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Article

Responsible Research and Innovation in Enterprises: Benefits, Barriers and the Problem of Assessment

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Abstract: In the paper, the author takes stock of the conceptual reflection and empirical studies described in the current scientific literature on responsible innovation in the context of the emergence of Responsible Research and Innovation (RRI) concept. RRI has been promoted in the European Union as a part of the Europe 2020 strategy with the objective of making research and innovation more sustainable and inclusive. As more than half of the EU's firms declare conducting innovation activities RRI problematic becomes more relevant than ever. There remain many open questions, unresolved dilemmas and empirical white spots that call for more research in this field. This paper's main focus is the problem of RRI acceptance as a global framework for responsible innovation and the scarcity of suitable instruments that may help industry understand and adopt this concept. The main contribution of this paper are: the critical analysis of the RRI concept and its implications for industry, proposing a concept of RRI index for innovating enterprises.

Keywords: Responsible Research and Innovation; responsibility; innovation; assessment; Technology Assessment; foresight

1. Introduction

Responsible Research and Innovation (RRI) is an emerging framework of governing the R&D activity and innovation in both public and private sectors. It is considered to be "the ongoing process of aligning research and innovation to societal values, needs and expectations" [1]. It has been promoted in the European Union as a part of the Europe 2020 strategy with the objective of making research and innovation more sustainable and inclusive. In the recent years, a significant number of research projects and industry-oriented initiatives have attempted to address RRI from different angles, in different geographical areas and with different methods.

There remain many open questions, unresolved dilemmas and empirical white spots that call for more research in this field [2]. As more than half of the EU's firms declare conducting innovation activities [3] RRI problematic becomes more relevant than ever. This paper's main focus is the problem of RRI acceptance as a global framework for responsible innovation and the scarcity of suitable instruments that may help industry understand and adopt this concept.

In the first par of, this work, author analyses the current scientific discourse on RRI. Bibliometric analysis is carried out together with a critical analysis of most common RRI related subjects, lines of thought and methodologies. The critical analysis approach is also used in the second part in which the issue of RRI costs and benefits are synthesized and discussed. Next, the problematic of RRI assessment is presented and deconstructed. Various approaches to measuring RRI in public and private entities are discussed. The paper concludes with the discussion of the results, identification of the limitations of the study and pointing at the possible future research directions.

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2. Responsible Research and Innovation – overview of current discourse

Scientific production on the topic of RRI has been steadily increasing since 2009 – the year of publication of Robinson's important work that used the term "responsible research and innovation" for the first time [4]. The same may be said about the diffusion of the concept in non-academic sources. Media intelligence tools that analyze public new items online suggest a steady societal uptake of RRI from 2010 to 2017, however the absolute numbers of news items with the term "responsible research and innovation" are not impressive (356 news items globally in 2017) [5].

Query in the Scopus database on the documents that contain phrases "responsible research and innovation" or "responsible innovation" in their title, abstract or keywords, returned 841 documents (mostly articles, conference papers and book chapters; including 127 papers from the *Journal of Responsible Innovation*) published between 2009 and 2019. Clear growing tendency in the number of published documents may be observed, however, the tendency seems to slow down as it is shown in Fig. 1.

