand the contextual factors that are affecting it. This has implications both at the process and outcome levels. When it comes to procedural dimensions (anticipation, inclusion, reflexivity, and responsiveness) it's important to understand what are the values and societal concerns underlying the society that you operate in, in order to integrate them and to anticipate and reflect on any possible issues that may be derived from the interaction of the research and innovation work and such values. For example, as observed in the biometrics and deep learning case, it is necessary to train biometric learning models with ethnically diverse profiles to avoid racial bias. Nevertheless, while this was essential for the development for the technology to be accepted and develop a competitive advantage in some regions, it was not as important in societies with limited ethnic diversity such as Japan.

From the outcome perspective, it is important to cater to local societies and to try to understand what that market needs. For example, while facial recognition is gaining ground as the dominant biometric recognition technology, in the case of the Arab States an important consideration is the fact that women often wearing the niqab, which does not allow for facial recognition. As a consequence, the most accepted technology is iris recognition: this allows for the use of technology for both men and women. However, in other cultural environments where facial or iris recognition does not have high

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social acceptance because of the capture of personal image is considered to take away a part of the self, other methods such as fingerprinting have been more successful. This shows how outcomes of the research and innovation processes need to be adapted to local context in response to local values.

Being responsive to context will increase the social acceptance of the research and innovation work and therefore increase the chances of developing a competitive advantage versus those companies who are not taken into consideration local factors when developing the research and innovation.

2. ***Participate in standards development***

Carrying out participatory reflective processes in product or service development helps to build a competitive advantage, through the inclusion of diverse perspectives that increase the innovation outcome's fit in the market. However, throughout the interviews for the study, it was observed that engaging in reflective processes to incorporate socio-ethical values in the research and innovation process was often costly, particularly in the case of participatory reflective processes, that may lengthen the time to market and may increase the chances of information leakage to some extent. One of the proposed solutions, which was particularly helpful for SMEs (who have less resources for research and innovation work), was to engage in reflective processes with other stakeholders, including other businesses. These joint participatory processes, particularly when developed at the pre-competitive stage, may result in standards that capture the results of the process. As a result, ethical guidelines that can be translated into technical requirements for the research and innovation process, with a pooling of resources and protection of intellectual property and sensitive information.

In order to fully benefit from standards, it is important to participate in their development. This might be more difficult for SMEs in cases when the standards are being developed at a high policy level (e.g., the OECD principles for artificial intelligence). However, very often such standards are industry specific and geography specific and allow for further participation of smaller enterprises as well (e.g., Algo Rules in Germany). By engaging and implementing these standards, companies might overcome the barriers to developing a competitive advantage that are derived from engaging in participatory reflective processes, while benefiting from increased social acceptance and avoidance unanticipated consequences, as revealed in their participatory standard setting process.

3. ***Participate in networks***

Beyond standard development, which is directly related to the research and innovation work, participating in networks will also indirectly support the development of RRI-like practices. Establishing a network that involves other stakeholders will support further openness in the research and innovation process with well-known partners and frequent collaborators. Such openness and transparency were shown to be related with competitive advantage in the survey, and the benefits of open innovation have been widely researched before: RRI-like practices provide the ethical support base and add diverse social needs to open innovation practices (Long & Blok, 2018). Opening research and innovation work might provide new ideas for product and market development; but besides that, engaging in networks might help to identify stakeholder needs, even if they are not directly involved

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in a given research and innovation process. In addition, participation in a network might support the development of a grid of closer collaborators with whom to share sensitive information for more extensive exchange of ideas in research and innovation work.

While having a fully open research and innovation process might not be possible in all cases because of the need to protect business secrets and information asymmetries, participation in networks provides a good opportunity for two way communication with other stakeholders whereby new information about local social values and concerns will be obtained. A t the same time, it provides the setting for the company to disseminate and share results of their own research and innovation processes; hence enhancing engagement with the general public.

4. ***Apply both process and outcome approaches***

The results of the survey showed how outcome approaches (that is, avoiding societal concerns and tackling societal needs through research and innovation) were directly related with increased customer performance. This means that outcome approaches are immediately identified and rewarded by customers through reputational effects. However, while the focus on these outcome approaches is important, the process and outcome dimensions of RRI-like practices are interlinked. As noted in the results of the case studies, in order to address societal problems and to avoid societal concerns, it is necessary to engage in anticipatory, reflective and inclusive processes and be responsive to changes in the research and innovation process they might imply: in order to fully benefit from the direct link between outcome approaches and competitive advantage, process dimensions should not be ignored, but rather built in in the innovation process early on.

An example of this was observed in the bioeconomy case, on GMOs and gene-editing techniques, where societal concern had limited the application of technology, and NGO pushed public outcry had resulted in stringent regulations. While public communication efforts and having an outcome perspective focused on development and avoidance of the pervasive effects of climate change on agriculture had been successful in some regions, the lack of understanding of the concerns raised by societal actors had led to an undermining of this outcome oriented approaches in others. This suggests that in order to really benefit from open communication and addressing societal needs, it is also important to include stakeholders with opposing views during the research process, in order to fully capture those concerns in the outcomes. Consequently, it is important to provide ethically acceptable, socially desirable and sustainable results, but in order to do so, procedural dimensions focused on mutual responsiveness will aid in the process.

5. ***Do and tell***

Reputational effects and obtaining a social licence to operate were identified as major drivers of competitive advantage based on RRI-like practices; in fact, customer performance was the dimensions of competitive advantage most directly related to engagement in RRI-like practices. However, in order to enjoy such increased performance, it is necessary to communicate with the customers and build a market sustained on brand recognition and reputational effects based on RRI. There are different ways

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to integrate such communications in the company's marketing strategy, which needs to be responsive to the domain and local context. For instance, for one of the companies involved in the biometrics case, this meant engaging with the public, with initiatives for science education that also increased brand awareness. The efforts made through RRI-like practices may also be communicated through certifications or front-of-pack labels (see Recommendation 2 on standard development), which also account for customers' trust. Participation in local and international networks where the results of research and innovation work and the processes leading to them may be shared are also effective ways of communication, in addition to the development of association bodies to share and promote efforts made at the domain level (such as the development of standards).

6. ***Engage and protect***

Intellectual property protection was often cited as a barrier to developing a competitive advantage, despite the other side of the coin being increased efficiency of the innovation process and the ability to tap onto new markets. Hence, particularly in domains where intellectual property protection may be vital for the development of a competitive advantage, it is relevant to collaborate and engage with the whole spectrum of stakeholders, while protecting intellectual property. In order to do so, informal measures may apply during the research and innovation process; for instance, collaborating more closely with a smaller network of usual partners, establishing layers of disclosure with different collaborators, or integrating diverse perspectives into the firm by integrating people with diverse backgrounds in the research and innovation team. Intellectual property may also be protected formally through the signing of non-disclosure agreements with stakeholders invited to reflect on the research and innovation process. In this way, competitive advantage based on information asymmetries may be protected while still benefiting from inclusive engagement.

7. ***Embed RRI-like practices into company strategies***

In order to fully benefit from the implementation of RRI-practices, they should be built into the organizational strategy. Implementing 'ornamental' or merely formal RRI-like practices might mean an additional cost while not realising the advantage derived from it. Hence, *strategic* RRI-like practices that are built into the company's mission and value creation strategies are recommended to develop a competitive advantage.

A clear example of this was observed in the case of gender and diversity considerations. In general, in the survey, companies that engaged in such practices had a slightly lower financial performance. When examined qualitatively through the case studies, it shows that, on the one hand, many companies take an equality approach based on numerical parity, which may sometimes produce difficulties in finding qualified candidates in certain domains or add costs in compensation programmes. On the other hand, companies that had built in diversity in research and innovation teams, found that they could strategize their work based on the embedded diversity; hence helping them to avoid societal concerns and unanticipated consequences, identify stakeholder needs better, and access new markets.

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5.2. Recommendations for policy-makers

1. ***Facilitate contextual factors***

Contextual factors – that is, the background conditions under which companies must operate – were shown to be a very relevant factor in the development of a competitive advantage at the micro level, adding up to macro-economic performance (and hence, the development of a national or regional competitive advantage). These factors could operate both as a driver (for instance, through the development of regulations and policy programmes that reward the implementation of RRI-like practices, or level the field for all players), but also as a barrier (as the example of needing to train locals for community engagement). Policymakers may design regulations that promote RRI-like practices and reward companies that incorporate socio-ethical concerns in their research and innovation work; for example, including ethical stage-gates to access public funding or fostering participatory processes from a quadruple helix perspective. Domain-specific measures may also be adopted to facilitate engagement of the private sector in RRI-like practices, such as development of STEM education programmes for women, minorities or disadvantaged groups, which would increase access to diverse research and innovation teams in a strategic manner.

