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OPERATIONALISING RESPONSIBLE RESEARCH AND INNOVATION – TOOLS FOR ENTERPRISES

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A B S T R A C T
Responsible Research and Innovation (RRI) is an emerging paradigm and a novel approach to governing science and innovation with the aim of making them ethically acceptable and socially desirable. RRI concept has become a popular term as a result of making it a cross-cutting theme for the Horizon 2020 Framework Programme. Up to date, research on the topic has focused on conceptual problems (relation with similar concepts as well as ethical, moral, philosophical, cultural underpinnings and assumptions) and on the possibilities of making the concept relevant to the Research & Innovation community in Europe and worldwide. Despite some initial efforts, there is still a need to further develop methods and techniques that could make RRI a useful framework for conducting innovation activities, especially in the business environment. The aim of this paper is to propose a range of approaches that help operationalise RRI. The approaches employ methods such as weighted indicators, maturity models and scorecards.

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INTRODUCTION

Technological progress and radical innovation carry promise of a higher life quality but at the same time are inseparably connected with risks and uncertainties. Many inventions also raise critical ethical issues. Genetically modified organisms (including food), vaccinations (especially for children), shale gas drilling, gene editing, mass surveillance, nanotech-

nologies, robotics, brain-machine interface – these are just examples of controversial topics where hopes and fears collide in society. Supporters and opponents of particular scientific and technological achievements may have very diverse mixes of values and beliefs. They support their positions with scientific evidence and economic considerations that may overlap or diverge. In this context, strong tensions may arise.

OECD identifies several trends that are currently prominent in the Science, Technology and Innovation (STI) policy practices. The first trend is related to design thinking and experimentation as novel approaches to policy formulation and delivery, with the aim of making STI policy more agile. The second trend concerns the digitalisation of STI policy which enables basing the policy on evidence that can be uncovered thanks to sophisticated big data analysis techniques. The last trend, which is relevant to the topic of this paper, is the growing influence of Responsible Research and Innovation, which places greater emphasis on broader public engagement in STI policymaking (OECD, 2016).

There is a growing tendency to see science, technology and innovation not as a goal *per se* but a crucial means to tackle societal problems and Grand Challenges. This calls for an inclusive, anticipatory governance of technological change that includes assessment of benefits and costs and an active shaping of future development pathways. In this light, increased attention is paid to a concept called Responsible Research and Innovation (RRI).

Since the introduction of the RRI concept around 2011, RRI principles have diffused into policy agendas, funding programmes and governance arrangements. European Commission has funded dozens of RRI-related projects with the amount of more than 100 million EUR (Nazarko, 2019). The aims of those projects were related to grounding the RRI concept in the current theory and making this concept relevant to various groups of stakeholders. In author's opinion, the challenge that still needs further effort concerns the perception and reception of RRI in the business/industry environment. This paper's goal is to contribute to this effort by proposing several approaches to operationalising RRI for enterprises. The work starts by summarising the current discourse on the topic of responsibility in research and innovation. Next, it reviews the achievements of projects that aimed at developing RRI-related tools for enterprises. Finally, author's original concepts of RRI-related tools are proposed. The paper ends with conclusions and indication of further research directions.

1. Responsible Research and Innovation — concept still under construction

Responsibility is a term that, at the first glance, is non-controversial. Everyone agrees that people, businesses, state institutions should be responsible and act responsibly. However, there is no clarity as to what it means to be responsible or act responsibly in the context of research and innovation activity. As Pavie et al. (2014) conclude, responsibility for a firm is just as hard to define as for an individual. In the recent years, a number of definitions and interpretations of RRI has been proposed (Tab. 1).

The third column of Tab. 1 is the evidence of how diverse the perspectives on RRI might be. At the same time, some common lines of thought can also be distinguished: shared responsibility among various stakeholders, future orientation, focus on societal and environmental challenges, stress on reflection, deliberation, openness and inclusion.

Ceicyte (2019) presents a useful distinction between normative and processual approach to RRI (Tab. 2). Having in mind the variety of approaches to RRI it is necessary to delineate the boundaries of research field(s) that deal with RRI. The same author provides a comprehensive overview of perspectives though which RRI can be analysed (Tab. 3).