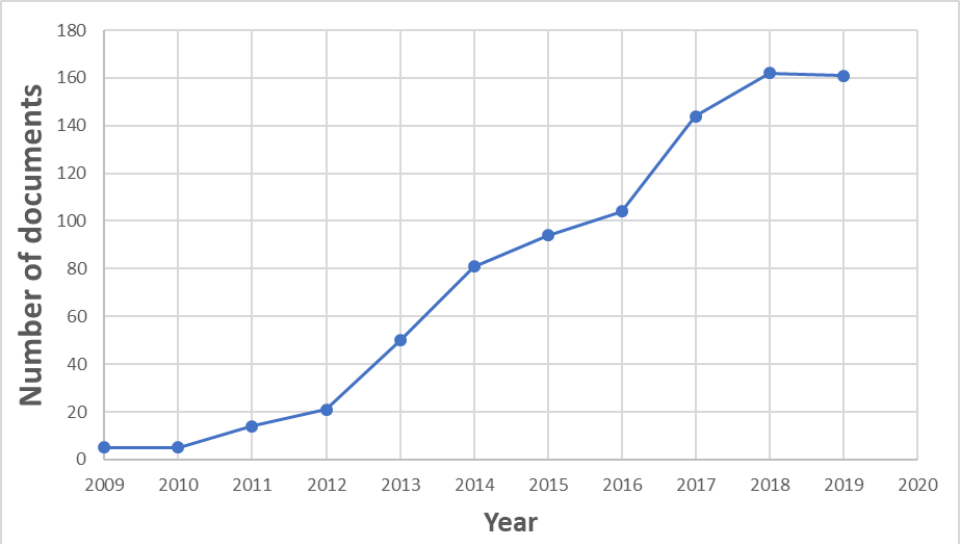

Figure 1. Number of publications that contain phrases "responsible research and innovation" or "responsible innovation" in their title, abstract or keywords, indexed in Scopus database (source: Scopus)

The slowdown is a new observation compared to previous analyses of this kind by Cuppen et al. [6] Timmermans [7] and Nazarko [8]. It remains to be seen if the slowdown constitutes a definite break in the sharp upward trend registered so far or is it only temporary. Some of Timmermans' conclusion in his mapping study [7] provide an argument for the former hypothesis. He observes that most of the RRI related activities took place in Western Europe and were funded by the European Union or public institutions in Western European member states. More than 100 million EUR from the Horizon 2020 Framework Program (2014-2020) were spent on more than 40 projects that dealt with RRI [8].

Since the RRI related activity may not be motivated by market demand of Research and Innovation (R&I) milieu, but rather has been pushed by policy-makers [7], the future extent of RRI related scientific production is heavily dependent on the available public funding for RRI activities. As the EU funding cycle within its Framework Program for Research and Technological Development (Horizon 2020) is coming to an end, the number of RRI related documents generated as the results of the H2020 projects is going down. For the time being, the EU planning documents for the next Framework Program (Horizon Europe, 2021-2027) do not mention RRI explicitly and do not foresee a separate funding stream similar to the current "Science with and for Society" (SwafS) program. There seems to be more emphasis on *excellence* rather than on *responsibility* [9]. Strategic implementation of RRI in future R&I policy at the EU level remains uncertain [1]. Such developments may herald stagnation in the research work on RRI unless the industry significantly

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increases its interest and involvement which has not happened so far (only 12,5% of consortia members in RRI related projects were for-profit organizations [8]).

Moving from the quantitative to the qualitative dimension, several categories of topics may be distinguished by analyzing the keywords of the RRI related documents indexed by Scopus. Visualization with VOSviewer has resulted in the identification of eight clusters of terms that co-occur most frequently (Fig. 2). The clusters (labelled with different colors in Fig. 2), however, are neither internally coherent nor qualitatively distinctive. It is, therefore, necessary to decompose the set of the most frequent keywords and make an attempt to form distinctive thematic categories based on substance and not on the co-occurrence.