2. ***Engage in participatory processes when regulating about controversial research and innovation processes***

Emergent technologies often pose a challenge for policymakers, since they often evolve faster than the regulation cycle is designed for. In addition, several challenges are present; first, the inherent uncertainty of novel technologies; second, the strength of public concern and reactions; and third, the need to incorporate techno-economic considerations in the regulation. In order to balance these aspects and develop regulation that are neither too stringent for technological advances and competitive advantage, nor dismissive of public concerns, participatory processes that foster inter-stakeholder dialogue might be promoted. Such dialogues would inform policymakers about the state of development from the technological perspective, the economic outlook and the socio-ethical concerns; hence helping to develop regulations based on technical and social evidence that are well-adjusted to the implementation of the technology in the local context.

3. ***Balance short-term and long-term development issues***

When designing policy – particularly when it comes to emergent technologies – it is important to balance short-term, economic development goals, with long-term development issues. Principles of RRI and RRI-like practices in policymaking might help to do so, as stated above, through participatory processes. Anticipatory and reflective processes might also help to identify issues that might emerge in the long-term, hurting sustainable development. An example of this is the regulation of GMOs in Latin America & the Caribbean, which varies across countries, but aims to protect natural and cultural diversity – in line with the Cartagena and Nagoya Protocols – while including short-term development considerations based on the wider development of the technology.

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5.3. Recommendations for RPOs

1. ***Introduce RRI-like practices fit to your context***

When introducing RRI-like practices in research processes it is important to be responsive to the local context, societal values and concerns. While the survey showed that procedural and outcome dimensions of RRI-like practices were considered important across regions, the diversity in detail of practices in the survey and the case studies also indicated that in selecting in which particular RRI-like practices to engage, the local context is determinant. Moreover, the case studies showed how domain specific issues are also relevant for the definition of RRI-like practices. These are important to take into consideration in order to implement practices that are relevant to address societal concerns and needs in the local environment. An example of this was found in the case of GMO use in the European Union. In this case, RPOs in Europe needed to foster two-way dialogue with opposing stakeholders, since engaging in this dialogue was the only way to be able to promote research on the topic and demonstrate accountability to policymakers and civil society. Science communication practices were sufficient for other RPOs in other regions where more favourable conditions allowed for one-way information sharing to gain social legitimacy. In these regions, the focus was placed on informing others about the safe handling of GMOs. This shows how the choice of practices within each of the dimensions of RRI-like practices must vary depending on context: in order to draw value and develop an advantage based on these activities, a bottom-up perspective about which practices to integrate is necessary.

2. ***Network with diverse stakeholders***

For RPOs, it is important to participate in networks, with a twofold objective. First, to expose themselves to the benefits of open research and innovation practices and second, to identify which are the societal concerns and values that should be addressed in future research processes. In terms of exposure, participating in networks might provide access to a closer net of collaborators while exploring synergies with other stakeholders. This supports the second objective, since integrating the visions of diverse stakeholders can increase the social acceptance of technologies, particularly in the case of emerging technologies. This would help to gain social legitimacy to proceed with research projects and develop consistent capabilities, while remaining close to issues of socio-economic development. In this respect, quadruple-helix networks are particularly relevant to include the vision of other stakeholders in the research process.

3. ***Embed participation and reflection processes in the research process***

When designing research, it is important to include collaborative reflection, in the form of open innovation or through the introduction of ethical stage gate processes, helping to embed RRI-like practices and achieving outcomes that are acceptable for society. In that sense, it is crucial that these practices are not merely ornamental, but rather, that they are firmly ingrained into the research process. As noted in the case studies, this might sometimes call for the integration of (external) ethics

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or social science experts in research processes, to support in the design of reflective process and integrate them better into the research project.

5.4. Recommendations for RFOs

1. ***Contextualize process and outcome dimensions in research requirements***

An important recommendation to support the competitive advantage of a region – but also at the micro level – through research funding is to level the field for different actors of research and innovation in applications for research funding. In order to do so, both process and outcome dimensions of RRI-like practices may be introduced into grants requirements. However, it is necessary to maintain a bottom up perspective and engage other stakeholders in the design of these goals, so that the visions and concerns of a varied spectrum of stakeholders are introduced into the calls for funding. As a consequence, calls for funding would stay relevant in terms of addressing societal needs and enhancing the development of local research capabilities. As noted in the results of the case studies, it is important to introduce baseline RRI concerns in the calls for funding, such as representation of gender and minorities, or the inclusion of ethical assessments. However, the most appropriate techniques for these ethical assessments are best determined in accordance with the disciplinary domain, geography and project specific concerns; therefore, the best way to come down to detail on these assessments would be in consultation with research and innovation actors and supporting stakeholders. In this way, these concerns can be integrated strategically rather than becoming a 'checkbox'.

2. ***Understand funding needs for participatory or reflective processes***

If these requirements of ethical assessments and increased stakeholder participation are to be included in calls for funding, in order to preserve the advantage of actors participating in the call, the costs associated with such processes also need to be acknowledged and built into calls. Participatory processes throughout the research project might imply some financial costs to bring stakeholders closer, which might be taxing – particularly in the case of SMEs and smaller RPOs – or might extend the time needed to finish the project – especially if considerations of responsiveness to reflective processes are taken into consideration.

Therefore, in order to allow research and innovation processes to be developed successfully and avoiding possible threats to competitive advantage, the funding needs derived from participatory reflective processes need to be acknowledged in the calls for funding. Thus, allocating research funds in the calls for the development of such RRI-like practices is particularly important in the case of calls for funding involving private actors, who need to make an economic profit out of the commercialization of the resulting product (and would be less inclined to participate in such calls for funding if the full costs of the inclusion of ethical requirements is not taken into consideration). By doing so, local research and innovation actors will gain capabilities on participatory ethical

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assessments, and the involvement of the RFO will level the field with other institutions who have more resources or research funding or capabilities (such as large enterprises).

3. ***Include post-hoc evaluation criteria***

In order to promote the development of a competitive advantage through RRI-like practices through research funding, it is important not only to include promotion criteria as requirements at the first stage (access to funding) and provide the resources to facilitate them. Aiming to assess how this has been carried out and what the outcome has been, both process and outcome dimensions should be included in post hoc evaluation criteria. In this way, the procedural approaches and the contributions (potential and realised) and risks of the research output can also be evaluated. This would aid not only the organizations participating in the call, but also the RFO, to investigate what are the best available techniques in the local context to conduct ethical assessments and RRI-like practices. In a circular manner, this would also help to develop guidelines and recommendations during the contextualization of process and outcomes dimensions in future calls for funding from the bottom-up.

5.5. Recommendations for investors

1. ***Understand the benefits of RRI-like practices and how to overcome the barriers***

For investors, it is important to understand what the benefits of RRI-like practices are in terms of market and financial performance. There are many ways in which RRI-like practices drive competitive advantage; mainly, being able to avoid uncompetitive regulation, increasing social acceptance, accessing new markets, increasing the efficiency of innovation and obtaining reputational effects. Mostly, the link between RRI-like practices and financial performance is not direct, as observed in both the survey and the case studies, but mediated by customer performance and reputational effects derived from engaging in such practices. Asking for risk assessment plans that include risks derived from the management of socio-ethical issues and how these will be hedged through RRI-like practices is advisable. Besides, engaging in RRI-like practices might also come with certain barriers (lengthening the innovation process, protection of intellectual property issues, lack of consumer awareness and other barriers derived from the institutional environments). It is important for the investor to understand the benefits of RRI-like practices for competitive advantage, but to also acknowledge the barriers and to assess, based on business plans, what actions the investee is adopting to overcome such barriers (if applicable to the project, domain and geography).

2. ***Introduce social and environmental ROI in expectations***

The inclusion of indicators of progress is linked to the need to understand return on investment from a triple-bottom line perspective. Even if RRI-like practices have shown to be a driver of competitive

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advantage in many contexts, sometimes through mediated relationships, (such as improving customer performance), there is a call for the inclusion of environmental and social indicators of progress, adjusted to the project, in addition to the financial pay off of the investment, to ensure that the outcome dimensions of RRI-like practices are realised in sustainability performance. In addition, expectations about when to receive financial payoffs might need to be adjusted to longer research and innovation processes (derived from the inclusion of ethical state-gates) plus the potential mediating effects of customer performance on market and financial performance (although further, longitudinal research is needed on such mediated relationships). The inclusion of such indicators on the social and environmental pay off would also help to ensure that the investee is following up with plans to introduce RRI-like requirements in the research and innovation processes and outcomes.

3. ***Introduce ethical requirements relevant to context***

As also noted for other stakeholders, it is very important to adapt the expectations of RRI-like practices in detail for the local environment. Even if the main procedural and outcome dimensions of RRI-like practices were observed throughout regions, the detail of practices was not, as well as the underlying societal values and need to be addressed. These varied in different geographies and domains and called for different application of RRI-like practices (as observed in the contrasting practices utilised by organisations in the bioeconomy and ICT cases, respectively). Consequently, it is important to develop ethical indicators that measure not only economic progress but also progress related to sustainable development and procedural dimensions of RRI-like practices that are well adapted to the organization and research and innovation project in terms of measuring how the investee is dealing with such issues.

