

A META-ANALYSIS OF RESPONSIBLE RESEARCH AND INNOVATION (RRI) CASE STUDIES - REVIEWING THE BENEFITS TO INDUSTRY OF ENGAGEMENT WITH RRI

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ABSTRACT

Responsible Research and Innovation (RRI) provides a framework that may overcome computer ethics problems such as the increasingly ubiquitous nature of computing technologies, the global nature of innovation, and the need to consider accountability at different stages of the innovation lifecycle. It shares with computer ethics the challenges of demonstrating relevance to, and providing practical guidance for, industry.

This paper will answer the following research question - what is the relationship between RRI implementation practices and outcomes for firms, considering contextual variables such as company size and sector? It will examine this question using a meta-analysis of published RRI case studies.

The contribution it makes to knowledge is the exploring and quantifying of relationships between RRI practices, and outcomes for businesses. It responds to the need for more quantitative research to get from 'perceptions to evidence', to explore the 'business case' for corporate engagement with RRI, and to relate RRI more explicitly to adjacent discourses on corporate responsibility.

The methodology developed helps pave the way towards a broader approach to evaluating the business case for companies to engage with RRI practices.

KEYWORDS: responsible research and innovation; RRI; responsible innovation; corporate social responsibility; CSR; industry.

1. INTRODUCTION

Responsible Research and Innovation is a relatively new concept that aims to democratise innovation and integrate ethical concerns into the earliest stages of the innovation process, including through anticipatory and deliberative governance methods (Lubberink et al., 2017).

A recent network analysis of citations (Loureiro & Conceição, 2019) indicates a high degree of convergence around the Stilgoe et al. (2013) RRI framework which incorporates Von Schomberg's (2012; 2013, p9) definition of RRI as:

“... a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)”,

and the four dimensions of ‘Anticipate’, ‘Reflexivity’, ‘Inclusion and Deliberation’, and ‘Responsiveness’. These can be referred to as the ‘AREA’ framework, with ‘Engagement’ substituting Inclusion and ‘Action’ substituting ‘Responsiveness’ (Owen, 2014).

Alternative framings of RRI suggest additional dimensions – for example the six ‘keys’ referenced in the EU’s Rome declaration include Governance, Gender Equality, Open Science and Science Education (European Commission, 2013). The Schomberg articulation of RRI is beneficial from an industry perspective both in terms of its centrality and consistency through RRI discussions, and in that it incorporates conceptions of product, and process/product lifecycle as well as the ‘purposes’ of research and innovation.

1.1. Defining RRI from the organisational perspective

RRI thus defined has both a normative, and descriptive aspect – it allows us to evaluate certain organisational behaviours as consistent (or not) with RRI, while also proposing how scientists, innovators and other societal actors should innovate, and for whom.

Many publications have discussed the normative considerations – for example whether RRI’s aims are extensible across borders (Macnaghten et al., 2014), reflect the power dynamics involved in engagement activities (Blok et al. 2015), or consider how technology futures are framed at an early stage (Grunwald, 2014). Less well explored is the question of how RRI takes shape at the organisation level – while it is possible to identify instances that most observers agree demonstrate irresponsible innovation (for example Von Schomberg 2013 p14-19 cites the initial development of GM maize), given that many organisations already carry out activities relevant to the RRI AREA framework under the banner of market research or new product development (van de Poel et al., 2017), it is difficult to distinguish organisations we would assess as ‘innovating responsibly’, from those which are not.

One conceptualisation of this problem is to ask whether RRI is best described as a property of various existing processes, or a specific (albeit broad) process that can be followed – in effect, whether it is an inclusive, or exclusive concept. While there is a case for an inclusive imagining of RRI – we have already noted that various existing organisational processes contribute to RRI – this definition is problematic, as it may not be analytically meaningful. If nearly all organisations can be described as carrying out RRI-related practices, we do not have a logical basis to differentiate ‘responsible’ from ‘irresponsible’ innovation. On the other hand, a truly exclusive definition – that an organisation is only engaging in RRI if it states an explicit commitment to do this and follows a rigid process – would deny the evidence that many organisations do carry out practices that contribute to RRI aims. We therefore conclude:

[1] That organisations may exhibit responsible research and innovation practice by degrees, applying different aspects in different situations.