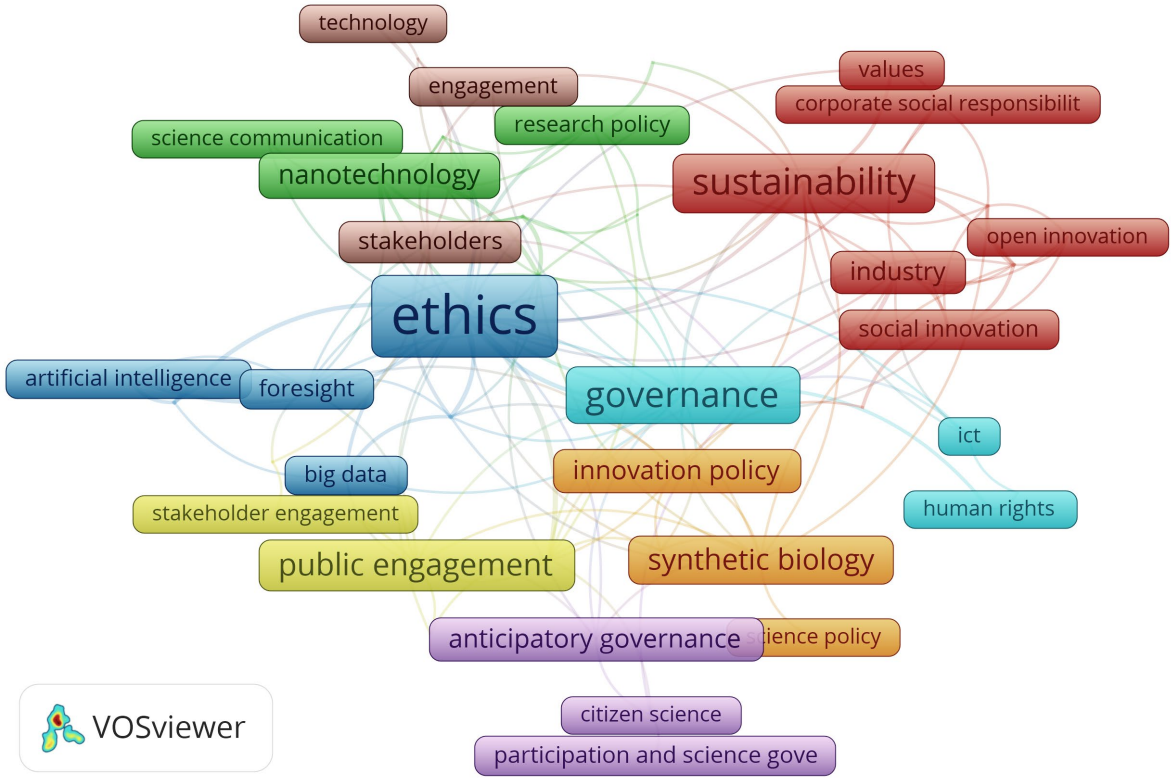

Figure 2. Visualization of the network of keywords in RRI related literature (source: own elaboration on the basis of Scopus data with use of VOSviewer software)

Thematic analysis of keywords in RRI related literature resulted in the identification of 9 categories of topics. The categories are named in Tab. 1. Relevant terms are assigned to categories (including terms that have been omitted in Fig. 1 for the sake of clarity).

Table 1. Thematic categories of RRI related literature.

	Category	Keywords
1	Epistemological foundations of RRI	values, Grand Challenges, ethics, human rights
2	Concepts and frameworks related to RRI	Corporate Social Responsibility, sustainability, sustainable development, social responsibility, value-sensitive design
3	Discussion on RRI principles	responsiveness, anticipation, participation, engagement
4	Analysis of RRI as a policy framework	research policy, anticipatory governance, participation and science governance, governance, innovation policy, science policy
5	Conceptualizing entrepreneurship and innovation in line with RRI	entrepreneurship, social entrepreneurship, social innovation, open innovation

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	principles	
6	Sectoral approach to RRI	industry, emerging technologies, nanotechnology, artificial intelligence, big data, human brain project, ICT, synthetic biology, technology
7	Educational and participatory aspect of RRI	science communication, public engagement, science education, stakeholder engagement, citizen science, science and society, stakeholders
8	Tools and methods for RRI	foresight, technology assessment, risk assessment
9	Institutional origin and source of funding	Horizon 2020

The obtained categories reveal the dominance of theoretical and conceptual themes in the RRI literature. Bulk of papers and book chapters concern the epistemological foundations of RRI together with many dilemmas, ambiguities and contradictions. Much attention is also devoted to localizing RRI among more established concepts such as Corporate Social Responsibility or sustainability. RRI principles [10] and RRI policy agendas are discussed against that epistemological and conceptual background. Moreover, RRI evokes new voices with regards to the (re)conceptualization of entrepreneurship and innovation. Considerable section of works deal with RRI agendas for particular technologies and innovation spheres. Public engagement and science education topics are also prominent. Finally, European Union (more specifically, Horizon 2020 Framework Program) is mentioned frequently, which is an indication of the policy-push evident in the current discourse. Generally, the works are conceptual rather that practical and process-oriented rather than outcome-oriented, which corresponds with findings of Cuppen et al. [6] and Timmermans [7].

4. Promised benefits and criticism of RRI

RRI remains a concept and a policy framework connected to selected funding streams in the European Union. As such, it has not been translated into concrete regulatory measures at the level of particular countries. Thus, the uptake of the RRI is dependent on the effective communication of the advantages that may accompany its broad adoption. In Tab. 2 and Tab. 3 a synthesis of the current discussion on both benefits and problems related to the implementation of RRI in enterprises are presented.

Table 2. RRI principles and promised benefits.