5.6. Recommendations for civil society

1. ***Stay informed and demand quality scientific information***

As a citizen, it is important to stay informed regarding emergent research and innovation processes that might affect society or the environment. However, it is often not possible to access quality information that is expressed in lay terms for everyone to understand, rather than in scientific jargon. Therefore, in order to stay properly informed it is imperative to demand quality information and engagement from the research and innovation actors and policymakers in order to be fully aware of the consequences of these emergent technologies (to the extent that they are known). This also applies to knowledge on already commercialised technologies, in order to be able to make informed decisions and provide informed consent. Beyond reading quality science communication, engaging with research and innovation actors and dialoguing with them both during and after the research and innovation process is conducted is recommended, in order to translate the vision of civil society in research and innovation processes and outcomes.

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2. ***Understand trades-off and be clear about ethical red lines***

While it is important to demand information about science and technology, it is also vital to understand the trades-off between socio-ethical and socio-economic dimensions that accompany emergent technologies. For instance, in the case of GMOs, it was observed that while issues of safety and concerns for biodiversity were often voiced by civil society and NGOs, it was identified as a driver of development in certain regions. For this reason, it is important to assess risks and benefits of emergent research and innovation processes and to establish ethical red lines, in order to inform regulatory developments and during participation in reflective processes during research and innovation. At the regulatory level, the precautionary principle protects basic elements of safety; but beyond safety, ethical redlines grounded on one's own and societal convictions need to be determined to balance potential risks and unanticipated consequences. The balance between ethics, social and environmental goals and the development of a competitive advantage is necessary to ensure a sustainable development, but it also important to be clear on the ethical, social and environmental thresholds – also to provide guidance to research and innovation actors.

3. ***Aim for sustainable and ethical development in consumption decisions***

Citizens also have a very important role in defining what kind of outcomes of research and innovation processes will sustain a competitive advantage based on purchasing decisions. For that, it is important to aim for sustainable and ethical development, and so, in evaluating proposals based on novel technologies it is important to determine whether these will be contributing to sustainable and ethical development and translate that into purchasing decisions; hence exercising power through consumption. In addition, it is possible to join other citizens in association bodies or NGOs to inform and lobby research and innovation actors into an ethically acceptable direction and outcomes that are socially desirable. Moreover, it is possible to participate in reflective processes carried out by research and innovation actors, through which citizens can have a direct impact in the research and innovation process, yielding improved technologies and products that cater societal needs.

5.7. Recommendations for NGOs and association bodies

1. ***Engage in standard setting***

NGOs and association bodies might drive the direction of research and innovation processes in two ways; first, they are essential in shaping and mobilising the public opinion through communication and lobbying practices – as observed, from instance, in the bio-economy case –, and second, they can also collaborate and engage with other actors to guide research and innovation processes. Standard setting and certifications have been indicated as drivers of competitive advantage through RRI-like practices, since they concentrate the efforts of reflective processes that might lengthen the research and innovation timelines at the precompetitive stage and pool the resources of companies who might

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otherwise be unable to engage (mostly SMEs). For these standards to gain legitimation and incorporate diverse visions and societal concerns, NGOs can play an essential role, through the setting of ethical baselines and the incorporation of social and environmental concerns in the development of the standards. Such type of engagement can be very effective, and such processes may even be initiated by NGOs themselves, as noted in the ICT case.

2. ***Understand multiplicity of motives in other organizations***

When engaging with other organizations, particularly those that need to develop a competitive advantage for their survival, understanding the multiple drives that might guide negotiation processes is necessary. Particularly, in the case of NGOs that are very focused on the achievement of one particular goal (for instance, environmental NGOs) or one-topic association bodies (such as mitigating climate change) it might be complicated to sit at the table with a business organisation that claims to have environmental and social motives objectives, while also having an underlying economic motive. However, different logics are present in this type of organisations, with the co-existence of moral and instrumental motives. This is especially relevant when NGOs are engaging in collaborative process for standard setting or to steer research and innovation processes. Although it is important to voice and table the issues that are relevant for the NGO, the trades-off and balances with economic considerations also need to be considered in the negotiations to support competitive advantage, while also achieving the inclusion of socio-ethical concerns In the process and outcomes of research and innovation.

3. ***Voice and dialogue***

Beyond collaboration of NGOs in standard setting and certification processes, NGOs have a very relevant role is lobbying and communicating. To this extent, it is important to raise relevant issues and inform civil society about any issues that should be tabled and debated in a public forum. In addition, this also means coming into the debate, even in the case of opposing points of departure with organisations and stakeholders involved in research and innovation. An example of this is the case of GMOs, in which it was noted how certain NGOs had decided not to participate in dialogue processes because of the other stakeholders invited to the conversation. However, this meant that their voice was not heard in this context and not taken into consideration in the debate, hence reducing the possibilities of finding common ground, and resulting in unanticipated economic consequences (such as hurting the competitive advantage of SMEs, rather than the one of larger enterprises, by pushing for the regulation of CRISPR techniques as GMOs). This suggests that two way communication could be beneficial for the objectives of both NGOs and other actors with economic motives.

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7. Appendixes

Appendix 1 – Data collection guide for exploratory interviews

Date of interview:

Length of interview:

Interview core aim questions

1. How are RRI or RRI-like practices understood by the interviewee?
2. How is CA understood by the interviewee?
3. How do RRI-like practices and CA intersect?
4. Are RRI or RRI-like practices a barrier or a driver for CA, and how so?

Guiding protocol

We are an international consortium of researchers and institutions funded by the European Commission to understand what Responsible Research and Innovation (RRI) is in different world regions.

Behind the idea of responsible research and innovation lies the idea that business and research institutions work with different social actors to develop and market new products, services, processes or business models that respond to social, environmental and ethical challenges. In this part of the project, we deal with how these socially-inclusive innovation activities are related to competitive advantage, that is, the ability to position businesses to survive and / or thrive in the market.

In order to understand this relationship better, we are interviewing experts in different world regions to know more about existing innovation practices that consider this collaborative approach with social, environmental or ethical objectives in different parts of the world, how they may contribute to positioning the firm in the market and the possible obstacles that engaging with social actors and including social values may pose for companies that participate in research and innovation.

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[Introductory questions]

1. What are your main activities in the organization?
2. What are the main research and innovation activities in your organization?

   Note: in the case of interviewees focused on research OR innovation only, adjust questionnaire to refer to research or innovation only (see questions 3, 5, 6 9 and 10).

[RRI activities]

3. How do social and ethical values drive the research and innovation processes at your company?
4. Can you tell us about some of the important things that you think your society/people in your society value the most?
5. How does your organization integrate such societal values in research and/or innovation activities?

   Procedural or outcome-oriented

   Inclusion might not appear as a dimension of RRI in different geographies

   Some issues might be neglected / not want to talk about them

   If necessary, prompt asking about local values

6. How does this integration of values affect the research innovation process and outcomes? What practices does it entail?

   If not mentioned before (see practices in industry in Lubberink et al., 2017, appendix I, to use as prompts if necessary):

   - *How does the company include social actors in its research and innovation processes? Examples: vigilance (consumer research, values polling); participating in multi-stakeholder initiatives, consulting stakeholders (e.g. NGOs, research organizations, government....), co-creation...*
   - *How does the company prepare to avoid and mitigate possible socially or ethically negative effects from its research and innovation processes? (Anticipation)*
   - *How do you assess and take responsibility for these potential socially or ethically negative effects? (Reflexivity)*
   - *How do you make sure that social and ethical concerns are tackled when developing new products, services, processes or business models? (Responsiveness)*

[Competitive advantage]

7. As a company, what do you understand as success?

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Prompts, if necessary: economic success, helping local community, creating jobs, nurturing livelihoods, contributing to sustainable development...

8. And regarding its ability to survive and compete in the market, when do you think a company is successful?
9. Would you say this understanding is distinctive from your company, or is it shared in your region?

If not: then, what would you say is the general understanding in your region?

[Drivers]

10. How do your research and innovation activities create value for society?
    a. And how do they create value for the company?
    b. *Does the integration of societal values create additional value for the company?*
    c. What enabled you to obtain full benefit from these socially-inclusive innovations?
    d. *How does the organization capture the value created?*

[Barriers]

11. Does the implementation practices that create value for society limit your research and innovation processes in any way?
12. Does the incorporation of societal values such as [interviewer to mention a value from the participant's initial response here] prevent the company from being more profitable, in any way?

[Closing question]

13. Do you have any additional comments about how integrating social or ethical concerns in your innovation process affects your ability to achieve success as a business or compete in the market?