- [2] That the introduction of 'objectively' assessed, standardised management processes and quality benchmarks relating to RRI is needed to provide a reliable method of defining whether organisations have a robust process for innovating responsibly.

It is noteworthy that the independent assessment methods indicated in [2] were identified as being needed by Flipse and Yaghmaei (2018,) and are under active development at both the EU and country level (for example the draft European 'Guidelines to develop long-term strategies/roadmaps for RRI' to and BSI Responsible Innovation standards). Similarly, frameworks have been advanced that incorporate both 'unconscious', and 'conscious' engagement with RRI, and seek to assess the degree of integration into an organisation's practices (for example Stahl et al., 2017).

1.2. RRI and Industry

While discussion of the responsibility of business can be traced back to the early twentieth century, the RRI discourse has developed in the context of the publicly funded research sector (Stahl, 2015). Owen et al's Framework (ibid) locates the roots of RRI in Social and Technology Studies (STS), a discipline developed by the US Office for Technology Studies to manage concerns over nanotechnology development, and Technology Assessment, a methodology primarily developed to contribute to the formation of public and political opinion.

Although their work focusses on the products as well as the purpose of research and innovation, and discusses industry-relevant techniques such as stage gating, both Stilgoe et al,'s (2014) paper and Rene von Schomberg's (2012, 2013) work that informs its core definition, position RRI as a tool to manage science's relations with society rather than primarily a need to reimagine innovation.

The Cambridge Analytica incident - a major landmark for discussions of innovation governance - highlights the idea that technology developments frequently span academic, industry, and public organisations. In this case, what would be viewed by many as irresponsible innovation and resulted in legal and regulatory sanctions, was enabled by a combination of governance failures in a Higher Education institution (management of access to research APIs), a technology company (Facebook's safeguards around API access), entrepreneurs (Cambridge Analytica), and political parties (in their use of illegally-obtained data products; Berghel, 2018). In this case, RRI practices in any of these organisations may have prevented the subsequent outcomes - if all stakeholders had embraced responsible innovation principles, adverse consequences may have been avoided.

In proposing an alternative framing of RRI that more closely relates it to business, Lubberink et al. (2017) state that:

"the problem with the current concept of responsible innovation is that it is developed by researchers and policy makers who are focused primarily on the conduct of responsible science and technological development without differentiating between research, development and commercialisation".

Dreyer et al. (2017) support this position with a detailed critique of RRI from an industry perspective by members of the European Industrial Research Management Association. While

strongly endorsing the importance of RRI for business and society, they highlight a number of weaknesses:

- *Failure to consider the innovation dimension* – the framing of RRI too often emphasises research aspects, and does not sufficiently account for the nature of the innovation process. The tensions between the precautionary principle and innovatory principles, and innovation and democratic governance, are insufficiently considered.
- *Research integrity* - RRI frameworks typically underemphasise this, but it is critical to high-profile examples of ‘irresponsible innovation’.
- *Failure to reflect established business practices* – companies typically already have activities that support RRI, under the banners of (for example) product development, consumer research and compliance.
- *Failure to reflect parallel sustainability debates* – RRI discussions should be situated in relation to parallel corporate sustainability debates such as CSR, corporate shared value (CSV), sustainable finance and investment, and leadership.
- *Failure to accommodate emerging issues associated with digital developments in industry* - developments in big data and smart information systems in the industry context pose new challenges for RRI (see next section).

Lubberink et al. (2017) suggest additional aspects of innovation that require contextualisation of RRI, including the financial imperatives that apply at the commercialisation stage of innovations, and the social innovation perspective – use of technology may develop independent of ‘traditional’ regulators and innovation actors.

As a final comment on RRI’s compatibility with industry, the EU framing of RRI includes Open Science and Science Education ‘pillars’ which invoke particular challenges in relating RRI to the industry context in terms of their interaction with commercial confidentiality and intellectual property. This study will primarily focus on the AREA framework as noted above.

