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Responsible research and innovation in practice an exploratory assessment of Key Performance Indicators (KPIs) in a Nanomedicine Project

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ABSTRACT

While originally intended to transform research and innovation practice, the concept of responsible research and innovation (RRI) has largely remained a theoretical, policy-oriented construct, thereby engendering a perception that RRI indicators are very different from organizational or business indicators. As there is currently limited experience with RRI in businesses, in an attempt to gain more insights into RRI in practice, this paper focuses on an exploratory assessment of key performance indicators (KPIs) in a nanomedicine project. Based on correspondence analysis, we visually demonstrate associations among KPIs of RRI dimensions and of organizational ongoing R&D dimensions implying that these two indicators are not entirely different from each other and may even be potentially aligned. This finding may stimulate the motives of the RRI uptake in practice.

1. Introduction

Research and innovation can be at the root of transformative changes in our society. To stimulate these changes to align with the needs and values of the society, a framework for responsible research and innovation (RRI) has been proposed (Owen et al., 2012; Stilgoe et al., 2013; Von Schomberg, 2011, 2013). The need to incorporate this framework in practice is preceded and reinforced with the current European policy of RRI in addressing grand societal challenges (European Commission, 2014), defined as *"formulations of global problems that can be plausibly addressed through coordinated and collaborative effort"* (George et al., 2016, p.1880).

To embed societal needs and values in innovation processes, Stilgoe et al., (2013) propose four dimensions of RRI: anticipation, reflexivity, inclusion, and responsiveness. Although these four dimensions set the agenda for researchers/scientists, stakeholders and policy makers to incorporate a more responsible vision of research and innovation, there is currently limited experience with the operationalization of RRI dimensions in businesses (Stahl et al., 2017; Van de Poel et al., 2017; Yaghmaei, 2018). There is also limited evidence of the added value of RRI in industry and how RRI measures are explicitly considered and integrated into a company's ongoing research and innovation processes (Van de Poel et al., 2020). The four conceptual dimensions need to be further advanced with substantive measures and assessment in research and innovation practices.

This paper attempts to address the above limitations by assessing a pilot project in an industrial innovation practice (i.e. a nanomedicine project), in which a number of product- and process-oriented RRI dimensions are compared with organizational innovation management dimensions. We use data from a nanomedicine project which is one of the eight pilot projects that we conducted for the EU-funded project 'PRISMA' (Piloting RRI in industry: a roadmap for transformative technologies, 2016–2019). The PRISMA project is a relevant context as it fits with the purpose of the paper in exploring and investigating the uptake of RRI in practice. In particular, the focus on the nanomedicine project is applicable for an in-depth analysis since this project is conducted in a company that is actively involved in RRI strategies and is at various stages of transformation towards RRI and relatedly corporate social responsibility (CSR).

In essence, this paper provides an exploratory analysis of how to assess RRI in businesses and is based on three main key research questions:

1 How do managers of a company active in research and innovation of transformative technology (nanotechnology-based medicine) assess the relevance of RRI dimensions?
2 How does an intervention such as a workshop change or adjust their assessment of their own RRI performance?
3 How are RRI dimensions related with organizational dimensions for ongoing R&D processes?

To address the first two questions, we conducted an interactive stakeholder-dialogue workshop (which we refer to as 'intervention') in which managers and innovation team members were asked to select the relevant key performance indicators (KPIs) for their innovation project. We then analysed if the intervention may or may not cause any

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adjustment to their assessment of KPIs. In addressing the third question, we further used correspondence analysis (CA) to visually demonstrate how certain KPIs of RRI dimensions correspond with those of organizational dimensions for ongoing R&D processes and how over time managers and innovation team members may assess the importance of certain KPIs differently.

The measurements of RRI and organizational dimensions were done before (Q4 2017) and after the workshop (Q1/Q2 2018) on RRI with the company. Consequently, we gain knowledge on how RRI dimensions correspond with organizational ongoing research and innovation/development processes (i.e. organizational dimensions) from the perspective of innovation managers and team members. This approach, however, may be subject to selection bias. For instance, the discussion of whether managers in a company apply RRI (or its adjusted version) as an organizational-instrumental tool to profile themselves as a responsible company (i.e. a form of window-dressing) or as a genuine commitment to RRI (Van de Poel et al., 2020). Hence, the associations of RRI dimensions with organizational dimensions that we found in this paper should rather be interpreted as an exploratory evidence that still needs to be further investigated in future research (Section 5.2).

To structure our discussion, in Section 2 we discuss the theoretical background of RRI and CSR. Based on literature, in Section 3, we develop KPIs for organizational and RRI dimensions and then assess the KPIs in practice by asking the project managers and team members of the nanomedicine project to score how well they consider their achievement in certain KPIs on a seven-point Likert scale at two points in time (i.e. before and after the intervention). In Section 4, we analyse the data collected by using CA and present the results of the analyses. Finally, in Section 5, we conclude with the key findings, research implications and directions for future research.

2. Theoretical Background

2.1. Aligning Definitions of Responsible Research and Innovation (RRI)

When discussing RRI in industry, the construct is, to a large extent, analogous to the construct of responsible innovation (RI). While the construct of RRI can be considered as administrative (since it was originated from science policy makers and funding agencies such as the European Commission), the construct of RI may be regarded as a scholarly research field of RRI (Burget et al., 2017; Owen & Pansera, 2019). As such, there are administrative definitions for RRI (e.g. European Commission, 2013; Sutcliffe, 2011; Von Schomberg, 2011) and academic definitions for RI (e.g. Stahl, 2013; Stilgoe et al., 2013). We highlight one key definition for RRI and RI respectively.

Aligning with European policy processes and values, Von Schomberg (2011, p. 9) defines RRI as: "*Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on 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)*." Translating Von Schomberg's RRI definition into a broader and prospective notion of responsibility, Stilgoe et al., (2013, p. 1570) define RI as: "*Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present.*"

A careful analysis of the above definitions indicates that the distinction between RRI and RI is not merely terminological, but also conceptual. The rationale lies in the observation of the source of normativity in RRI and RI (Owen & Pansera, 2019). Whereas in RRI the substantive values are fixed by the values anchored in the European Commission (structured around six key areas), in RI the question of which substantive norms should guide innovation is at stake and remains abstract. Nevertheless, RRI and RI each offer their own normative guiding principle for innovation and science. For instance, while the discourse of RI seems to advance on deeper institutional and systemic transformation towards anticipatory, inclusive, reflexive, and responsive innovation; the discourse of RRI seems to be rather isolated rather than coherent and it does not substantively engage with innovation and thus offer little likelihood of systemic transformation (Owen & Pansera, 2019).

Within our nanomedicine project, the difference between research (possibly more academic, fundamental in nature) and innovation (more industrial, application-oriented) disappears. Rather, research and innovation become intertwined: research has an applied character and is oriented towards innovation. So, RI and RRI are practically interrelated in our context. While RI scholars incorporate the products, processes, and purposes of innovation, in RRI they focus specifically on products and processes. In this paper, we will use the term RRI in which it predominantly means embedding public values (e.g. social and ethical values) in the innovation process, and also in a timely manner, while innovation is still ongoing.