[Supplementary Material (if available)]

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Appendix 2 – Codebook for exploratory interviews

Code categories	I/D	Meaning	Codes	I/D	Meaning
Approaches to RRI	D	How RRI is understood within the company	a. Cross-cutting	D	Shows an understanding of RRI as process dimensions; mainly, consistent with anticipation, deliberation, inclusion and / or responsiveness, transparency and mutual responsiveness. Ethical concerns in the research and innovation process
			b. Gender	I	Shows support of the RRI gender pillar, including gender balance, gender equality or diversity in leadership
			c. Outcome	D	Shows an understanding of RRI as an innovation outcome, focusing on ethical acceptability, social desirability and/or sustainability of the innovation result.
			d. Procedural	D	Shows an understanding of RRI as both procedural and outcome dimensions in research and innovation.
Barriers to developing a competitive advantage	D	Obstacles to economic profitability or unfolding the company's mission posed by engaging in RRI	a. Context or environment related	I	The surrounding institutional environment disincentivizes RRI-like practices (e.g., undemocratic environments, preference for top-down or push approaches for innovation) or rewards unethical behaviour (e.g. widespread corruption)
			b. Differing interests with involved stakeholders	I	The innovation process is stuck, becomes unprofitable because the interests or values of involved stakeholders are too diverse.
			c. Innovation process related barriers	D	The engagement in RRI practices results in complex innovation processes, excessive innovation criteria, difficulty to translate values into design criteria
			d. Lack of social awareness	I	The lack of social awareness / consumer recognition results in lack of pay-off of RRI practices
			e. Market	I	Market not ready or does not reward RRI efforts
			f. Policy or governance related barriers	D	The policies and regulations are not supportive, engaging in certain RRI practices goes against policy or institutional customs
			g. Time to market	I	Engaging in RRI practices (e.g. technology assessment, ethical stage-gate, precautionary intervention) results in a longer time-to-market or holding from marketing of innovations.

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Drivers	D	Levers of competitive advantage based on engagement in RRI	a. Attracting talent	I	Being able to recruit better, more motivated candidates to the firm.
			b. Development	I	Contributing to the wider local socio-economic development; which, in turn, facilitates the company operations.
			c. Development of different products	I	Tapping on new markets thanks to having identified new market demands through RRI processes.
			d. Financial gain	I	Obtaining financial gain, through access to new markets on commercialization of products
			e. Innovation process related drivers	D	For example, minimising the risk of innovation failure thanks to inclusive processes
			f. Market related drivers	D	Tapping on new markers or responding to market pull
			g. Policy or governance related drivers	D	Responding to policy programmes that reward RRI
Sense of belonging	I	Engaging in RRI in response to a sense of belonging in the community, opportunity to give back			
Social and market recognition	I	Obtaining consumer and stakeholder awareness and reward (in terms of reputation, consumer satisfaction, etc. because of RRI efforts)			
Socio-ethical values	D	Identification of socio-ethical values important to the company	a. Data protection procedures	I	Procedures to ensure that the data is stored safely and cannot be accessed by third parties have been implemented, following concerns of data access
			b. Moral obligation	I	The respondent manifests a moral duty towards the community or towards acting ethically, which is transferred to organizational practices
			c. Open source	I	Open source (particularly in ICT development) or transparency in the development and results of the innovation
			d. Privacy	I	Concerns over data privacy, and taking measures to protect it

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			e. Promoting community resilience	I	Enhancing the resilience of the local community by providing opportunities associated to own success
			f. Security	I	Ensuring security in the development of R&I, and that risks are sufficiently hedged.
RRI-like practices	D	Engagement in RRI or RRI-like practices (regardless of the nomenclature used by the interviewee)	a. Anticipation	D	Practices consistent with anticipation as defined by Stilgoe et al. (Foresight, Technology assessment, Horizon scanning, Scenarios, Vision assessment, Socio-literary techniques) or Lubberink et al. (see interview protocol)
			b. Inclusivity	D	Practices consistent with reflexivity as defined by Stilgoe et al. (e.g. Multidisciplinary collaboration and training, Embedded social scientists and ethicists in laboratories, Ethical technology assessment, Codes of conduct, Moratoriums) or Lubberink et al. (see interview protocol)
			c. Reflexivity	D	Practices consistent with inclusivity as defined by Stilgoe et al. (e.g. Consensus conferences, Citizens' juries and panels, Focus groups, Science shops, Deliberative mapping, Deliberative polling, Lay membership of expert bodies, User-centred design, Open innovation) or Lubberink et al. (see interview protocol)
			d. Responsiveness	D	Practices consistent with responsiveness as defined by Stilgoe et al. (e.g. Constitution of grand challenges and thematic research programmes, Regulation, Standards, Open access and other mechanisms of transparency, Niche management, Value-sensitive design, Moratoriums, Stage-gates, Alternative intellectual property regimes) or Lubberink et al. (see interview protocol)
Societal Values	D	Identification of social values relevant for the community (beyond organizational of personal values). Values guiding the community	a. Development	I	Socio-economic development, particularly in the context of underdeveloped economies

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			b. Education	I	Facilitating proper education for the whole society
			c. Equality of outcome	I	Ensuring that everyone has access to the same opportunities to succeed, regardless of their departing conditions
Understanding of competitive advantage	D	How the company understands competitive advantage, beyond the traditional definitions	a. Ambition	I	Ambition to the best in market, to do better and better over time
			b. Being successful in exercising values	I	Fulfilling the company's and individuals' values through the business activity
			c. Contribution to society	I	Aiming to have a positive impact on society or the environment, consideration of employee or local community wellbeing
			d. Creating global impact	I	Successfully tackling global problems (e.g. poverty, climate change) beyond local communities
			e. Local development	D	Creating wealth for the community, promoting economic development of other local businesses and communities
			f. Meeting expectations	I	Complying with the bottom line, establishing a lasting business
			g. Outperforming others	D	Earning more than competing companies, doing better in the market that competing companies, have a better customer satisfaction than others
			h. Pride	I	Being recognised by society as a good company, either informally (reputation) or formally (awards).
			i. Shared value	D	Creating value for society AND the company
			j. Success in the market	D	Being able to grow in the market, good sales performance
			i. Measuring success	I	Being able to measure the results of success, performance measures
			j. Survival	I	Being able to survive market up and downs over time
			k. Wellbeing	I	Enhancing wellbeing of employees and local community

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Appendix 3 – Interview protocol for case studies

Date of interview:

Length of interview:

Interview core aim questions

- How do businesses balance the trade-offs between managing socio-ethical issues and developing a competitive advantage?
- How does engaging in RRI-like practices favor the development of a competitive advantage?
- How does engaging in RRI-like practices obstacle the development of a competitive advantage?

Guiding protocol

[Introduce oneself and the RRING project, etc.).

We are an international consortium of researchers and institutions funded by the European Commission to understand what Responsible Research and Innovation (RRI) is in different world regions.

Behind the idea of responsible research and innovation lies the idea that business and research institutions work with different social actors to develop and market new products, services, processes or business models that respond to social, environmental and ethical challenges. In this part of the project, we deal with how these socially inclusive innovation activities are related to competitive advantage, that is, the ability to position businesses to survive and / or thrive in the market.

In order to understand this relationship better, we are interviewing experts in different world regions to know more about existing innovation practices that consider this collaborative approach with social, environmental or ethical objectives in different parts of the world. We are seeking insight into how such an approach may contribute to positioning the firm in the market. Also, we are interested in the possible obstacles that engaging with social actors and including social values may pose for companies that participate in research and innovation.

[Introductory questions]

1. What are the main research and innovation activities in your organization (company, enterprise, ministry, institute...)? What are your main functions in the organization?
   Asked as opening, breaking the ice questions, but should be known by the researcher due to prior desktop research – no need for extensive answer.
2. What value is created by research and innovation activities in your field?

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a. How much of this value accrues to society generally? How do they relate to the lives of women, men and people having other gender identities *(particularly in ICT case or health related gene editing)*?

b. How much of this value accrues to the (your) organization?

c. Is there a trade-off between generating societal value and organizations value or does more societal value naturally generate more organizational value?

[Socio-ethical issues relevant to domain]

3. What are the main socio-ethical challenges that you face in research and innovation in {AI Identification systems/Gene-editing}?
    a. Are any of these challenges particular to your organization or region?

Particularly, in relation to the issues that the organization was selected for: gene-editing or deep learning

Prompt with issues, if necessary

4. How did these issues come to the attention of the organization?
Public opinion, personal responsibility, industry concern, regulatory framework…

5. How does your organization respond to such societal issues in research and/or innovation activities? How is the organization affected by them?

6. What approaches do you use in responding to these societal issues?
    a. Are they used by the whole organization?

Might be responded as part of the previous question

Procedural or outcome-oriented

Some issues might be neglected / not want to talk about them

    b. How does this integration of values affect the research innovation process? What practices does it entail?