Performed literature review resulted in the conclusion that a large portion of earlier scientific publications about RRI relate more to STI policy actors and public institutions rather than to industry (Grunwald, 2014). This is also reflected in the composition of project consortia that have ran RRI-related activities funded through European Union's Horizon 2020 programme. Clear majority of the consortia members are universities and public funding agencies with for-profit organisations constituting less than 15% of all participants (Nazarko, 2019). However, recent publications address the business context more intentionally (Halme and Korpela, 2013; Gurzawska et al., 2018). The awareness is rising among scholars and policy makers that making RRI relevant to enterprises is the primary challenge and the ultimate test of the significance of RRI as a conceptual framework guiding innovation. This paper attempts to strengthen the RRI concept and contribute to the current discourse (Flipse et al., 2015) by offering ideas for operationalising RRI at the organisational level.

2. Overview of RRI-related initiatives

Reflection on responsibility in the context of research and innovation activity is not a new phenomenon and it has been present in academic, policy and business circles for decades. However, the very

Tab. 1. Definitions and interpretations of RRI

Author(s)	Definition/Interpretation	Distinguishing elements
Sutcliffe (2011)	1. The deliberate focus of research and the products of innovation to achieve a social or environmental benefit	Social or environmental benefit as the main goal
	2. The consistent, ongoing involvement of society, from beginning to end of the innovation process, including the public & non-governmental groups, who are themselves mindful of the public good	Involvement of society
	3. Assessing and effectively prioritising social, ethical and environmental impacts, risks and opportunities, both now and in the future, alongside the technical and commercial	Assessing social, ethical and environmental risks
	4. Where oversight mechanisms are better able to anticipate and manage problems and opportunities and which are also able to adapt and respond quickly to changing knowledge and circumstances	Anticipatory and adaptive
	5. Where openness and transparency are an integral component of the research and innovation process	Open and transparent
Grunwald (2011)	RRI as a new umbrella term with new accentuations which may be characterized by:	Distribution of Responsibility
	- involving ethical and social issues more directly in the innovation process by - integrative approaches to development and innovation;	Reflection about responsibility at all levels of the innovation process
	- bridging the gap between innovation practice, engineering ethics, technology assessment, governance research and social sciences (STS);	
	- giving new shape to innovation processes and to technology governance according to responsibility reflections in all of its three dimensions mentioned above;	
	- in particular, making the distribution of responsibility among the involved actors as transparent as possible	
Geoghegan-Quinn (2012)	Responsible Research and Innovation means that societal actors work together during the whole research and innovation process in order to better align both the process and its outcomes, with the values, needs and expectations of European society. RRI is an ambitious challenge for the creation of a Research and Innovation policy driven by the needs of society and engaging all societal actors via inclusive participatory approaches	Alignment of processes and its outcomes with the society's values, needs and expectations
von Schomberg (2012)	A transparent, interactive process by which societal actors and innovators become mutually responsive with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)	Multidirectional (mutual) responsibility of societal actors

Ethical acceptability

Social desirability |
| van den Hoven (2013 and 2014) | Responsible Innovation is an activity or process which may give rise to previously unknown designs either pertaining physical world (...), the institutional world (...) or combinations of these, which when implemented expand the set of relevant feasible options regarding solving a set of moral problems | Providing new options for solving pertaining moral/ethical problems |
| Stigloe et al. (2013) | Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present | Future-oriented look at collective responsibility |
| Owen et al. (2013) | The first and foremost task for responsible innovation is then to ask what futures do we collectively want science and innovation to bring about, and on what values are these based? | Collective nature of RRI processes

Future orientation |
| Stahl (2013) | RRI is a higher-level responsibility that aims to shape, maintain, develop, coordinate and align existing and novel research and innovation-related processes, actors and responsibilities with a view to ensure desirable and acceptable research outcomes | RRI as meta-responsibility |
| Pavie and Carthy (2013) | RRI is an iterative process throughout which the project's impacts on social, economic and environmental factors are, where possible, measured and otherwise taken into account at each step of development of the project, thereby guaranteeing control over, or at least awareness of, the innovation's impacts throughout the entire life cycle | Relevance for business context

Reflection on impact through the entire product life cycle |
| Wilford (2015) | RRI re-engages the individual with personal responsibility at the same time as reinforcing institutional responsibility. This means that RRI creates a step-change in the way that those who are engaged in research and innovation should consider the impact of what they do | Combination of personal responsibility and institutional responsibility |
| Gianni (2016) | RRI is a model and an active process by which we can achieve the social objectives set by the European Commission, i.e. the development of research and innovation for the sake of increasing the general level of well-being in democratic societies. | Duality of RRI: model (normative dimension) and process (processual dimension)

RRI valid in a democratic society |

Tab. 2. Conceptual distinction between normative and processual approach to RRI

| Responsible Research and Innovation | RRI as a **normative goal** | To tackle the Grand Challenges, solve moral/ethical issues connected scientific and technological development |
| | RRI as a **normative process** | Making sure that the R&I activities follow the principles of anticipation, inclusion, reflexivity and responsiveness |

Source: author's elaboration on the basis of (Ceicyte, 2019).