2.2. RRI and Corporate Social Responsibility (CSR)

The 'responsibility' notion in RRI indicates a strong link with CSR. The RRI-CSR link offers complementarities in which CSR may bring RRI closer to industries and may strengthen the relationship between business and society towards a corporate sustainable development over time (Bansal, 2005; Bansal & Song, 2017). When relating RRI to CSR, the previous definitions of RRI and RI are very much in line with the definition of CSR. By definition, the European Commission (2011) defines CSR as "*the responsibility of enterprises for their impacts on society*" and McWilliams & Siegel (2001, p. 117) define CSR as "*actions that appear to further some social good, beyond the interests of the firm and that which is required by law*". Additionally, McWiliams & Siegel (2011, p.1480) further developed the theoretical angle of CSR by introducing the concept of strategic CSR, defined as "*any "responsible" activity that allows a firm to achieve a sustainable competitive advantage, regardless of motive*".

There are, however, some key differences between RRI and CSR in their conceptions of responsibility and their incentives for uptake as summarized in Table 1. The first two key differences between RRI and CSR is around the question of who is responsible and who needs to participate to ensure responsibility. First, regarding 'who-is-responsible', the notion of responsibility in CSR is unidirectional in which it is the firm that is held responsible, whereas RRI has multifaceted denotational meanings including role, task, capacity, authority, virtue or care, responsiveness, obligation, accountability, blameworthiness, liability, causes or outcomes (Van de Poel, 2011; Vincent, 2011). These multifaceted meanings can have both negative as well as positive interpretations (Pellé & Reber, 2015) which resonates with the positive and negative views on CSR. For instance, the agency theory perspective (Jensen & Meckling, 1976; Ross, 1973) regards CSR as problematic since CSR can be misused by managers to advance their own personal interests rather than to create values for shareholders, whereas the stakeholder theory (Freeman, 1984; Donaldson & Preston, 1995) has a more positive view of CSR in which CSR is considered to motivate managers to not only focus on shareholders but also on stakeholders (such as employees, customers, suppliers, community) as altogether they give meaning to firm outcomes. This requisite focus is reiterated in the perspectives of stewardship theory (Donaldson & Davis, 1991) and institutional theory (Campbell, 2007) because moral and ethical obligations form fundamental trust and integrity which in turn, make firms to be seen as legitimate by their shareholders and stakeholders (Chiu & Sharfman, 2011). Second, regarding which actors to be engaged, in CSR a firm involves its shareholders and stakeholders in fulfilling the responsibility, while in RRI the firm also engages societal actors (actors who in principle might not have specific interests at stake) along with the firm's shareholders and stakeholders to contribute to achieving a responsive and collective responsibility.

The third difference between RRI and CSR is about when to intervene to ensure responsibility. CSR, as a broader principle to ensure ethical responsibility of a company to all its legitimate stakeholders

Table 1
Key differences of RRI and CSR

	Key differences RRI/RI	CSR
Who is responsible	Multidirectional: mutually responsive/collective stewardship by all stakeholders	Unidirectional: The firm is responsible
Actors to be engaged	Societal actors and stakeholders and shareholders	Stakeholders and shareholders
Time to intervene	During the whole process and mostly from the earlier phases of research and innovation	Mostly at the later phases of research and product development
Source of normativity	• In RRI: The norms and purposes are grounded in the six keys areas coined by EC (top-down) • In RI: The norms and purposes emerge during the ongoing normative assessment process (bottom-up)	Creating strategic benefit/advantage is required by law
Incentives for uptake	Corporate reputation and critical consumerism, certification, employee engagement and governance	Superior financial performance, non-financial performance such as corporate attractiveness for job seekers, and employee engagement

(Crouch, 2006), mostly relates to the later phases of research and product development, whereas RRI is a more specific principle to include social values and needs from the earlier phases of research and innovation (Van de Poel et al., 2017).

The fourth difference of RRI and CSR lies in the source of their normativity. In CSR creating strategic benefit/advantage is required by law (McWiliams & Siegel, 2011). In RRI, the norms and purposes are grounded in the normative anchor points of the European Commission and aligned with the considered six key areas (top-down); whereas in RI, the norms and purposes emerge during the ongoing normative assessment process (bottom-up).

Finally, the difference lies in the incentives for uptake. In CSR, the incentives for uptake are superior financial performance (Flammer, 2015a; Orlitzky et al., 2003), non-financial performance such as corporate attractiveness for job seekers (Jones et al., 2014) and employee engagement (Flammer & Luo, 2017). The incentives for the uptake of RRI in companies are corporate reputation and critical consumerism, certification, employee engagement and governance (Gurzawska et al., 2017). Additionally, like CSR, there is also criticism that RRI may be used mostly instrumentally such as explicitly pinpointed by Owen et al., (2012, p.757): "*If RRI risks becoming a new label for business-as-usual, it also risks being used instrumentally, to smooth the path of innovation in society, and/or to achieve precommitted policies*". Despite the debate of the positive and negative motives for implementing RRI and CSR, our view is that reasons for considering and implementing RRI may neither be purely idealistic nor purely economic, but a balance between the two (cf. Penders et al., 2009).

Notwithstanding the RRI and CSR differences, there is a lack of clarity with whether and how the RRI guiding principles can be a key element of CSR and can be embedded in an organization's CSR strategy. To embed RRI in CSR or innovation strategy, RRI may be considered as a strategic resource, i.e. a source of sustained competitive advantage (Eccles et al., 2014; Flammer, 2015b). As such, the integration of RRI and CSR may be referred to as corporate social innovation as a resource for creating competitive advantage and simultaneously for innovating for the greater good (Mirvis et al., 2016). Regarding the view of strategic resource, building on the study of McWilliams et al., (2006) we argue that having RRI as part of CSR practices may have two key strategic implications: (1) RRI/CSR can be a firm's differentiation strategy and hence should be considered as a form of strategic investment, reputation building or maintenance; and (2) managers may expect a positive relation between RRI/CSR and R&D.

2.3. Dimensions of RRI

Based on the literature review of RI and/or RRI, we synthesise conceptual dimensions that can further substantiate the general framework for RRI. Table 2 presents the dimensions that were considered by scholars so far when thinking about the RI/RRI indicators for the intervention.

As this paper is oriented towards practices of RRI in a company, we also investigate the conceptual RRI dimensions from a practical outlook. Here in an attempt to cover all sources of normativity in RRI, RI, and CSR, besides the prominent four dimensions of RI proposed by Stilgoe et al., (2013) – i.e. anticipation, reflexivity, inclusion, and responsiveness – there are two added dimensions in Table 2: openness & transparency and sustainability. Correspondingly, the sustainability dimension is further delineated into 'environmental sustainability' and 'social sustainability'. In fact, to incorporate a corporate setting, these two sustainability dimensions are based on the metrics and indicators of RRI (MoRRI) proposed by Ravn et al., (2015), a report on RRI indicators from the European Commission (European Commission, 2015; Spaapen et al., 2015), and the notions of CSR in Section 2.2. The 'environmental sustainability' dimension refers to companies actively embedding environmental values (benefits and risks) in their innovation process while the 'social sustainability' dimension refers to companies actively embedding societal values (privacy, safety, health, security, data ownership, etc.) in their innovation process.

Subsequently, when developing KPIs[1] for both RRI and organizational dimensions, we build on Stilgoe et al., (2013) who suggest to develop a line of questioning at product, process, and purpose levels. While product questions focus on the issues of technological risks (conventional governance), process questions focus on research integrity through ethical governance. When the governance issues are extended further, purpose questions probe into motivations of research and innovations. For the PRISMA project, however, we focused on the product and process levels only, since we expect the purpose of this industrial innovation project will be rather commercial. Although the purpose level can have socially desirable outcomes and economically feasible outcomes, there may be multiple purposes involved. These different purposes are too complex to assess because it is intricate to really tell if the motives are purely instrumental or normative (cf. Penders et al., 2009). Our focus on product and process levels is also in line with Von Schomberg (2013) in which he features RRI in both product and process levels as they are interrelated for a comprehensive RRI uptake.