If not mentioned before (see practices in industry in Lubberink et al., 2017, appendix I, to use as prompts if necessary):

- *How does the company include social actors in its research and innovation processes? Examples: vigilance (consumer research, values polling); participating in multi-stakeholder initiatives, consulting stakeholders (e.g. NGOs, research organizations, government....), co-creation... Is gender taken into account working with social actors?*
- *How does the company prepare to avoid and mitigate possible socially or ethically negative effects from its research and/or innovation processes? (Anticipation)*

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- *How do you assess and take responsibility for these potential socially or ethically negative effects? (Reflexivity)*
- *How do you make sure that social and ethical concerns are tackled when developing new products, services, processes or business models? (Responsiveness) Do you consider gender differences while creating/developing new products, services, ….*
- *How (through what processes) are diverse voices in the organization and society heard or enabled to be heard?*

c. How does this integration of values affect the research innovation outcomes?

If not responded before, focusing on tackling sustainability problems / the SDGs, social desirability and ethical acceptability of the outcomes

[Gender] as we have here separate set of questions on gender, maybe it would be reasonable to include gender aspect in research questions above?

7. How does your company guarantee promote gender equality?
   Might have been (partially) answered as part of the previous questions
8. How are culturally determined gender roles addressed in your company to overcome certain difficulties that women face (e.g. being innovators/ leading decision-makers and children, elderly carers)? Do you integrate gender differences in your research and innovation outcomes?
   Always relevant, but prompt regarding identity recognition and gene-editing

   Might have been (partially) answered as part of the previous questions
9. Do you include human (NB: for gene editing, we need to specify human because there may be gender differences in the organism being edited} gender differences into the formulation of the methods and goals in your research and innovation? If so, how, if not, why not?
10. Do you measure human gender differences in the evaluation of outcomes of your research and innovation? If so, how, if not, why not?
11. How many women, men and people of other gender identities work at your organization? What is distribution of responsibilities between women and men (if there is no other) – women, men and people of other gender identities?
12. Can you give me any example(s) when purposeful inclusion of women/men/people of other gender identities into your research and/or innovation activities significantly contributed to creation value for society? Hindered it?

[Competitive advantage]

13. As an organization, what do you understand as success?
    Prompts, if necessary: economic success, helping local community, creating jobs, nurturing livelihoods, contributing to sustainable development, strengthening gender equality, bringing improvements into lives of wo/men and people of other gender identities...

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14. What is your view of the relationships of socio-ethical issues to your organization's success?
15. Does addressing socio-ethical issues contribute to or limit economic value derived from research and innovation?
16. How does addressing the socio-ethical issues we have been discussing hinder achieving this success?
17. What added value (including social, environmental or cultural value) does consideration to socio-ethical issues create for your company?

[Closing question]

18. Do you have any further comments about the relationship between socio-ethical issues and your research and innovations processes as they effect the competitiveness and value of your organization?

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Appendix 4 – Codebook for case studies

The codebook is divided in two sections: the deductive codes, and the inductive codes.

- The deductive codes have been set in accordance to the key conceptual frameworks, the research questions and previous research within the work package. They are used as an initial guide to structure the coding and depart from aggregated code categories (e.g.: 'RRI practices') and break into more specific code categories, still grounded on the literature (e.g. anticipation).
- The inductive codes will be developed in the course of the analysis. If there are relevant statements that are not covered by the deductive codes, a new code should be created.
- The new inductive codes may belong to completely new aggregate code or code category (to be developed on second round of coding), or may fit in under the existing, deductive code categories- particularly the descriptive codes developed in the first round of coding- (e.g. descriptive "scenario planning" or "identifying unanticipated consequences" would be fitting under "anticipation" and "RRI practices").

Deductive codes

Aggregate codes	Meaning	Code category	Meaning
Approaches to RRI	This category refers to how the interviewee understands RRI-like practices, either from a procedural point of view (related to transparency or mutual responsiveness, inclusion of ethical gate-checks), from an outcome perspective (obtaining a sustainable, ethically acceptable and / or socially desirable result) or cross-cutting (including both procedural and outcome requirements	Procedural	Shows an understanding of RRI as process dimensions; mainly, consistent with anticipation, deliberation, inclusion and / or responsiveness, transparency and mutual responsiveness. Ethical concerns in the research and innovation process
		Outcome	Shows an understanding of RRI as an innovation outcome, focusing on ethical acceptability, social desirability and/or sustainability of the innovation result.
		Cross-cutting	Shows an understanding of RRI as both procedural and outcome dimensions in research and innovation.
	Collects RRI-like practices that are consistent with the AIRR framework	Anticipation	Practices consistent with anticipation as defined by Stilgoe et al. (Foresight, Technology assessment, Horizon scanning, Scenarios, Vision

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RRI practices (AIRR)			assessment, Socio-literary techniques) or Lubberink et al. (see interview protocol)
		Reflexivity	Practices consistent with reflexivity as defined by Stilgoe et al. (e.g. Multidisciplinary collaboration and training, embedded social scientists and ethicists in laboratories, Ethical technology assessment, Codes of conduct, Moratoriums) or Lubberink et al. (see interview protocol)
		Inclusion	Practices consistent with inclusivity as defined by Stilgoe et al. (e.g. Consensus conferences, Citizens' juries and panels, focus groups, Science shops, Deliberative mapping, Deliberative polling, Lay membership of expert bodies, User-centered design, Open innovation) or Lubberink et al. (see interview protocol)
		Responsiveness	Practices consistent with responsiveness as defined by Stilgoe et al. (e.g. Constitution of grand challenges and thematic research programmes, Regulation, Standards, Open access and other mechanisms of transparency, Niche management, Value-sensitive design, Moratoriums, Stage-gates, Alternative intellectual property regimes) or Lubberink et al. (see interview protocol)
RRI practices (pillars)	Collects RRI-like practices that are consistent with the six pillars of the European Commission	Open science	Practices consistent with increasing access to scientific results (public talks, sharing patents, CC licenses...).
		Gender equality (GE)	Practices consistent with ensuring gender equality in innovation process and outcomes (tag also under the gender categories)
		(Sub-code - GE) Equality programmes	The organization has implemented formalized equality programmes, either to improve gender balance, to improve balance in leadership or breaking with stereotypes
		(Sub-code - GE) Representation	Wo/men's representation on the top (decision taking) levels
		(Sub-code - GE) Gender in R&I process	Measures to ensure balance during the process, including (non-exhaustive), balance in number and leadership in research and innovation teams, wo/men's careers/participation in the RRI practices/processes

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		(Sub-code - GE) Gender in R&I outcomes	Gender is considered in the R&I outcomes, with tailored outcomes, gender integration in research (i.e. planning, disseminating, etc.)
		Ethics	Practices consistent with the integration of socio-ethical values in the innovation process (e.g., project selection criteria, stoppers, purposeful design...)
		Science education	Practices aimed to increase the public's knowledge of science or technology (e.g. public talks, blogging, school visits).
		Public engagement	Practices to engage society more broadly in its research and innovation activities (may also be tagged under inclusion)
		Governance	Practices consistent with the establishment of an innovation process and system (either formal or informal) that aims to pursue the above.
Drivers of competitive advantage	Explain factors through which RRI-like practices might be directly or indirectly may be positively related to achieving a competitive advantage, a differential compared to others	Attracting talent	Being able to recruit better, more motivated candidates to the firm.
		Socio-economic development	Contributing to the wider local socio-economic development; which, in turn, facilitates the company operations.
		Development of different products	Tapping on new markets thanks to having identified new market demands through RRI processes.
		Innovation process related drivers	For example, minimizing the risk of innovation failure thanks to inclusive processes
		Licence to operate	Obtaining the legal and social allowance and acceptance of the activities
		Policy or governance related drivers	Responding to policy programmes that reward RRI
		Value creation through diversity	Diversity is perceived as a source of cultural / economic value, a source for competitive advantage
		Social recognition	Obtaining consumer and stakeholder awareness and reward (in terms of reputation, consumer satisfaction, etc. because of RRI efforts)
Barriers to competitive advantage	Explain factors that might hinder achieving a competitive advantage through RRI-like practices	Context or governance related	The surrounding institutional environment disincentivizes RRI-like practices (e.g., undemocratic environments, preference for top-down or push approaches for innovation) or rewards unethical behavior (e.g. widespread corruption)