	RRI principle	Promised benefits
1	Anticipation	• Awareness of possible future legislation • Increased foresight competences and better risk management • "first mover" advantage
2	Reflexivity	• Higher quality of innovation outcomes due to third-party critical appraisal • Higher probability of innovation success
3	Transparence	• Better ability to interpret available information thanks to the culture of sharing knowledge • Higher effectiveness and efficiency of collaboration initiatives
4	Responsiveness	• Better ability to match social expectations • Increased trust from customers • Improved corporate image and increased public trust in offered goods • Better insight into needs and preferences of customers

Source: own elaboration on the basis of [11-18]

Table 3. RRI criticism and identified barriers to its implementation

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	Problematic issue	Implications for innovating organizations
1	RRI concept under constant development; different views and understandings of RRI framework in the literature	Negative attitude towards the idea of RRI Low level of understanding of the RRI concept
2	Western Eurocentrism of the RRI concept	Little chance of buy-in at the global level Regulatory and cultural differences between countries even within EU
3	No clear "division of labor" in the sphere of responsibility in the innovation activity as a consequence of the "shared responsibility" [19] or "meta-responsibility" [20] concepts	No clear indication of what is actually expected and at what stage from innovating businesses
4	Tension between "excellence" and "responsibility" both in science and business	Treating all activities related to RRI as an additional burden that makes innovation more costly and time consuming
5	Insistence on transparency and open access	Corporate intellectual property strategies not in line with the open access model
6	Shortage of understandable and easy-to-use tools to measure responsible innovation in business	Little interest in filling out long surveys and exhausting self-reflection forms

Source: own elaboration on the basis of [11,21,22]

5. Towards an RRI index for innovating organizations

5.1. One RRI index does not fit all

When attempting to compile metrics and indicators or to design indices that allow the comparison of different units from the perspective of RRI the following facts become apparent.

Firstly, separation of "research" and "innovation" within RRI concept seems appropriate since these two terms may be ascribed to different phenomena/processes with different actors involved [12,23]. "Research", as it is normally described in RRI literature, belongs to universities, laboratories, research institutes and research funding agencies. Research, in this sense, is associated with the production of new knowledge, often on the basis of public funding. "Innovation", in turn, is a process of turning existing or new knowledge into a marketable good, improved process or organizational arrangement. It is mostly associated with market context and the for-profit activity. In consequence it is more suitable to speak about Responsible Research in the context of public institutions and Responsible Innovation (RI) in the corporate/industrial context. This is not to say that research entities don't innovate and private sector does not conduct research, however the above distinction is helpful in making sense of differences between R&I in the non-profit/public and for-profit contexts.

Secondly, as a consequence of the above observation, different ways of assessing RRI are proposed for public entities (research conducting and research funding bodies) and for innovating enterprises. In Tab. 4 and Tab. 5 an overview of RRI assessment criteria proposed in the literature is presented.

Thirdly, it needs much scientific effort both theoretically and empirically to evaluate appropriateness of the RRI assessment criteria presented below. As in the case of Corporate Social Responsibility (CSR), despite higher maturity of the concept, there is still much doubt as to whether

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the available CSR metrics and indicators are suitable, optimal and transparent [24], and what is the relationship between CSR and firm performance [25].

Table 4. Examples of RRI assessment criteria for public entities

	RRI policy agenda	Names of Indicators
1	Gender equality	share of organizations with gender equality plans, share of female researchers, share of female authors and inventors, gender wage gap
2	Science literacy and science education	importance of societal aspects of science in science curricula, availability of RRI-related training at higher education institutions, number of citizen science publications in Scopus, organizational membership in European Citizen Science Association
3	Public engagement	models of public involvement in science and technology (S&T) decision-making, Active information search about controversial technologies innovation democratization
4	Open Access	share of Open Access publications, citation scores for Open Access publications, incentives and barriers for data sharing
5	Ethics	presence and performance of research ethics structures at research performing and research funding organizations
6	Governance	use of science in policy making, RRI-related governance mechanisms within research-funding and performing organizations

Source: own elaboration on the basis of [5] [26] [27]

Metrics and indicators presented in Tab. 4 are of a very diverse nature. Some are quantitative and objective, other are qualitative and more arbitrary. Some are based on data already available, other require new surveys. It is quite obvious that performance in some RRI dimensions (like gender, open access) is easier to capture with the use of indicators than in other (ethics, governance). Many of the indicators offer information about formal settings and structures established at research performing or research funding institutions, however it needs a much deeper look to see how those formal settings influence researchers, innovators and a wider society [5]. Categorizing the assessment criteria according to the defined RRI policy agendas also has its implications. Much emphasis is put on the process but less on the outcome of R&I. The presented metrics seem to miss the Grand Challenges and sustainability dimension of the RRI discourse [28]. Moreover, some indicators relate to the democratization of science and technology decision-making, which could be serious barrier in the adoption of RRI in non-democratic political systems.