Tab. 3. Boundaries of the research field and research focus regarding RRI

RESPONSIBLE RESEARCH AND INNOVATION					
Research Subdiscipline	Public Governance	Science and Technology Studies	Business Ethics / CSR	Philosophy of Management	Innovation and Technology Management
Systemic dimension	micro		meso		macro
Sectoral dimension	Industry/Business		Public Administration/Policy Bodies		Universities and Research Institutions
Organisational dimension	Micro (individuals in an organisation)		Meso (teams)		Macro (organization as a whole)
Place in innovation ecosystem	Input		Throughput		Output
Innovation type	Low-tech innovation			High-tech innovation	

Source: author's elaboration on the basis of (Ceicyte, 2019).

concept of RRI is relatively new (about 8 years since its introduction in the EU jargon) and, as a matter of fact, quite Europocentric. Nevertheless, one can notice that principles similar to those included in the RRI concept have been integrated into innovation policy agendas in some non-EU countries too. Japan's 5th S&T Plan for 2016-2020 focuses on sustainable growth and solving global problems. Funding agencies in Norway and Peru have also been targeted to mainstream RRI principles (OECD, 2016). In the USA, STIR (Socio-Technical Integration Research) project offers an experimental platform for scientists and engineers to incorporate the RRI thinking into their activities.

Horizon 2020 and other EU programmes like Interreg focus on societal challenges and have provided funding for a number RRI-related projects. About 500 participants from ca. 50 countries formed consortia to implement RRI-related projects in the framework of the H2020 programme. Only 5% participants represented non-European countries (Nazarko, 2019). Low number of cross-continental partnerships is a serious problem if RRI is to be promoted globally (van de Poel et al., 2017).

Conducted projects resulted in the development of several interesting self-assessment and self-reflection tools oriented at business actors. "Responsible innovation flash diagnostic" and responsible innovation criteria have emerged from the Karim project (KARIM, 2014). Responsibility Navigator of the ResAgorA project presents a process-oriented view and suggests ten RRI-related principles divided in three groups: 1) Ensuring Quality of Interaction, 2) Positioning and Orchestration, 3) Developing Supportive Environments (ResAgorA, 2016). Classical RRI policy agendas (Ethics, Gender Equality, Governance, Open Access, Public Engagement, Science Education) form the backbone of a comprehensive self-reflection tool developed in the framework of the RRI Tools project. ORBIT Self-Assessment Tool presents a more focused approach as it serves needs of the ICT sector in the United Kingdom (Stahl, 2017). Self-relflection and in-depth assessment tools have also been developed in the ROSIE project ("Responsible and Innovative SMEs in Central Europe"). It is the only project so far that is addressed at enterprises in Central Europe.

Based on the results achieved in the mentioned projects, the following section offers author's original contribution to the development of RRI tools suitable for enterprises.

3. Proposals for Operationalising Responsible Research and Innovation

This section is a result of research performed by the author with the aim of formulating possible and

feasible approaches to implementing RRI in enterprises. The approaches concern either the product (economic viability, ethical acceptability, sustainability, social and environmental desirability) or the process (ethics as a design factor, moral responsibility, legal liability) dimensions of RRI (von Schomberg, 2013).

3.1. APPLYING WEIGHTED RESPONSIBILITY CRITERIA

Innovation may lead to the simultaneous improvement of all (economic, ethical, environmental, social) parameters of a particular product or service. However, a more realistic situation involves the consideration of alternative costs and trade-offs. For example, increasing product's environmental friendliness decreases its economic viability or addressing certain social needs in a designed service may have adverse environmental consequences.

By considering the issue of moral overload (van den Hoven et al., 2012) and enhancing Pavie's proposal (Pavie et al., 2014), the following principle could be applied when assessing if innovation meets RRI criteria:

$$\alpha VEcon_{t1} + \beta VSocial_{t1} + \gamma VEnv_{t1} > \alpha VEcon_{t0} +$$
$$+ \beta VSocial_{t0} + \gamma VEnv_{t0}$$

where,
$VEcon$ – contribution of a product/service to economic efficiency and welfare,
$VSocial$ – contribution of a product/service to addressing social problem(s),
$VEnv$ – contribution of a product/service to protecting the natural environment,
$t0$ – time before the introduction of innovation,
$t1$ – time after the introduction of innovation,
α – weight of the economic criterion,
β – weight of the social criterion,
γ – weight of the environmental criterion.