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		Differing interests with involved stakeholders	The innovation process is stuck, becomes unprofitable because the interests or values of involved stakeholders are too diverse.
		Innovation process related barriers	The engagement in RRI practices results in complex innovation processes, excessive innovation criteria, difficulty to translate values into design criteria
		Lack of social awareness	The lack of social awareness / consumer recognition results in lack of pay-off of RRI practices
		Time to market	Engaging in RRI practices (e.g. technology assessment, ethical stage-gate, precautionary intervention) results in a longer time-to-market or holding off marketing of innovations.
Understanding of competitive advantage	Expresses how the interviewee perceives success and the achievement of competitive advantage	Contribution to society / wellbeing	Aiming to have a positive impact on society or the environment, consideration of employee or local community wellbeing
		Creating global impact	Successfully tackling global problems (e.g. poverty, climate change) beyond local communities
		Local development	Creating wealth for the community, promoting economic development of other local businesses and communities
		Meeting expectations / survival	Being able to survive market up and downs over time, complying with the bottom line, establishing a lasting business
		Outperforming others	Earning more than competing companies, doing better in the market that competing companies, have a better customer satisfaction than others
		Pride and recognition	Being recognized by society as a good company, either informally (reputation) or formally (awards).
		Success in the market	Being able to grow in the market, good sales performance
Diversity	Refers to how diversity (beyond gender) is incorporated in the R&I process	Diversity of workforce	Existence of formal or informal measures to integrate and empower minorities in the workforce

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Inductive codes

Aggregate codes	Code category	Meaning
Socio ethical challenges	Trust of infrastructure for secure data	Being able to ensure that the infrastructure for collecting, storing and sending data is safe in terms of privacy
	Anonymization	Applying measures to anonymize data to protect the individual giving away the data
	Use of data	Actual use of the data collected, beyond the original intention for which it was collected
	Uncertainty of new technologies	Inability to fully predict the direction the technology will take, its uses or consequences on society and the environment
	Legitimacy to modify nature	Questions about whether technology or humans should modify natural design
	Protection of biodiversity and biosafety	Concerns about the consequences of introducing new, modified species in the natural environment
	Social acceptance	Social acceptance of technology influenced by multiple factors, beyond technology safety or state of development
	Protection of minority groups	Protection of the beliefs and lifestyles of minority groups that are particularly affected or discriminated by the technology

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Appendix 5 - RRI-like measures in the survey

Diversity

Please specify your level of agreement with the following statement:

Likert scale

'It is important to involve individuals/organizations with a diverse range of perspectives and expertise when planning my research and innovation work.'

[Strongly Disagree | Disagree | Somewhat Disagree| Neutral | Somewhat Agree | Agree | Strongly Agree | Not applicable / No Opinion]

In the last 12 months, have you involved individuals/organizations with a diverse range of perspectives and expertise when planning your research and innovation work?

Multiple choice, single response

[Never | Occasionally | Sometimes | Frequently | Usually | Always | Not applicable / No Opinion]

Shown if Occasionally, Sometimes, Frequently, Usually, Always selected in previous question

In the last 12 months, in which of the following practices has your organization engaged in? Tick all that apply.

Multiple choice, multiple response

- Consult individuals / organizations obtain ideas during the R&I process
- Consult individuals / organizations during the R&I process
- Consult individuals / organizations to test the desirability of the R&I results
- Crowdsourcing or other forms of user-innovation
- Community visits
- Setting up a public platform to express ideas and concerns
- Worked with individuals / organizations with similar values
- Worked with individuals / organizations with opposing values
- Other
- Don't know / rather not say

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Gender equality

Please specify your level of agreement with the following statement:

Likert scale

'It is important to promote gender equality in my research and innovation work.'

[Strongly Disagree | Disagree | Somewhat Disagree| Neutral | Somewhat Agree | Agree | Strongly Agree | Not applicable / No Opinion]

In the last 12 months, have you taken steps to promote gender equality in your research and innovation work?

Multiple choice, single response

[Yes | No | Unsure | Prefer not to say | Not applicable / No Opinion]

Shown if Yes selected in previous question

In the last 12 months, in which of the following practices has your organization engaged in? Tick all that apply.

Multiple choice, multiple response

- Aim for gender balance in the research and innovation team
- Aim for gender balance in the decision-making team
- Achieved gender balance in the research and innovation team (50% women or more)
- Achieved gender balance in the decision-making team (50% women or more)
- Integrated the perspective of women in the research and innovation process
- Integrate the gender dimension in the results of research and innovation
- Collect gender disaggregated data
- Other
- Don't know / rather not say

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Ethnic minorities

Please specify your level of agreement with the following statement:

Likert scale

'It is important to include ethnic minorities in my research and innovation work.'

[Strongly Disagree | Disagree | Somewhat Disagree| Neutral | Somewhat Agree | Agree | Strongly Agree | Not applicable / No Opinion]

In the last 12 months, have you taken any steps to include ethnic minorities in your research and innovation work?

Multiple choice, single response

[Yes | No | Unsure | Prefer not to say | Not applicable / No Opinion]

Shown if Yes selected in previous question

In the last 12 months, in which of the following practices has your organization engaged in? Tick all that apply.

Multiple choice, multiple response

- Aim for the inclusion of ethnic minorities in research teams
- Achieved ethnic diversity in research teams
- Consulted ethnic minorities during the research process
- Integrated the perspective of ethnic minorities in the research and innovation process
- Developed innovations targeted to ethnic minorities
- Other
- Don't know / rather not say

Societal risk management

Please specify your level of agreement with the following statement:

Likert scale

'It is important to ensure that my research and innovation work does not cause concerns for society.'

[Strongly Disagree | Disagree | Somewhat Disagree| Neutral | Somewhat Agree | Agree | Strongly Agree | Not applicable / No Opinion]

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In the last 12 months, have you taken any steps to include ethnic minorities in your research and innovation work?

Multiple choice, single response

[Yes | No | Unsure | Prefer not to say | Not applicable / No Opinion]

Shown if Yes selected in previous question

In the last 12 months, in which of the following practices has your organization engaged in? Tick all that apply.

Multiple choice, multiple response

- Activities to determine and anticipate the desired impacts of innovation (e.g. prospective processes, identifying social or environmental needs)
- Activities to prevent or mitigate negative impacts (e.g. monitoring regulatory framework, technology assessment)
- Developing innovation roadmaps (scenario planning, alignment of business strategy)
- Other
- Don't know / rather not say

Societal needs

Please specify your level of agreement with the following statement:

Likert scale

'My research and innovation work should address societal needs.'

[Strongly Disagree | Disagree | Somewhat Disagree| Neutral | Somewhat Agree | Agree | Strongly Agree | Not applicable / No Opinion]

In the last 12 months, in which of the following practices has your organization engaged in?

Multiple choice, single response

[Yes | No | Unsure | Prefer not to say | Not applicable / No Opinion]

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Shown if Yes selected in previous question

In the last 12 months, in which of the following practices has your organization engaged in? Tick all that apply.

Multiple choice, multiple response

- Aiming to solve environmental problems through research and innovation
- Aiming to solve social issues through research and innovation
- Aiming to solve economic problems through research and innovation
- Preventing detrimental effects of research and innovation by not introducing it to the market
- Developing research and innovation processes for disadvantaged groups
- Other
- Don't know / rather not say

Open and transparent methods and processes

Please specify your level of agreement with the following statement:

Likert scale

'It is important to make my research and innovation methods/processes open and transparent.'
[Strongly Disagree | Disagree | Somewhat Disagree| Neutral | Somewhat Agree | Agree | Strongly Agree | Not applicable / No Opinion]

In the last 12 months, have you taken steps to ensure your research and innovation methods/processes are open and transparent?

Multiple choice, single response

[Yes | No | Unsure | Prefer not to say | Not applicable / No Opinion]

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Shown if Yes selected in previous question

In the last 12 months, in which of the following practices has your organization engaged in? Tick all that apply.

Multiple choice, multiple response

- Two-way exchange of opinions with stakeholders
- Sharing information and criteria with stakeholders
- Feedback about stakeholder dialogue and explaining how results are integrated in research or innovation
- Co-creation with stakeholders
- Crowdsourcing
- Other open innovation practices
- Open code / open access data
- Dissemination of research or innovation results
- Other
- Don't know / rather not say

Ethics

Please specify your level of agreement with the following statement:

Likert scale

'Ethical principles guide my research and innovation work.'

[Strongly Disagree | Disagree | Somewhat Disagree| Neutral | Somewhat Agree | Agree | Strongly Agree | Not applicable / No Opinion]

In the last 12 months, have you taken steps to ensure that ethical principles guide your research and innovation work?

Multiple choice, single response

[Yes | No | Unsure | Prefer not to say | Not applicable / No Opinion]

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Shown if Yes selected in previous question

In the last 12 months, in which of the following practices has your organization engaged in? Tick all that apply.