Table 5. Examples of RRI assessment criteria for enterprises

	RRI policy agenda	Names of Metric/Indicator
1	Gender equality	• Implementation of a gender equality plan and practices regarding teams composition, management positions, work spaces, salary levels, contract conditions • Systematic evaluation of the state of gender equality in the organization • Provision of gender equality training • Identification of gender stereotypes present in R&I activity
2	Science literacy and science education	• Supporting citizens in making informed decisions • Increasing stakeholder awareness that R&I can create solutions that have impact on their lives • Using different outreach channels and adapting contents according to the target group

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3	Public engagement	• Engagement of relevant stakeholders in the innovation process (civil society organizations, local government, education community, customers, patients, families, etc.) • Conducting outreach activities and reflecting on them • Addressing conflicts of interests
4	Open Access	• Ensuring transparency and open access throughout the innovation process • Clear traceability of ownership and authorship
5	Ethics	• Anticipation of the benefits and risks of innovation project (including long-term side effects) • Ensuring project outcomes are used responsibly even after the project ends • Alignment with the Code of Conduct for Research Integrity • Encouragement of critical peer review and internal discussion on ethical issues throughout the process • Consultation with external ethics experts or committees
6	Governance	• Openness to emerging societal needs • Readiness to change the research plan or innovation project in response to unforeseen results or as a result of a dialogues with the stakeholders • Providing time for reflection during the innovation processes • Appointment of a staff RRI expert • Providing RRI training to employees

Source: own elaboration on the basis of [29] [30] [31]

Assessment criteria for enterprises presented in Tab. 5 are clearly different from the ones presented in Tab. 4. This confirms the argument for a separate approach to RRI in for-profit, market driven entities and in public research performing and research funding bodies. The indicators suitable for enterprises are predominantly based on the subjective judgement and self-assessment. Moreover, it should be noted that not all criteria are relevant to the activity of each innovating organization. Additionally, certain criteria may have more importance in a particular sector/technological domain than in others. All these conclusions have implications for the design of an assessment framework in the form of a RRI index presented below.

5.2. Proposal of RRI index for innovating organizations

There is a clear tension between the need to measure and quantify the responsibility aspect of the innovation activity ("you can only manage what you can measure") and the broad, heuristic and often ambiguous nature of RRI concept. "Monitoring RRI by utilizing closed response surveys, questionnaires, and other highly quantified methodologies risks serving to reify narrow interpretations of its application and constitution" writes van de Klippe [32]. Nevertheless, industry expects academia to provide concrete solutions and to propose concrete metrics against which RRI could be measured. The conceptual work presented below has been inspired by existing approaches to sustainability evaluation [33].

The proposed RRI index for innovating organizations has the following features:

1. It is based on respondent's subjective/arbitrary judgement (semi-quantitative nature)
2. Its ingredients may be customized according the needs of a particular sector or a group of enterprises
3. Components of the index are weighted. Weights are also arbitrarily determined by the users of the index.

First stage of the development of the RRI index for enterprises consists in conducting a survey among innovating companies. Companies judge their own performance in the RRI relevant fields.

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As a result, each company obtains it score in RRI relevant fields compared to the highest score in the group. Examples of RRI fields that may be assessed are presented in Fig. 3.