3. Data and Methods

3.1. Research Setting

Our study is based on a pilot nanomedicine project from the PRISMA project (Table 3). Nanomedicine is based on nanotechnology which is considered as one of transformative technologies. Transformative tech-

[1] The complete list of KPIs is available upon request. Please send an email to the corresponding author.

Table 2
Summary of dimensions of RRI

Dimension of RRI	Concept	Key Reference
Diversity and inclusion	Engaging different stakeholders (members of the wider public) upfront, i.e. in the early stages of research and innovation to become legitimate	De Saille, 2015; Lubberink et al., 2017; Macnaghten & Chilvers, 2014; Stilgoe et al., 2013; Von Schomberg, 2011, 2013
Anticipation	Foresight of the future of research and innovation through a.o. upstream public engagement, constructive and real-time technology assessment, and anticipatory governance	Barben et al., 2008; Karinen & Guston, 2009; Lubberink et al., 2017; Owen et al., 2012; Owen & Pansera, 2019; Stilgoe et al., 2013; Von Schomberg, 2011, 2013
Reflexivity and deliberation	Reflecting on institutional or public values and ethics or morality in research and innovation processes through early engagement and deliberation of diverse range of stakeholders	Lubberink et al., 2017; Macnaghten et al., 2005; Owen & Pansera, 2019; Schuurbriers, 2011; Stilgoe et al., 2013; Wynne 1993; Von Schomberg, 2011, 2013
Responsiveness and adaptive change	Assimilating and adjusting courses of action as new knowledge and values emerge to become more responsive to grand challenges	Lubberink et al., 2017; Owen et al., 2012; Owen & Pansera, 2019; Stilgoe et al., 2013; Von Schomberg, 2011, 2013
Openness and transparency	Being open and transparent by providing free and equitable access to knowledge and to facilitate inclusive deliberation	Owen & Pansera, 2019; Stilgoe et al., 2013; Von Schomberg, 2011, 2013
Sustainability	Being able to continue for a long period of time, i.e. resource efficiency; this is related to both environmental and social sustainability	Bozeman et al., 2015; Burget et al., 2017; Forsberg et al., 2015; Von Schomberg, 2011, 2013

nologies refer to technologies that have the potential to transform existing modes of production and to change the relation of the company with users, suppliers and other stakeholders (Lynskey, 2006). Such transformative technologies can make important, if not, indispensable contributions to a sustainable society and to the economic competitiveness providing that risks are foresighted, mitigated and managed responsibly.

As shown in Table 3, the company which we study in this paper is a small-medium enterprise with main activities in R&D, prototyping and production of nano-based products to be used in the industrial fields of pharmaceuticals, nanomedicine, and other related research. Translating the company's core values into the RRI vision, the company aims at realizing a personalized, patient-centric and point of care therapy, for a highly effective, accessible and affordable treatments of severe diseases. This vision is further embedded in the company's in-house corporate sustainability policy.

In this paper, we focus on an ongoing nanomedicine project of the company with an innovation stage around mid-to-near market. It is a large in-house project funded by different cooperative parties to create a technology platform for providing an integrated and modular system, for the diagnosis and treatment (theranostic) of cancer and nervous system diseases. The nanomedicine project is a nanotechnology-based system using a combination of targeted and controlled drug delivery, hyperthermia, radiofrequency and laser imaging methods. In such a project, health, risk and safety considerations are of prime importance. With these considerations in mind, the assessment of RRI is highly related to Environmental, Health and Safety (EHS) and Ethical, Legal and Societal Aspects (ELSA) issues in which the inclusion of multiple stakeholders is essential.

3.2. From Dimensions to Key Performance Indicators (KPIs)

In the PRISMA project, one of the primary deliverables was to develop scalable KPIs for both organizational and RRI dimensions for ongoing R&D processes. This was motivated by the idea to study the value of RRI practices in the "midstream" (Fisher et al., 2006) of industrial innovation, i.e. on the R&D work floor (Schuurbiers &Fisher, 2009; Schuurbiers, 2011). This focus is essential when studying RRI-relevant aspects of innovation processes on the actual, ongoing R&D projects of transformative technologies such as nanotechnology.

Regarding KPIs of organizational dimensions, we made use of the innovation management literature review (e.g. Cooper & Kleinschmidt, 1995; Flipse et al., 2013; Maidique & Zirger, 1984; Tepic et al., 2013; Van der Panne et al., 2003) emphasising quality performance indicators for ongoing R&D processes from the perspectives of management/organization, R&D work floor, and outcomes of R&D processes. For KPIs of RRI dimensions, quality performance indicators are not explicitly found in peer-reviewed scholarly publications. Accordingly, we used reports of EU-funded projects and policymakers (e.g. Ravn et al., 2015; Scholten et al., 2016; Strand et al., 2015). From these papers and reports in both organizational and RRI dimensions, we initially found approximately 250 indicators (Yaghmaei et al., 2019). For further selection, we considered indicators as relevant when they align with RI four dimensions, RRI six keys, and environmental and social sustainability dimensions (Table 2). After removing redundant and irrelevant indicators, we obtained a list of 92 KPIs (see Table 4; for the full list of KPI statements, see Yaghmaei et al., (2019)).

Finally, we formulated the 92 KPIs into statements which respondents (managers, team members) might agree or disagree with, on a seven-point Likert scale (1: strongly disagree, 2: disagree, 3: slightly disagree, 4: neither disagree nor agree, 5: slightly agree, 6: agree, 7: strongly agree). The actual score of the Likert scale indicates how well the respondents consider the company is doing on certain KPIs.

3.3. Data Collection and Analysis Methods

Before the 92 KPIs are implemented in the nanomedicine project, we first asked the company's managers and team members (i.e. researchers/scientists) to further select KPIs which they think are relevant for their organization and their innovation projects specifically, since we foresaw not all 92 KPIs may be relevant for the project. For this purpose, we had the 92 KPIs printed on individual cards (business-card format) and then asked the participants to categorize the KPIs into the following three categories: yes (relevant), maybe (perhaps not so relevant at present but may be relevant in the near future), and no (irrelevant either at present or in the near future). Prior to this categorization, at the beginning of the workshop, the workshop participants received explanation about each of the dimensions/content of the indicators. KPIs that fall into the "no" category were removed while those "maybe" category were subject to a second round of review of which only the new "yes" indicators were included. With this approach, we address the first question of how managers of a company active in research and innovation of transformative technology (nanotechnology) assess the relevance of RRI dimensions.