It may be noted that weights α, β and γ play a key role in determining the final result of the equation. Determining weights in this context is non-trivial as different stakeholders in the innovation ecosystem will have different views and priorities. In this context, Analytic Hierarchy Process (AHP) could be applied to determine weights. The following characteristics of this method are especially suitable in determining weights of economic, social and environmental value of innovation in the context of RRI principles: 1) AHP derives ratio scales from paired comparisons of criteria, and allows for some small inconsistencies in judgments, 2) Inputs can be actual measurements, but also subjective opinions (Goepel, 2018).

Another interesting evolution of this approach could be the application of Data Envelopment Analysis (DEA) to managing innovation projects portfolio with the focus on their "responsibility potential" (Chodakowska and Nazarko, 2017). Competing innovation roadmaps/trajectories could be evaluated with DEA with the view on how well they transform inputs (e.g. resources and time needed to complete the innovation process) into outputs (economic, social and environmental added value resulting from innovation).

3.2. APPLYING RRI MATURITY MODELS

Maturity models are used to evaluate companies and organisations in different aspects of their operation (Rohrbeck, 2011). Some authors propose the application of responsibility maturity models to help companies realise what their level of engagement in RRI-related issues is (Stahl et al., 2017; Pavie et al., 2014). Maturity models related to RRI are more focussed on process (Anticipation, Inclusion, Reflexivity, Responsiveness) rather than on products of innovation. Tab. 4 offers a synthesis of three approaches that could be used in applying RRI maturity models (as they are or as a starting point for customised tools).

Tab. 4. Examples of RRI maturity models

MATURITY LEVEL	LEVEL NAME BY PAVIE ET AL. (2014)	LEVEL NAME BY STAHL ET AL. (2017)	LEVEL NAME BY HEDSTROM (2019)
1	Comply with the law	Unaware	Engaging
2	Anticipating future legal requirements	Exploratory/ reactive	Accelerating
3	Thinking the value chain as an ecosystem	Defined	Leading
4	Developing responsible products and services	Proactive	Transforming
5	Leading the change (communicating and educating to responsibility, create standards, developing responsible business models)	Strategic	-

Source: author's elaboration on the basis of (Stahl et al., 2017; Pavie et al., 2014).

It is worth mentioning that maturity models could be effectively combined with the scorecard approach described below.

3.3. Applying RRI scorecards

Scorecards are rating systems developed to facilitate improvement, comparison and reflection. They are effective benchmarking tools. They are created to be filled in by one entity. It may be used to track company's progress over time or to monitor enterprise's position in the sector (if the same scorecard is used and made public by other companies). Creating an RRI scorecard and distributing it among companies in a particular sector or region may be an instrument of positive competition and a move towards excellence in implementing responsibility approach to innovation.

RRI scorecards may use different criteria and different levels of detail. Criteria may be divided by RRI policy agendas (Ethics, Gender Equality, Governance, Open Access, Public Engagement, Science Education), RRI processual requirements (Anticipation, Inclusion, Reflexivity, Responsiveness), or a wider set of RRI principles (Ethics, Gender equality,

Governance, Open Access, Public Engagement, Science Education, Sustainability, Risk Management, Human Wellbeing, Anticipation, Reflexivity, Deliberation, Inclusion, Responsiveness). Example of RRI scorecard is presented in Fig. 1.

Conclusions

Key role of science, technology and innovation in tackling global and societal challenges has already been acknowledged by governments across the globe. Ageing, spread of non-communicable diseases, food scarcity, pollution, depletion of Earth's resources, are among those issues that are hoped to be effectively dealt with thanks to the scientific and technological progress. Such view is reflected in the Daejeon Declaration on STI Policies for the Global and Digital Age signed by the ministers of OECD countries. The declaration reiterates the commitment to support science, technology and innovation to foster sustainable economic growth, job creation and enhanced wellbeing (OECD, 2015).