Multiple choice, multiple response

- Making sure that there are formal ethical evaluations
- Becoming aware of the function and power of the organization in society
- Reflecting and prioritizing own values and motivations
- Determining how to deal with opposing values and motivations
- Assessing subjectivity of information and origin of knowledge
- Becoming aware of different perceived realities between actors
- Other
- Don't know / rather not say

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Appendix 6 – Questions on competitive advantage for policy-makers

Impact performance

During the last year, how do you find the following issues to have fared in your organization? (1=much worse; 7=much better)

Degree to which the organization's goals for the year were achieved, compared to last year	1	2	3	4	5	6	7
Degree to which R&I programs have been successfully implemented, compared to last year	1	2	3	4	5	6	7
Prospects for the promotion of R&I in the territory, compared to last year	1	2	3	4	5	6	7

- Don't know / rather not say

Local sustainability performance

During the last year, how do you find the following issues to have fared in your organization? (1=much worse; 7=much better)

Degree to which the organization has contributed to resolving environmental problems in the areas of operation, compared to last year	1	2	3	4	5	6	7
Degree to which the organization has contributed to resolving social problems in the areas of operation, compared to last year	1	2	3	4	5	6	7
Degree to which the organization has contributed to the socio-economic well-being in the areas of operation, compared to last year	1	2	3	4	5	6	7

- Don't know / rather not say

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Appendix 7 – Summary of results of the structured literature search

Title and reference	Journal	Key domain	Focus stakeholders	Region	Type of paper
A Mobilising Concept? Unpacking Academic Representations of Responsible Research and Innovation (B. E. Ribeiro et al., 2017)	Science and Engineering Ethics	N/A	Researchers	Europe & North America	Literature review
A Problem with Societal Desirability as a Component of Responsible Research and Innovation: the "If we don't somebody else will" Argument (Weckert et al., 2016)	NanoEthics	N/A	N/A	Global	Normative
Absent, yet present? Moving with 'Responsible Research and Innovation' in radiation protection research (Oudheusden et al., 2018)	Journal of Responsible Innovation	Energy	Researchers	Europe & North America	Normative
Addressing Climate Change in Responsible Research and Innovation: Recommendations for Its Operationalization (Ligardo-Herrera et al., 2018)	Sustainability	Energy	N/A	Europe & North America	Literature review
Against the tide of depoliticisation: the politics of research governance (Hartley et al., 2017)	Policy & Politics	N/A	Researchers / RPO	Europe & North America	Qualitative
Agriculture Technology Choices and the Responsible Research and Innovation (RRI) Framework: Emerging Experiences from China and India (Chaturvedi et al., 2016)	Asian Biotechnology and Development Review	Agriculture	Policy-makers	Asia & the Pacific	Conceptual
An Investigation into Risk Perception in the ICT Industry as a Core Component of Responsible Research and Innovation (Chatfield, Borsella, et al., 2017)	Sustainability	ICT	Industry	Europe & North America	Qualitative
Anchoring European Governance: Two Versions of Responsible Research	NanoEthics	N/A	N/A	Europe & North America	Conceptual

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and Innovation and EU Fundamental Rights as 'Normative Anchor Points' (Ruggiu, 2015)					
Assembling Upstream Engagement: the Case of the Portuguese Deliberative Forum on Nanotechnologies (Carvalho & Nunes, 2018)	NanoEthics	N/A	N/A	Europe & North America	Qualitative
Assessment of science and technologies: Advising for and with responsibility (Forsberg et al., 2015)	Technology in Society	N/A	N/A	Europe & North America	Normative
Beyond Cost-Benefit Analysis in the Governance of Synthetic Biology (Wallach et al., 2018)	Hastings Center Report	Biotechnology	N/A	Europe & North America	Normative
Beyond the dissemination of Earth Observation research: stakeholders' and users' involvement in project co-design (L'Astorina et al., 2015)	Journal of Science Communication	Agriculture	N/A	Europe & North America	Qualitative
Broader Impacts or "Responsible Research and Innovation"? A Comparison of Two Criteria for Funding Research in Science and Engineering (Davis & Laas, 2014)	Science and Engineering Ethics	N/A	RFO / Policy-makers	Europe & North America	Conceptual
Cataloguing the barriers facing RRI in innovation pathways: a response to the dilemma of societal alignment (Kuzma & Roberts, 2018)	Journal of Responsible Innovation	N/A	Researchers	Europe & North America	Normative
Communitarian and Subsidiarity Perspectives on Responsible Innovation at a Global Level (Malsch, 2015)	NanoEthics	N/A	N/A	Europe & North America	Conceptual
Company Strategies for Responsible Research and Innovation (RRI): A Conceptual Model (van de Poel et al., 2017)	Sustainability	N/A	Industry	Europe & North America	Conceptual
Competitive advantage through responsible innovation in the New Zealand sheep dairy industry (Lees & Lees, 2018)	International Food and Agribusiness Management Review	N/A	Industry	Asia & the Pacific	Qualitative

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CSR, innovation strategy and supply chain management: toward an integrated perspective (Russo Spena & de Chiara, 2012)	International Journal of Technology Management	N/A	Industry	Europe & North America	Qualitative
Definitions and Conceptual Dimensions of Responsible Research and Innovation: A Literature Review (Burget et al., 2017)	Science and Engineering Ethics	N/A	N/A	Europe & North America	Literature review
Development of Wheat With Hypoimmunogenic Gluten Obstructed by the Gene Editing Policy in Europe (Jouanin et al., 2018)	Frontiers in Plant Science	N/A	Policy-makers / researchers	Europe & North America	Normative
Devices of Responsibility: Over a Decade of Responsible Research and Innovation Initiatives for Nanotechnologies (Shelley-Egan et al., 2018)	Science and Engineering Ethics	N/A	N/A	Europe & North America	Conceptual
East African Perceptions of Barriers/Facilitators for Pediatric Clinical Research Participation and Development of the Inclusive Research Model (O'Connor et al., 2018)	Journal of Pediatric Nursing	N/A	N/A	Africa	Qualitative
ELSI practices in genomic research in East Asia: implications for research collaboration and public participation (Yoshizawa et al., 2014)	Genome medicine	N/A	Policy-makers	Asia & the Pacific	Policy review
Empowering citizens in international governance of nanotechnologies (Malsch et al., 2015)	Journal of Nanoparticle research	N/A	Citizens	Europe & North America	Qualitative
Enacting Responsibilities in Landscape Design: The Case of Advanced Biofuels (Di Lucia & Ribeiro, 2018)	Sustainability	Energy	Industry, policy-makers	Europe & North America	Qualitative
Ethical governance is essential to building trust in robotics and artificial intelligence systems (Winfield & Jirotka, 2018)	Philosophical Transactions of the Royal Society	ICT	N/A	Europe & North America	Conceptual
Ethics and Privacy in Al and Big Data: Implementing Responsible Research and Innovation	IEEE Security and Privacy	ICT	N/A	Europe & North America	Qualitative

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(B. C. Stahl & Wright, 2018)					
EU Research Agendas: Embedding What Future? (Levidow & Neubauer, 2014)	Science as Culture	N/A	Policy-makers	Europe & North America	Normative
For a Sustainable Future and a Democratic Management of Energy: an Experience of Developing an Alternative Generation System in Armstrong City, Argentina (Garrido, 2018)	Estudios Avanzados	Energy	Industry	LAC	Qualitative
Framing inclusive innovation within the discourse of development: Insights from case studies in India (Pansera & Owen, 2018)	Research Policy	N/A	Industry / grassroots movements	Asia & the Pacific	Qualitative
From enterprise development to inclusive innovation - A systemic instruments framework for regional innovation support (Grobbelaar et al., 2016)	African Journal of Science, Technology, Innovation and Development	N/A	Policy-makers	Africa	Action research
Governing Nanotechnology in a Multi-Stakeholder World (Malsch, 2013)	NanoEthics	N/A	N/A	Global	Normative
Grassroots innovation movements: challenges and contributions (Smith et al., 2014)	Journal of Cleaner Production	N/A	Grassroots movements	LAC	Qualitative
Implementation of Responsible Research and Innovation (RRI) Practices in Industry: Providing the Right Incentives (Gurzawska et al., 2017)	Sustainability	N/A	Industry	Europe & North America	Conceptual
Implementing Responsible Research and Innovation Practices in SMEs: Insights into Drivers and Barriers from the Austrian Medical Device Sector (Auer & Jarmai, 2018)	Sustainability	N/A	Industry	Europe & North America	Qualitative
Inclusive Innovation: A Source of New Ideas to Deliver Business Growth (Jones, 2016)	Research-Technology Management	N/A	Industry	Europe & North America	Normative
Innovating innovation policy: the emergence of	Journal of Responsible Innovation	N/A	Policy/makers	Europe & North America	Qualitative