The assessment results based on the workshop (see Table 5) show that for organizational dimensions, 36 indicators (19 product and 17 process indicators) were considered relevant while 13 indicators (8 product and 5 process indicators) were considered irrelevant. For RRI

Table 3
Key information of the nanomedicine company (Source: PRISMA project)

Core values	The following values guide the overall business model of the company:Quality and excellence in research and innovation (R&I)Attention to environmental health and safety issues in R&D and production processesRespect of ethical standards in R&IDevelopment of innovative solutions to tackle societal challenges.
Activities	The company is active in research and development, prototyping and production of nano-based products to be used in the industrial fields of pharmaceuticals, nanomedicine, coatings and environmental protection, as well as to provide services in term of research, chemical and chemical-physical analysis, compliance with environmental and safety regulations in force, IT and process plant engineering.
RI vision	Realize a personalized, patient-centric and point of care therapy, for a highly effective, accessible and affordable treatments of severe diseases
Firm size	Small-medium enterprise
Project analysed with KPIs	An advanced nano-based theranostic platform for cancer and nervous system diseases. It is a nanotechnology-based system using a combination of targeted and controlled drug delivery, hyperthermia and radiofrequency and laser imaging methods. The technology platform will lead to different products, including a contrast agent, a formulation (drug), a cell therapy system and a portable and integrated medical device to produce the cell therapy system.
Type of R&I activities	The project is based on in-house resources from the company but it is funded by different cooperative projects.
Type of business	Business-to-business
Time to market	(indicative) 5-10 years, i.e. medium- to long-term time frame
Regulatory regimes relevant for the project	• Nanomaterials • Advanced Therapy Medicinal Product • Medical devices
CSR policies	In-house corporate sustainability policy
Gender balance and gender policy in R&D	• Similar composition of R&D personnel in terms of men and women • No relevance of gender and diversity in recruitment criterial and selection of R&D personnel
Key stakeholders	• Company (R&D, Quality and Management) • R&D partners (research centres and academia, hospitals) • Business partners (public and private investors, suppliers) • Market clients and end-users (hospitals, healthcare professionals, patients associations, patients, advocacy groups) • Policy makers and regulators (healthcare sector) • Society (media and the public)
Key ethical and social values	• Product efficacy • Safety (use of nanomaterials in particular) • Excellence in R&D • Ethics (respect of patients' rights) • Patient-centric procedures for both clinical trials and cure • Respect of the principles of precaution, beneficence, dignity, informed consent, data protection and ownership

Table 4
Number of KPIs for organizational and RRI dimensions

Dimension	*Dimension category*	KPIs	Product indicators	Process Indicators	Total
Organization	*Internal organization*	Technology	4	5	9
		Sales/marketing	3	2	5
		Planning/management	1	4	5
		Resources	1	4	5
		Collaboration/communication	0	2	2
	External organization	Market	8	0	8
		Customer/end user	10	5	15
		Total Organizational KPIs	*27*	*22*	*49*
RRI	*Diversity and inclusion*	Gender equality	1	2	3
		Engagement	2	8	10
	Anticipation and reflection	Legislative landscape	1	2	3
		Assessment	3	3	6
		Public and ethical issues	1	1	2
	Responsiveness and adaptive change		0	3	3
	Openness and transparency	Intellectual property and confidentiality	1	2	3
		Open access	2	3	5
	Environmental sustainability		3	1	4
	Social sustainability		3	1	4
		Total RRI KPIs	*17*	*26*	*43*
Total Organizational and RRI KPIs			44	48	92

Note: For the full list of KPI statements, please refer to Yaghmaei et al., 2019.

Table 5
Comparison of original number of KPIs (total 92) with selected number of relevant KPIs (total 65) by managers and innovation team members of the nanomedicine project

Dimension	*Dimension category*	KPIs	*Original* #product/#process indicators (cf.Table II)	*Selected* #product/#process indicator by the company
Organization	*Internal organization*	Technology	4/5	2/4
		Sales/marketing	3/2	3/2
		Planning/management	1/4	1/4
		Resources	1/4	1/3
		Collaboration/communication	0/2	0/0
	External organization	Market	8/0	6/0
		Customer/end user	10/5	6/4
		Total Organizational KPIs	27/22	19/17
RRI	*Diversity and inclusion*	Gender equality	1/2	1/2
		Engagement	2/8	1/4
	Anticipation and reflection	Legislative landscape	1/2	1/1
		Assessment	3/3	3/3
		Public and ethical issues	1/1	0/0
	Responsiveness and adaptive change		0/3	0/3
	Openness and transparency	Intellectual property and confidentiality	1/2	0/2
		Open access	2/3	1/2
	Environmental sustainability		3/1	3/1
	Social sustainability		3/1	1/0
Total RRI KPIs			17/26	11/18

dimensions, 29 indicators (11 product and 18 process indicators) were considered relevant while 14 indicators (6 product and 8 process indicators) were considered irrelevant. In total, managers and team members assess that there are 65 relevant KPIs for the nanomedicine project (out of the original 92 KPIs in Table 4).

Subsequently, we took the measures of the selected KPIs in two waves: before (Q4 2017) and after the intervention (Q1/Q2 2018). The intervention here refers to a stakeholder-dialogue workshop with participants from all eight pilot companies, civil society groups, academics and policy makers, to formulate and discuss an RRI-CSR roadmap[2]. The workshop helped the company representatives facilitate informal networking of the stakeholders for exchanging ideas/feedback (mutual learning), and for the companies to provide feedback on each other's roadmap and outcomes of each company's project. Fig. 1 shows the timeline of the appraisal of KPIs in the nanotech pilot.

In the first wave (prior to the intervention), two managers entered the score (7-Likert scale) for the 65 selected KPIs while in the second wave (post intervention), four innovation team members entered the score. With this setting of different respondents in two waves (two in the first wave and four in the second wave) and 65 KPIs, we have in total 390 data points (i.e. scores of KPIs for both organizational and RRI dimensions).

To analyse the data, we perform two key analyses. The first one is the Mann-Whitney test (Mann & Whitney, 1947) which is the nonparametric equivalent of the independent t-test to compare two independent conditions. This is to test if the assessment of RRI KPIs (reflected by the scores) differ significantly or not, before and after the intervention. Since the test is to address the second question if an intervention may change or adjust the team's assessment in KPIs of RRI dimensions, we run this test for the KPIs of RRI dimensions only.

In the second analysis, we use CA in two ways. The first one is to find associations of KPIs of organizational dimension categories with KPIs of

Fig. 1. Timeline of PRISMA project for the nanomedicine project

RRI dimension categories (third research question). CA can provide a visual answer to our question of how RRI dimensions relate with organizational dimensions for ongoing R&D processes. The second use of CA is to further delineate the result of the Mann-Whitney test which is to obtain a deeper insight of how KPI scores.

CA is an exploratory data analysis method to visualize tabular data graphically (Greenacre, 2007); it is a nonparametric interdependence technique that enables a perceptual mapping of nonmetric (multivariate categorical) data yet with nonlinear relationships (Hair et al., 2006). CA has been used in marketing (e.g. consumer perceptions of brands (Hoffman & Franke, 1986; Higgs, 1991)), ecology (e.g. species composition (Palmer, 1993)), and psychological research (e.g. community psychology (Doey & Kurta, 2011)). CA is also increasingly used in many other areas such as archaeology, geology, medicine (Greenacre, 2007) and social science research including management science (e.g. Owen-Smith et al., 2002). CA is a variant of principal component analysis for categorical rather than continuous data (Greenacre, 1984, 2007). CA uses the chi-square statistic to test for total variance explained in which high chi-square statistic indicates a high correspondence between the

[2] The roadmap is a two-dimensional matrix in which the Y-axis shows four important aspects (1: drivers and challenges, 2: risks and barriers, 3: RI approaches, tools, actions, 4: R&I technologies and products) and the X-axis show the time to market (around 10 years) categorized in three timeframes: present/short term, medium term, and long term.