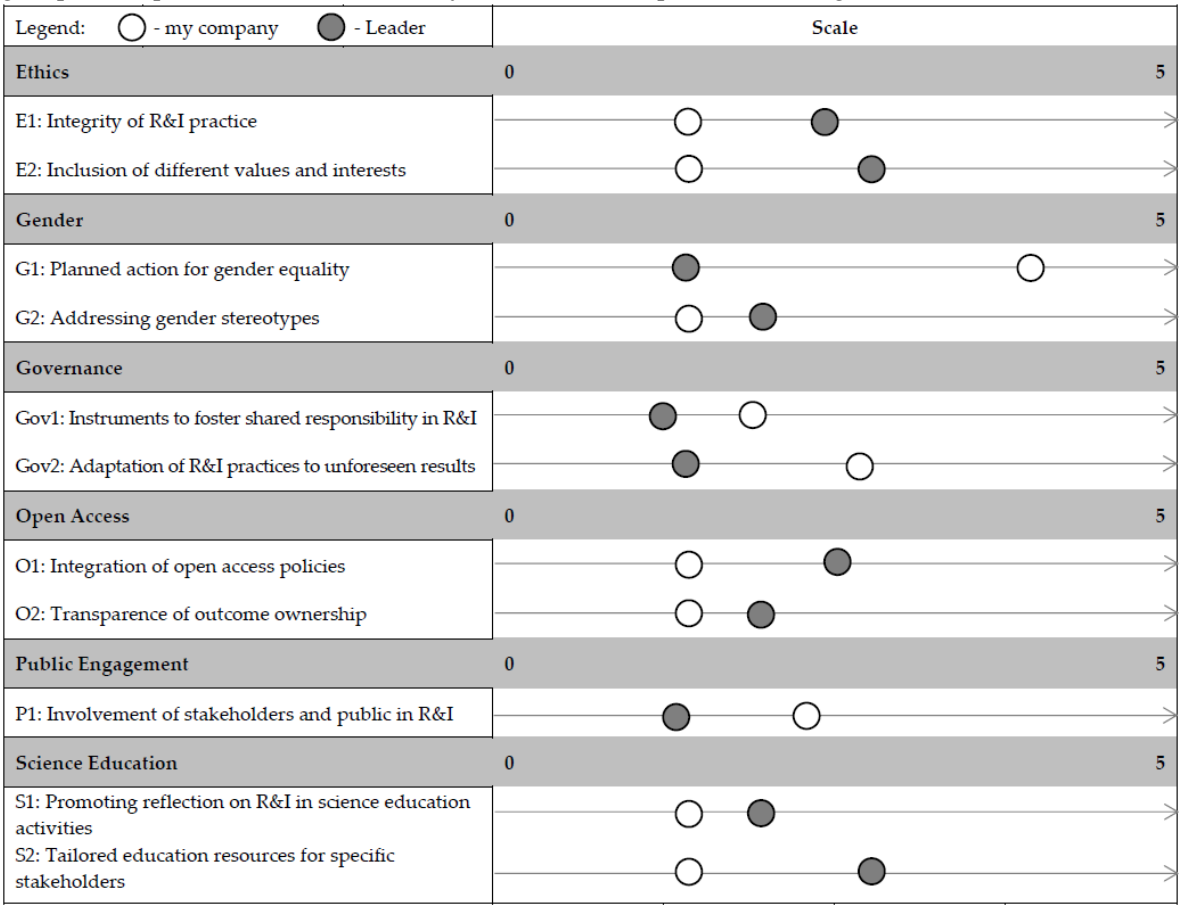

Figure 3. Stage 1 of the RRI index development from the perspective of a single enterprise

Second stage consists in determining wights of the index components (E1, E2, G1, G2, Gov1, Gov2, O1, O2, P1, S1, S2). Weight could be determined by arbitrarily by a researcher or policy maker or they may be determined collectively by the enterprises participating in the survey. The sum of weight should be equal 1.

Third stage is carried out separately for each enterprise. Distance between the enterprise's score and the leader's score should be calculated for each component (it will be added to the index with a negative value) (Fig. 4). In components where the company is actually the leader the distance between the second best enterprise is calculated (it will be added to the index with a positive value).

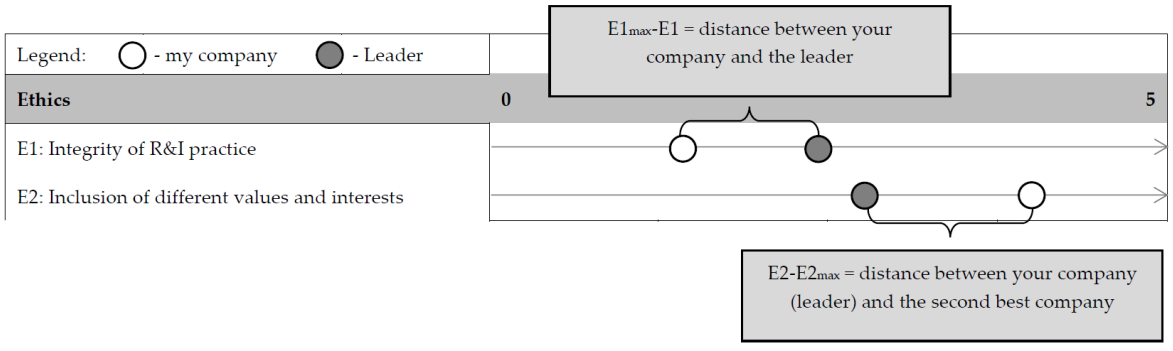

Figure 4. Stage 3 of the RRI index development from the perspective of a single enterprise