At the same time, it is evident that ethical and moral implications of research and innovation will
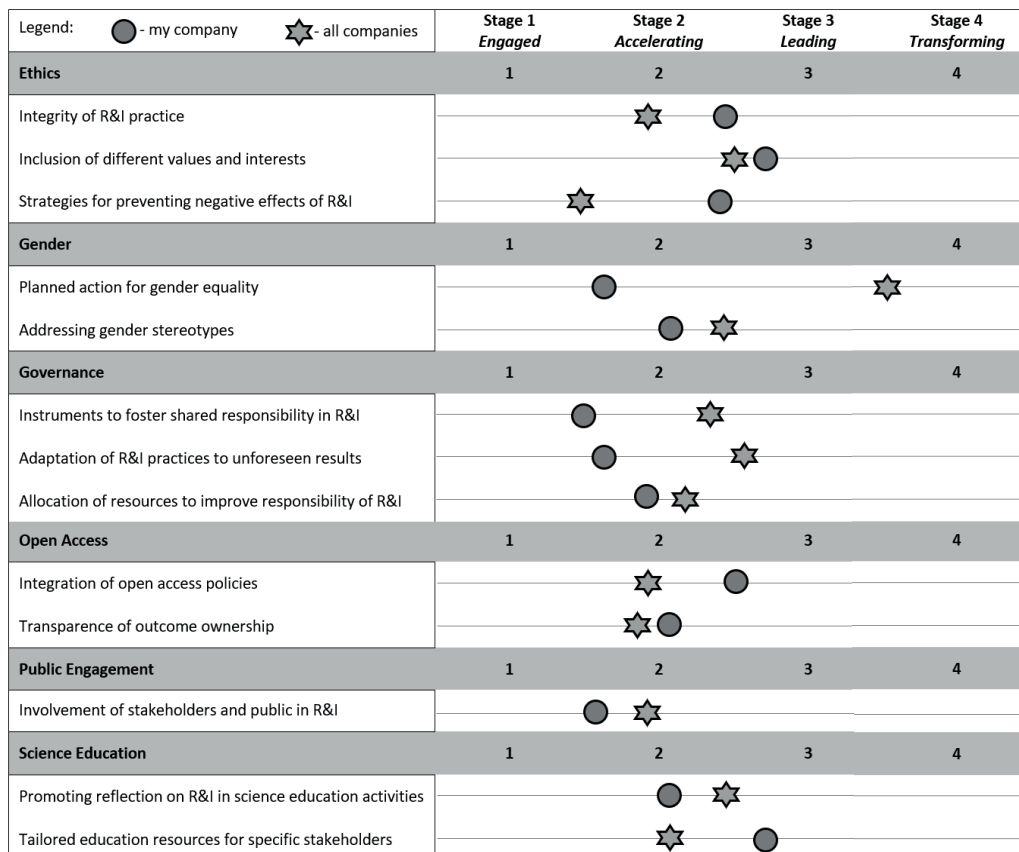

Fig. 1. Example of a RRI scorecard
Source: author's elaboration on the basis of (Pavie et al., 2014; Hedstrom, 2019) and RRI Tools.

put scientists and the R&I community under a closer surveillance and, possibly, critique. Educating the public about science and technology will move towards a more active involvement of different social groups in the science and innovation ecosystems. As noted by OECD, this may put additional pressure on science to provide clear and unambiguous answers and solutions, though it is perhaps just as likely that it will not, since involved citizens may come to better appreciate the provisional nature of much scientific evidence (OECD, 2016).

The RRI policy mix is far from simple and institutionalisation of RRI will not automatically lead to the emergence of a truly responsive, inclusive and reflexive approach to governing innovation (Genus and Iskandarova, 2018). Variety of policy instruments must be put in place at different stages of the R&I processes and at different stages of the policy cycle. There has appeared a tendency to design public and private interventions as dynamic processes that are prudent and preliminary rather than assertive and persistent (Kuhlman et al., 2019).

Operationalising the vision of Responsible Research and Innovation in a form of new priorities, evaluation criteria, corporate practices and governance arrangements will remain a major challenge for a long time. The general ideas of RRI tools for enterprises presented in this paper should be further analysed and developed.

Fears that RRI may be a hampering and delaying factor in scientific progress and may weaken the innovation capabilities and the competitive capacity of national economies are reasonable and should not be ignored. These tensions should be a subject of an in-depth interdisciplinary discussion that involves researchers from fundamental, applied and social sciences as well as humanities. Assessment of the trajectories of emerging technologies would be more holistic and would better relate to the RRI imperatives if future-oriented methodologies (Ejdys and Nazarko, 2014; Ejdys et al., 2015; Halicka, 2015; Nazarko et al., 2015) were utilised more extensively in these processes.

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