Table 6
Descriptive statistics of KPIs for RRI dimensions

KPIs for RRI dimension	Prior-intervention	Post-intervention
Number of respondents	2	4
Total data points (based on 29 relevant RRI KPIs, Table IV)	58	116
Median	6	5
Minimum; Maximum	1; 7	1; 7
Range	6	6
Interquartile range	5	2

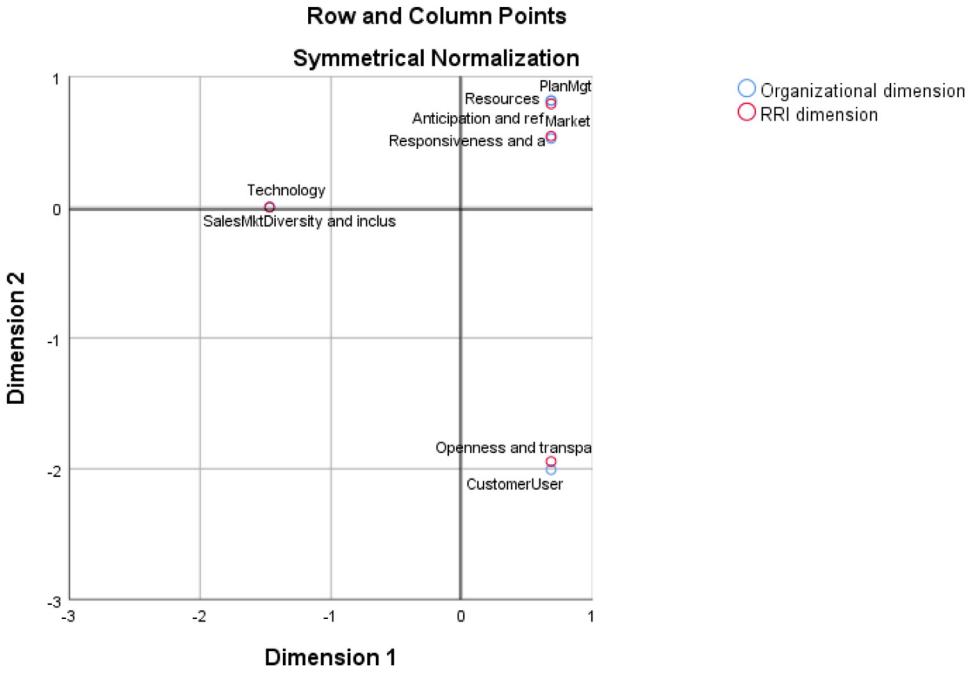

Fig. 2. CA (prior-intervention): Graphical maps (biplot) displaying spatial relationships between KPIs of organizational dimensions with KPIs of RRI dimensions.
Note: The total variance explained in the model is 24.8% and highly significant (Chi-square = 247.807, sig. at the .000 level with an alpha of .05) of which Dimension 1 and Dimension 2 explains about 70% and 28% respectively of the total variance explained.

rows and columns of a table and vice versa (Fellenberg et al., 2001). This technique fits with the nature of the categorical data we collected: organizational and RRI dimensions of KPIs are nominal data and the 7-Likert scale scores are ordinal data.

4. Analysis and Results

Table 6 shows the descriptive statistics of our nonparametric data regarding KPI scores on RRI dimensions in both prior- and post-intervention. Subsequently, we performed the Mann-Whitney test. The test shows that the prior-intervention scores of RRI dimensions (Median = 6) do not differ significantly from the post-intervention scores (Median = 5), U = 2719, z = -1.442, n.s., r = -0.111.

Likewise, the CA analyses are conducted for prior- and post-intervention data. The first CA analysis, i.e. for corresponding KPIs of organizational dimension categories with KPIs of RRI dimension categories, we focus solely on the original four RRI dimensions suggested by Stilgoe et al., (2013) (i.e. anticipation, reflexivity, inclusion, and responsiveness). Hence, for the RRI dimensional category, we exclude '*environmental sustainability*' and '*social sustainability*'. We also exclude the organizational dimensional category of "collaboration/communication" since the KPIs for this category were considered as irrelevant by the company (see Table 5).

Fig. 2 and Fig. 3 display the CA outputs (CA biplots) relating KPIs of organizational dimensions with KPIs of RRI dimensions[3] for, respectively, prior-intervention and post-intervention data. The CA outputs provide a graphical representation in a chi-squared metric such that the KPIs that are closely related are grouped together. For prior-intervention results (Fig. 2), the graphical map depicts three groups of spatial association. The first correspondence group (x-axis) is an association between two organizational indicators "sales and marketing" and "technology" with the RRI indicator '*diversity and inclusion*'. On the y-axis, we see the second and third correspondence groups: "customer/end user" is associated with '*openness and transparency*'; and "plan/management", "resources" and "market" are closely associated with two RRI dimensions '*anticipation and reflection*' and '*responsiveness and adaptive change*'.

For the post-intervention data (Fig. 3), the associations seem to be almost analogous to the ones in prior-intervention (Fig. 2), except the associations are more diverse and more equally distributed on the x-axis and y-axis. Another difference is that there are more distinctive associations between three organizational dimensions (i.e. "plan/management", "resources" and "market") with two RRI dimensions (i.e. '*anticipation and reflection*' and '*responsiveness and adaptive change*') in which now that "resource" and "plan/management" are more closely related with '*anticipation and reflection*' whereas "market" is more closely related with '*responsiveness and adaptive change*'; while previously in the prior-intervention data, these relationships are grouped into one. Table 7 shows the summary of the comparison between prior- and post-intervention results.

Although the result of the Mann-Whitney test shows that there is no significant difference between the prior- and post-intervention scores of RRI dimensions, we use CA as a fine-grained analysis to further explore and delineate how KPI scores of RRI dimensions are associated with certain RRI dimension categories. In other words, which KPIs of RRI the participants considered as well done, i.e. score five to seven (and not

[3] KPIs of organizational dimensions are denoted in double quotation marks (" ") and KPIs of RRI dimensions are denoted in single quotation marks (') and in *italics*.

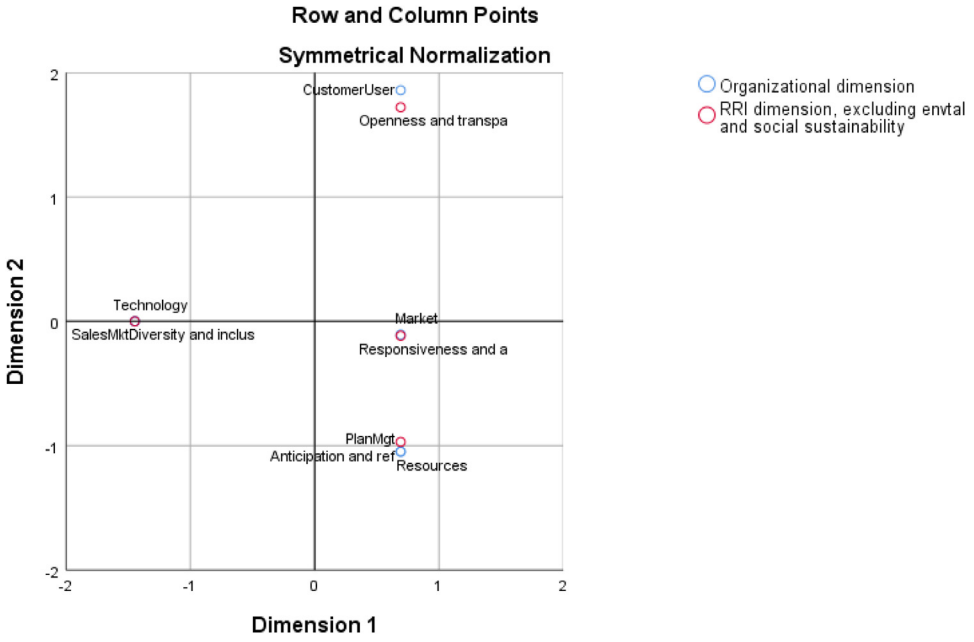

Fig. 3. CA (post-intervention): Graphical maps (biplot) displaying spatial relationships between KPIs of organizational dimensions with KPIs of RRI dimensions
Note: The total variance explained in the model is 23.8% and highly significant (Chi-square = 243.743, sig. at the .000 level with an alpha of .05) of which Dimension 1 and Dimension 2 explain about 72% and 26% respectively of the total variance explained.