Fourth stage consists in summing up the distances calculated in the third stage taking into account the weights determined in the second stage. The enterprises may be ranked according to the

obtained result. The higher the number the better RRI performance. Normalization procedures may be applied if needed.

The advantage of the proposed RRI index is its flexibility and simplicity which makes it understandable, usable and easy to interpret. It should be noted that the optimal use of the index consists in benchmarking i.e. in calculating the index with the same components and the same weights for a number of similar organizations. Such exercise may help identify leaders and followers in RRI, thus spreading best RRI practices.

6. Discussion and Conclusions

Complexity and dynamism of innovation ecosystems is growing on regional, national and global levels. Impact of new technologies, products and services on society, economy, environment, culture and values is increasingly difficult to predict as the world is increasingly characterized by volatility, uncertainty, complexity and ambiguity (VUCA). In this context, classical perspectives on responsibility that focus on its individual dimension are insufficient to reflect the complexity and multifaceted reality of modern socio-technical systems [14]. That calls for a new, relational and networked understanding of responsibility which transits from "responsibility in and to society" towards "responsibility for and with society" [19].

Gianni's position that RRI is essentially a "performative framework that can never be accomplished" [34] carries both risks and opportunities. On one hand, its unfinished nature allows for a big deal of flexibility and adaptability to different contexts. On the other, lack of one common understanding of the concept poses serious difficulties in its operationalization and buy-in from the industry [35].

The distinctive feature of RRI approach consists in the aspiration to take stakeholders' needs, concerns and values *before* a product, service or technology enters the market; to go beyond "not doing wrong" (for example by introducing environmental management systems [36]) towards "doing good". Thus, anticipation, in addition to regulation, becomes a new critical element of innovation governance [37].Even more than before, innovators are encouraged to practice reflexivity in the form of foresight [38], Future-Oriented Technology Analysis [39] or innovative forms of Technology Assessment [40,41]. Easier said than done: anticipation of future impacts of innovation (often unintended and ambiguous) falls into Collingridge dilemma: "When change is easy, the need for it cannot be foreseen; when the need for change is apparent, change has become expensive, difficult, and time-consuming" [42].

The main limitation of the presented study derives from the lack of a representative empirical component. It is therefore author's ambition to continue studies in that direction. Two avenues seem especially enticing: investigating RRI adoption and testing RRI assessment tools in selected sectors (for example food industry [43] or machinery building industry[44]) and exploring territorial aspect of RRI in less studied European regions (namely Eastern and Central Europe [45]).

In author's opinion, further research may be directed towards two goals. First, attempts should be made to overcome the Eurocentrism of the RRI and to increase its global reception. After all, RRI should foster innovation that tackles major societal challenges that are global by nature: i) tightening supplies of energy, water and food; ii) pandemics and public health issues; iii) ageing societies; iv) security and v) climate change [46]. Thus, it should not be impossible to establish a certain set of social desirability criteria necessary for RRI to go global [47].

Secondly, context sensitive, business relevant and user friendly tools for RRI evaluation should be further developed and continuously improved to increase industry acceptance of the framework. Development of valid measures of the responsibility of innovation processes and outcomes are perhaps the most important challenge for researcher and innovation stakeholders alike. Innovation responsibility ratings of enterprises could be strong tool capable of influencing ethically sensitive investors and mobilizing consumers, potential employees and social movements. As awkward as it sounds, there is a big deal of responsibility attached to responsibility assessment.

Universally accepted set of social desirability criteria would be a very good starting point for global responsibility benchmarking surveys [48] and analyzes. Application of more sophisticated

analytical instruments would be desirable. For example, Data Envelopment Analysis (DEA) could be used to evaluate how efficiently innovating organizations transform their resources and time (input) into socially desirable "outputs" [49,50]. Such "RRI productivity" approach could also be used at the strategic planning stage to choose between competing technology roadmaps [51-53] with different anticipated inputs and outputs.

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