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'Responsible Research and Innovation' (Saille, 2015)					
Innovating Responsibly in ICT for Ageing: Drivers, Obstacles and Implementation (Chatfield, Iatridis, et al., 2017)	Sustainability	ICT	Industry	Europe & North America	Qualitative
Innovation for Inclusive Growth: Towards a Theoretical Framework and a Research Agenda (George et al., 2012)	Journal of Management Studies	N/A	Industry	Global	Conceptual
Innovation, social inclusion and coherent regional development: A new diamond for a socially inclusive innovation policy in regions (Guth, 2005)	European Planning Studies	N/A	Policy-makers	Europe & North America	Qualitative
Introducing responsible innovation in health: a policy-oriented framework (Pacifico Silva et al., 2018)	Health Research Policy and Systems	N/A	Policy-makers	Europe & North America	Literature review
Lessons for Responsible Innovation in the Business Context: A Systematic Literature Review of Responsible, Social and Sustainable Innovation Practices (Lubberink et al., 2017)	Sustainability	N/A	Industry	Europe & North America	Literature review
Locating Responsible Research and Innovation Within Access and Benefit Sharing Spaces of the Convention on Biological Diversity: the Challenge of Emerging Technologies (Laird & Wynberg, 2016)	NanoEthics	Biotechnology	Policy-makers	Global	Normative
Looking through different windows: How inclusive research can influence policy (Strike & Robinson, 2016)	Journal of Intellectual Disability Research	N/A	Policy-makers	Global	Normative
Making the case for gender sensitive climate policy - lessons from South Asia/IGP (Jafry, 2016)	International Journal of Climate Change Strategies and Management	N/A	Policy-makers	Asia & the Pacific	Literature review
Modeling the effect of responsible research and innovation in quadruple helix innovation systems (Paredes-Frigolett, 2016)	Technological Forecasting & Social Change	N/A	Policy-makers	Global	Modelling

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Nanotechnology and Risk Governance in the European Union: the Constitution of Safety in Highly Promoted and Contested Innovation Areas (Rodriguez, 2018)	NanoEthics	N/A	Policy-makers	Europe & North America	Conceptual
National Ethics Advisory Bodies in the Emerging Landscape of Responsible Research and Innovation (Mali et al., 2012)	NanoEthics	N/A	Policy-makers	Europe & North America	Qualitative
Networked Responsibility Approach for Responsible Innovation: Perspective of the Firm (Ceicyte & Petraite, 2018)	Sustainability	N/A	Industry	Europe & North America	Conceptual
Orchestrated efforts to foster responsible research (Tang & Hu, 2018)	Journal of Clinical Epidemiology	Health	Researchers	Asia & the Pacific	Normative
Process, outcomes, virtues: the normative strategies of responsible research and innovation and the challenge of moral pluralism (Pellé, 2016)	Journal of Responsible Innovation	N/A	Policy-makers	Europe & North America	Conceptual
Profitable margins: The story behind 'our stories' (Ryan, 2009)	Journal of Management & Organization	N/A	Industry	Asia & the Pacific	Qualitative
Redefining responsible research and innovation for the advancement of biobanking and biomedical research (Yu, 2016)	Journal of Law and the Biosciences	Biotechnology	Industry / researchers	Europe & North America	Conceptual
Renewable energy research and technologies through responsible research and innovation looking glass: Reflexions, theoretical approaches and contemporary discourses (Carbajo & Cabeza, 2018)	Applied Energy	Energy	Researchers / policy-makers / indusrtry	Europe & North America	Literature review
Research and innovation processes revisited - networked responsibility in industry (Timmermans et al., 2017)	Sustainability Accounting, Management and Policy Journal	N/A	Industry	Europe & North America	Qualitative
Research for a Sustainable Development. Criteria for Socially Responsible Research Processes (Daedlow et al., 2016)	Current Opinion in Environmental Sustainabilty	N/A	Researchers	Global	Conceptual

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Responsibility and intellectual property in synthetic biology A proposal for using Responsible Research and Innovation as a basic framework for intellectual property decisions in synthetic biology (König et al., 2015)	Science & Society	Biotechnology	Researchers / industry	Europe & North America	Normative
Responsibility versus Profit: The Motives of Food Firms for Healthy Product Innovation (Garst et al., 2017)	Sustainability	Food	Industry	Europe & North America	Qualitative
Responsible innovation in the financial sector: an Islamic perspective (Hilmi, 2018)	Journal of Responsible Innovation	Banking	Industry	Arab States	Conceptual
Responsible Innovation: A Complementary View from Industry with Proposals for Bridging Different Perspectives (Dreyer et al., 2017)	Sustainability	N/A	Industry	Europe & North America	Normative
Responsible Research and Innovation and Its Implications for China (Yang & Han, 2017)	China & World Economy	N/A	Industry / policy-makers	Asia & the Pacific	Conceptual
Responsible research and innovation in contrasting innovation environments: Socio-Technical Integration Research in Hungary and the Netherlands (Lukovics et al., 2017)	Technology in Society	N/A	Researchers / policy-makers	Europe & North America	Qualitative
Responsible Research and Innovation in Industry-Challenges, Insights and Perspectives (Martinuzzi et al., 2018)	Sustainability	N/A	Industry	Europe & North America	Conceptual
Responsible research and innovation key performance indicators in industry: A case study in the ICT domain (Yaghmaei, 2018)	Journal of Information, Communication and Ethics in Society	ICT	Industry	Europe & North America	Qualitative
Responsible research and innovation: a productive model for the future of medical innovation (Demers-Payette et al., 2016)	Journal of Responsible Innovation	Health	Policy-makers / industry	Europe & North America	Qualitative

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Responsible Research Is Not Good Science: Divergences Inhibiting the Enactment of RRI in Nanosafety (van Hove & Wickson, 2017)	NanoEthics	N/A	Researchers / policy-makers	Europe & North America	Qualitative
Risk analysis and technology assessment in support of technology development: Putting responsible innovation in practice in a case study for nanotechnology (van Wezel et al., 2018)	Integrated Environmental Assessment and Management	Nanotechnology	Industry / policy-makers	Europe & North America	Action research
Roadblocks to responsible innovation: Exploring technology assessment and adoption in US public highway construction (Kimmel et al., 2016)	Technology in Society	Construction	Industry	Europe & North America	Qualitative
Science, technology, innovation and IP in India: new directions and prospects (Greenhalgh, 2016)	Economic Change and Restructuring	N/A	Policy-makers	Asia & the Pacific	Normative
Systemic policy instruments for inclusive innovation systems: Case study of a maternal mHealth project in South Africa (Merwe & Grobbelaar, 2018)	African Journal of Science, Technology, Innovation and Development	Health	Policy-makers	Africa	Qualitative
The added value of inclusive research (Walmsley et al., 2018)	Journal of applied research on intellectual disabilities	N/A	Researchers	Global	Literature review
The Approach of the Business Sector to Responsible Research and Innovation (RRI) (Inzelt & Csonka, 2017)	Foresight and STI Governance	N/A	Industry	Europe & North America	Qualitative
The Developmental Potential of Frugal Innovation among Mobile Money Agents in Kitwe, Zambia (Peša, 2018)	The European Journal of Development Research	Banking	Industry	Africa	Qualitative
The framing of innovation among European research funding actors: Assessing the potential for 'responsible research and innovation' in the food and health domain (Khan et al., 2016)	Food Policy	Food and health	RFO / Policy-makers	Europe & North America	Qualitative

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The Influence of Local Governance: Effects on the Sustainability of Bioenergy Innovation (Cavicchi et al., 2017)	Sustainability	Energy	Industry	Europe & North America	Qualitative
The Responsible Research and Innovation (RRI) Maturity Model: Linking Theory and Practice (Bernd Carsten Stahl et al., 2017)	Sustainability	N/A	Industry	Europe & North America	Qualitative
The Unexplored Contribution of Responsible Innovation in Health to Sustainable Development Goals (Lehoux et al., 2018)	Sustainability	Health	Industry, NGOs, researchers	Global	Literature review
Towards a Framework to Guide the Evaluation of Inclusive Innovation Systems (Botha et al., 2016)	South African Journal of Industrial Engineering	N/A	Industry / policy-makers / researchers	Africa	Literature review
Towards principled Responsible Research and Innovation: employing the Difference Principle in funding decisions (Schroeder & Ladikas, 2015)	Journal of Responsible Innovation	N/A	RFOs	Europe & North America	Normative
Value Chain Upgrading and the Inclusion of Smallholders in Markets: Reflections on Contributions of Multi-Stakeholder Processes in Dairy Development in Tanzania (Kilelu et al., 2017)	The European Journal of Development Research	Agriculture	Industry	Africa	Qualitative
When the going gets tough, the tough gets going: towards a new - more critical - engagement with responsible research and innovation in an age of Trump, Brexit, and wider populism (Long & Blok, 2017b)	Journal of Responsible Innovation	N/A	Policy-makers / citizens	Europe & North America	Normative
Who works in a working region? Inclusive innovation in the new manufacturing economy (Lowe & Wolf-Powers, 2018)	Regional Studies	N/A	Industry / policy-makers	Europe & North America	Qualitative

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