Table 7
Summary of association of KPIs of Organizational dimension with RRI dimension (Prior- and Post-intervention)

Prior-intervention (Organizational dimension: *'RRI dimension'*)	*Post-intervention* (Organizational dimension: *'RRI dimension'*)
Sales & marketing, technology: *'Diversity and inclusion'* Customer/end-user: *'Openness and transparency'* Plan/management, resources, market: *'Anticipation and reflection', 'Responsiveness and adaptive change'*	Sales & marketing, technology: *'Diversity and inclusion'* Customer/end-user: *'Openness and transparency'* Plan/management, resources: *'Anticipation and reflection'* Market: *'Responsiveness and adaptive change'*

so well done, i.e. score one to three) before and after the intervention. Here we include social and environmental sustainability dimensions.

Fig. 4 and Fig. 5 visually show the CA outputs relating KPI scores of RRI with RRI dimensions for, respectively, prior-intervention and post-intervention data. For prior-intervention results (Fig. 4), participants considered '*social sustainability*' as not so well achieved (associated with score 3) while they were neutral to the '*environmental sustainability*' dimension (associated with score 4). The associations of other RRI dimensions on the x-axis are mixed: on the left side, dimensions '*diversity and inclusion*', '*openness and transparency*', and '*responsiveness and adaptive change*' have mixed results of assessment scores (associated with lowest score (1) to high/highest (5, 7)) and on the right side, '*anticipation and reflection*' also has mixed results (associated with low score (2) to higher score (6)). These mixed results indicate that there are rather large discrepancies of respondents' scoring of RRI KPIs (as also seen in the interquartile range in Table 6).

For the post-intervention data, Fig. 5 shows the CA biplot for the assessment scores of RRI dimensions. Compared to prior-intervention results, participants highly assessed the RRI dimensions of '*anticipation and reflection*' and '*responsiveness and adaptive change*' (associated with score 5) followed by '*diversity and inclusion*' (associated with score 6). The RRI dimension '*openness and transparency*' has a more diverse level of assessment (associated with score 2 and 6). The assessment of '*social sustainability*' seems to be much higher (associated with score 7) and '*environmental sustainability*' is, however, considered to be indifferent (associated with score 4). Table 8 summarizes and compares the results of prior- and post-intervention data of the association between scores and RRI dimensions. In sum, the post-intervention results demonstrate that respondents have, to some extent, better aligned their assessments than those of the prior-intervention results.

5. Discussion and Conclusion

5.1. Key Findings and Implications

Based on the CA results, there are three main findings, each leading to theoretical and managerial implications. First, the CA results (Fig. 2, Fig. 3, Table 7) provide a preliminary and exploratory evidence of the potential links between KPIs of organizational dimensions with KPIs of RRI dimensions (third question, Section 1). In particular, there are two associations grouped consistently (prior- and post-intervention): the first group shows RRI dimension '*diversity and inclusion*' corresponds with two organizational dimensions of "sales and marketing" and "technology"; while the second group shows '*openness and transparency*' corresponds with "customer/end-user". Additionally, the correspondence of two RRI dimensions ('*anticipation and reflection*', '*responsiveness and adaptive change*') with three organizational dimensions ("plan/management", "resources", and "market") is grouped into one in the prior-intervention result while in the post-intervention result, this correspondence becomes two distinctive groups: "resource" and "plan/management" are more closely associated with '*anticipation and reflection*' whereas "market" is more closely associated with '*responsiveness and adaptive change*'.

The above first finding of the associations of organization-RRI dimensions can be linked to both RRI and CSR literature. Regarding RRI, we may add to the theoretical reasoning of the incentives for the RRI uptake in companies (Gurzawska et al., 2017). The linkages of RRI with organizational dimensions show that the incentives and the practices of RRI tend to be highly associated with key organizational dimensions of ongoing R&D processes. This implies that in contrast to the belief that RRI indicators are different from organizational indicators they may not be

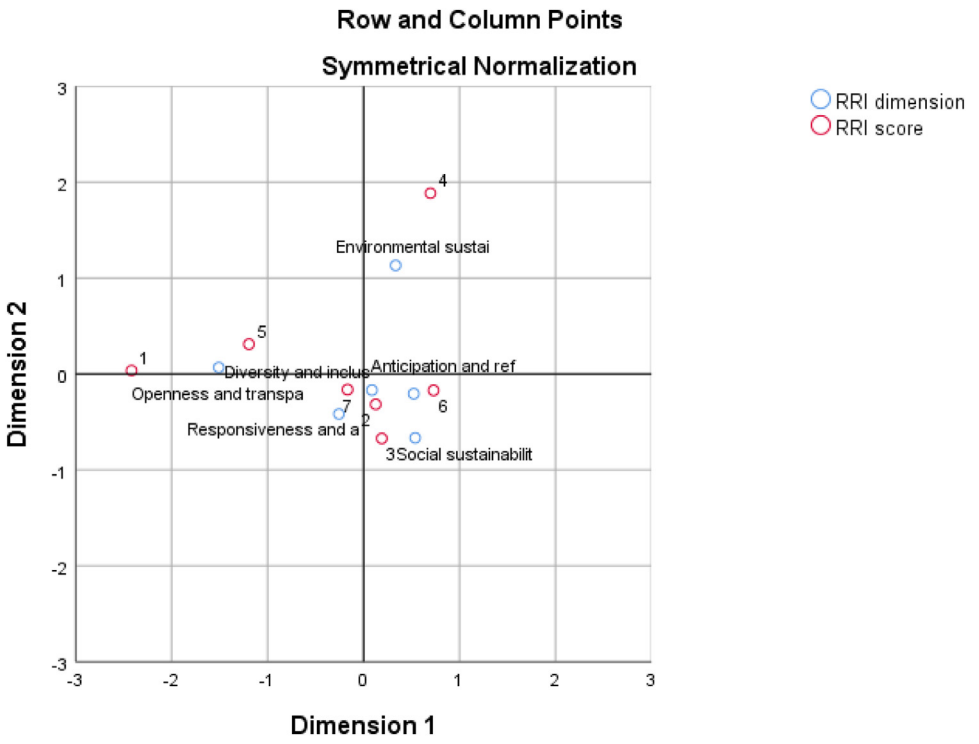

Fig. 4. CA (prior-intervention): Graphical maps (biplot) displaying spatial relationships between KPIs of RRI dimensions with RRI scores
Note: The total variance explained in the model is 34% and highly significant (Chi-square = 93.496, sig. at the .000 level with an alpha of .05) of which Dimension 1 and Dimension 2 explains about 62% and 19% respectively of the total variance explained.

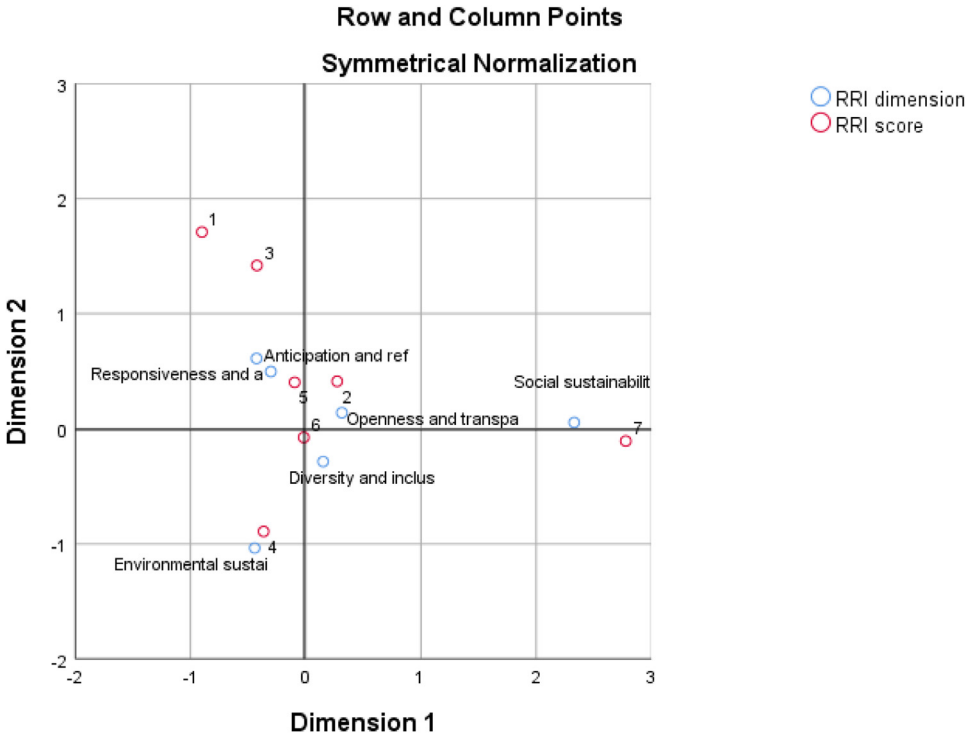

Fig. 5. CA (post-intervention): Graphical maps (biplot) displaying spatial relationships between KPIs of RRI dimensions with RRI scores
Note: The total variance explained in the model is 26.4% and highly significant (Chi-square = 143.472, sig. at the .000 level with an alpha of .05) of which Dimension 1 and Dimension 2 explains about 43% and 32% respectively of the total variance explained.

Table 8
Summary of association of scores of KPIs with RRI Dimensions (Prior- and Post-intervention)

Prior-intervention (Score: *'RRI dimension'*)	*Post-intervention* (Score: *'RRI dimension'*)
3: *'Social sustainability'*	2: *'Openness and transparency'*
4: *'Environmental sustainability'*	4: *'Environmental sustainability'*
1, 5, 7: *'Diversity and inclusion','Openness and transparency','Responsiveness and adaptive change'*	5: *'Anticipation and reflection','Responsiveness and adaptive change'*
2, 6: *'Anticipation and reflection'*	6: *'Diversity and inclusion'*
	7: *'Social sustainability'*

entirely different and can potentially even be aligned. This indicates that the intrinsic motivation of the RRI uptake can be beyond instrumental, as RRI activities could be central to core business activities prompting shared value between business and society.

Additionally, regarding the first finding, advancing on Yaghmaei et al., (2019), we also clarify the linkages of RRI and organizational dimensions in monitoring the value of RRI implementation. The link to the CSR literature is particularly visible when considering the study of McWilliams et al., (2006) which proposes that managers may expect a positive relation between CSR and R&D. Although the results based on CA associations do not explicitly indicate the direction of the relationships (positive or negative), we visually demonstrate the potential links of RRI dimensions with organizational ongoing R&D dimensions. For managers, this preliminary overview of linkages between RRI dimensions and organizational ongoing R&D dimensions implies that RRI strategy should be closely attuned to core business strategy. As the two strategies are closely related, managers may better align the motives of RRI uptake with organizational (CSR) strategy (or potentially vice versa) as when both are performed well they can contribute to competitive advantage. In sum, managers may extend the conservative aim of 'doing no harm to society' to progressively direct their research and innovation processes towards doing good (Doorn & Nihlén Fahlquist, 2010) for addressing grand societal challenges (George et al., 2016).

Our second finding is based on the association groups of KPI scores with RRI dimensions. The Mann-Whitney test shows that there is no significant difference of the assessment scores between prior- and post-intervention (second question)[4]. This may mean either the scores indeed did not improve or the first assessment was too optimistic. Looking beyond the assessment scores, we investigated the correspondence of KPI scores with RRI dimensions between prior- and post-intervention. In prior-intervention scoring, the spread is wider showing that participants tend to differ widely in their assessment of RRI KPIs. These large discrepancies are narrowed down in post-intervention in which the scores converge rather than disperse. In this sense, the intervention has, to some extent, influenced or adjusted the assessment of managers and innovation team members in which over time (the time between prior- and post-intervention) they may have learned and gained more experience of RRI practices. Hence, it seems that after the intervention, they are able to make better sense of KPIs and the scoring.

Theoretically, the second finding implies that the RRI uptake could contribute to learning experience and organisational change. In this case, the finding may also benefit from the influential construct of absorptive capacity (Cohen & Levinthal, 1990; Zahra & George, 2002; Todorova & Durisin, 2007) that can be delineated into potential and realized absorptive capacity. Regarding potential absorptive capacity, managers and innovation team members acquire knowledge externally (i.e. learning from other companies, experts and stakeholders of RRI during the workshop) and progressively assimilate the external knowledge internally through their internal coordination capabilities, e.g. through participation in decision making and cross-functional interfaces (Jansen et al., 2005). Regarding realized absorptive capacity, we propose that value-sensitive absorptive capacity (Garst et al., 2019) should be garnered and developed in such a way that the focus on R&D in companies should not be too dominating that it hinders the learning process to transform and exploit externally acquired knowledge (i.e. learning of RRI practices through stakeholder engagement). Here, the exploratory measures that we develop should be regarded as a systematic procedure for discussion and learning purposes (rather than simply for measuring and monitoring the indicators). The outcome of this effective learning of RRI uptake can further strengthen the value-sensitive absorptive capacity in a company and address RRI through forms of organisational change. For managers, this implies that they need to create internal knowledge-sharing network to gain benefit from externally acquired knowledge. Social underpinnings (Tortoriello, 2015) and power relationship (Todorova & Durisin, 2007) of absorptive capacity as a learning mechanism for RRI institutionalisation (Owen et al., 2020) may help explain how, through learning experience of RRI uptake, managers may create the ability to leverage external knowledge to generate innovation inside the companies in a responsible way.

The third finding is that the association of RRI scores with RRI dimensions may indicate at which RRI dimensions the managers and team members of nanomedicine project assessed themselves as doing well-to-better and at which dimensions they may need to further improve. Based on the post-intervention results, the respondents seem to consider doing well to very well (scores from 5 to 7) in four RRI dimensions ('*anticipation and reflection*', '*responsiveness and adaptive change*', '*diversity and inclusion*', '*social sustainability*'). However, there is an indication that the company may need to improve the RRI dimension of '*openness and transparency*' (score 2) and to decide on what the company wants to do regarding the RRI dimension of '*environmental sustainability*' (associated with score 4 which means neutral or indifferent). Recall from the first finding, if the company improves the RRI dimension of '*openness and transparency*', the outcome may also have a subsequent outcome to the organizational dimension of "customer/end-user" (and possibly vice versa).

When we cross-check this third finding through an interview in the company, it turned out that the company sees the need to address this issue of '*openness and transparency*' in their nanomedicine product design by communicating the production approach and use of nanomaterials to all actors along the research and innovation value chain as well as supply chain, including also end-users. In this case, a safe-by-design approach (Hale et al., 2007) is relevant to be implemented in the early stages of R&D, for instance, how nanomaterials are selected (adapted and in some cases, re-designed) to ensure they have a very low risk profile.

When linking the first and the third finding, we can see that although we initially excluded the RRI dimensions of '*environmental sustainability*' and '*social sustainability*' since we build on the four dimensions of Stilgoe et al., (2013), the post-intervention scoring shows that managers and team members of the nanomedicine project are aware of these two RRI dimensions and are implementing or considering them. Theoretically, these two RRI dimensions are not explicitly mentioned in Stilgoe et al., (2013) and some scholars (Bozeman et al., 2015; Burget et al., 2017; Forsberg et al., 2015; Von Schomberg, 2011, 2013) refer to these two dimensions as one dimension, i.e. 'sustainability'. However, we consider that they may be necessary to be regarded as two distinct dimensions. The RRI dimension '*social sustainability*' refer to societal values dimension such as privacy, trust, safety, solidarity, security, data ownership – values that are different from environmental issues as in the RRI dimension '*environmental sustainability*'. Our sample, which is based on a nanomedicine project, raises the concern of both environmental and societal (health) risks but at the same time, the technology offers both environmental (e.g. environmental remediation) and social sustainability (human health, privacy issues) (Macnaghten et al., 2005; Mnyusiwalla et al., 2003). For managers, this implies that they need to focus on attending both environmental and social concerns since by doing this, the trust that the company's stakeholders and wider public have in the company may increase (Blok &Lemmens, 2015).

In sum, our paper reveals three main findings. First, using CA, we visually demonstrate associations among KPIs of RRI dimensions and of organizational ongoing R&D dimensions. Such associations may imply that these two dimensions of indicators are not entirely different from each other and can be potentially aligned. This finding stimulate the motives of the RRI uptake in a company since if the company embeds RRI into its organizational innovation or product development processes,

[4] See Table VI (Section 4) that addresses the second question "How does an intervention such as a workshop change or adjust their assessment of their own RRI performance?". For Q1 "How do managers of a company active in research and innovation of transformative technology (nanotechnology-based medicine) assess the relevance of RRI dimensions", the answer is addressed in Section 3.3.

then innovation processes or products can receive high social acceptance, which in turn, can create a positive business outcome through shared values for business and society. Second, we demonstrate that the stakeholder-dialogue workshop (the intervention) plays a role in adjusting the assessment of RRI by managers and team members over time (the time between prior- and post-intervention) due to knowledge and experience gained from the RRI uptake. This finding can benefit from value-sensitive absorptive capacity to capture the values of RRI in practice. Third, we establish some indications of which RRI dimensions the company is doing better and which ones to be further improved.

5.2. Limitations and Suggestions for Future Research

Although our study in this paper reveals interesting findings, it has four main limitations that open up avenues for future research. First, although we provide KPIs for the assessment of RRI and organizational ongoing R&D dimensions, our sample is based on subjective assessments of managers and team members and is project specific. Corporate actors may tend to adopt and partially adjust RRI indicators as an organisational-instrumental tool to profile themselves as a responsible company (i.e. a form of window-dressing) or as a genuine commitment to RRI (Van de Poel et al., 2020). Hence, the associations of RRI-organizational dimensions that we found in this paper should rather be interpreted as an exploratory evidence that still needs to be further investigated in future research. Future research should also integrate our KPIs with objective company's data such as the number of female employees engaged in the projects, sales of the innovative products and relevant objective measures. The selection bias could also come from the nature of the company in which the nanotechnology industry is more likely to be aware of the responsible approach of innovation as their products are directly aimed for healthcare. This might be different for other industries (e.g. oil industry, electronics) where issues such as healthcare might be not indirectly related to their products; future research may consider investigating RRI in such industries.

Second, following the RRI approach as suggested by Von Schomberg (2013) our focus in this paper is limited to product and process level. Process level is excluded (see section 2.3) because operationalising this level is complex and intricate as it may deal with a multitude of ethically and politically complicated questions. The process-level questions, nevertheless, deserve further research to understand responsibility from the perspective of the political nature of innovation activities that may affect socio-technical future. Additionally, the resulting number of KPIs we use in this paper may still be considered relatively high for small-medium enterprises. Future research may explore additional possibilities (e.g. incorporating contexts such as sectors or projects) to further streamline the KPIs to better facilitate its application for smaller businesses.

Third, due to the nonparametric data we obtained, we were not able to show the direction of associations. When it is possible to obtain objective parametric data as we suggest, in future research one may collect parametric data and use other parametric analyses (e.g. regression analysis) to explore the directions of the associations between RRI dimensions and organizational ongoing R&D dimensions. It may also be useful to triangulate quantitative-approach outcomes with qualitative ones.

Finally, our study is based on a single nanomedicine project and hence may not be widely generalized. We suggest that future research may either have more project samples of companies in the nanotechnology industry or broaden the types of industry to be studied. It may be interesting to see how the assessment of RRI may differ among companies or among industries. The assessment approach that we employ, which is more oriented towards an internal analysis of a company, has a limitation in which complex external environment where the innovation takes place is not taken into account. Future study may benefit from employing a more external-oriented approach, such as industry environment.

5.3. Conclusion

Research on responsible research and innovation (RRI) has a strong root in the policy area yet limited practical experience in industry. Implementing RRI in companies help managers sensitise and incorporate societal values at the early stage of research and innovation projects. This may be one way to recontextualize research and innovation and their institution in society (Genus & Iskandarova, 2018) and to increase social acceptance of innovations. The study developed in this paper is intended as a primary step for assessing RRI implementation in companies and embedding RRI into the core purpose of a company and its network of stakeholders. The motives for the RRI uptake should go beyond instrumental to really gain the benefits of both financial as well as non-financial rewards. We argue that RRI dimensions need to be incorporated into organizational research and innovation practices. In so doing, companies create shared values which are relevant and essential for business and society.

To embed RRI in innovation projects in companies and to assess explicitly the added value of RRI in practice, we investigated RRI implementation in a company to get an idea of how to better embed RRI in practice. As such, this paper provides an exploratory assessment of a number of product- and process-oriented KPIs of organizational and RRI dimensions in a nanomedicine project. As such, there are two main contributions. First, we add to the theoretical reasoning of the incentives for the RRI uptake in companies (Gurzawska et al., 2017) in which we propose that the intrinsic motivation of RRI uptake should be beyond instrumental since RRI activities can be central to core business activities, i.e. RRI strategy may be more closely attuned to core business strategy. Second, as the RRI uptake could contribute to learning experience, we propose to use the influential construct of absorptive capacity (Cohen & Levinthal, 1990). We also propose to include absorptive capacity as learning mechanisms for influencing the dynamic of RRI institutionalisation identified by Owen et al., (2020), serves mainly for RRI organisational change in industry. Through stakeholder engagement in RRI, managers can develop social underpinnings of absorptive capacity (Tortoriello, 2015) to create an internal knowledge-sharing network to gain benefit from externally acquired RRI-relevant knowledge. This may contribute to a value-sensitive absorptive capacity framework as proposed by Garst et al., (2019).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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