1.3. RRI’s particular relevance to ICT

Several aspects of ICT with particular significance for RRI are highlighted by Dreyer et al. (ibid), and have been explored subsequently.

They include the complexity and rapid pace of technological change; the interaction of new technologies with rights such as privacy; emergent issues such as the need for algorithmic transparency and auditable code; the requirement for new forms of governance (for example of AI); new environmental impacts; workforce restructuring; and the need for different taxation models.

These issues have been explored elsewhere (for example Stahl et al. 2015, Stahl, Flick et al., 2017) and are evident in growing debates on (for example) AI regulation. They are synthesised in the Framework for Responsible Research and Innovation in ICT developed by Jirotko, Stahl and others (2017). For the purpose of this study they highlight the need for a wide-ranging definition of types of activity and impact relevant to RRI.

1.4. RRI and Corporate Social Responsibility (CSR)

Relating RRI to long-standing discourses on Corporate Social Responsibility (CSR) offers opportunities to apply approaches developed in the CSR literature in support of RRI research questions. A case can be made for the relevance of CSR 'tools' in informing RRI implementation practice (Iatridis & Schroeder, 2015).

Similarly for measurement, the evolution of RRI maturity models has been informed by the availability of CSR models drawing on a wide empirical evidence base (Martinuzzi & Krumay, 2013; Stahl et al., 2017). RRI and CSR share the challenges of definitional complexity, and difficulty in identifying empirical attributes. However while contested (for example Banerjee, 2008), the concept of CSR benefits from having been the subject of significant theory building and research. Reference is made where appropriate within this study to the existing evidence base for the 'business case' for CSR, primarily referring to Carroll & Shabana's (2010) review of meta-analyses which narrates the "30-year quest for an empirical relationship between a corporation's social initiatives and its financial performance".

1.5. Defining the term 'business case for RRI'

The 'business case for corporate responsibility' has been exposed to empirical scrutiny in the CSR literature since the 1960s, including through meta-review. Carroll and Shabana's (2010) meta-analysis synthesises different perspectives around the following definition (p92):

"the establishment of the 'business' justification and rationale, that is, the specific benefits to businesses in an economic and financial sense that would flow from [CSR] activities and initiatives"

The authors note that a 'business case' approach is only one of three potential approaches to corporate responsibility—a 'social values-led' approach sees responsibility as the organisation's 'lifeblood', as in the case of many voluntary organisations and social enterprises - a 'business case' can be seen as one that evaluates responsibility initiatives on a narrow economic basis - and a 'syncretic stewardship' model in which responsibility is an overarching approach to the business rather than assessed on a transactional basis.

The authors distil this distinction into 'narrow', and 'broad' views of the business case for responsibility – the former an expectation of direct and clear links from any responsibility initiatives to firm financial performance, the latter accepting the existence of both direct and indirect links between initiatives and outcomes and a perspective that values the additional, potentially non-quantifiable opportunities that may be generated through responsibility activity such as the development of stakeholder relationships (p101). This study will apply the broad sense of 'business case'.

1.6. Measuring impacts and benefits of RRI for organisations

In the wake of Dreyer et al.'s (2017) and Lubberink et al.'s (2017) problematisation, studies have begun to explore how RRI can be applied in industry settings, in many cases through outputs of the Responsible-Industry, PRISMA (Piloting Responsible Research and Innovation in Industry) and MORRI (Monitoring the Evolution and Benefits of RRI) EU Horizon projects. In

some cases these extended existing lines of enquiry such as the work of Steven Flipse and Emad Yaghmaei at Delft University of Technology on operationalisation and measurement of RRI in organisations (Flipse et al. 2015; Yaghmaei 2016; Flipse & Yaghmaei 2018).

Nonetheless, much discussion of RRI measurement has tended to focus either on society-level impact – from Von Schomberg's original (2013, p8-12) proposal of the 'right impacts' of RRI, flowing through to the European indicator framework proposed by Strand et al. (2015) that informed subsequent work in this area - or an individuated, company-specific RRI strategy, 'roadmap' and performance indicators as proposed by van de Poel et al.'s (2017) model, Porcari et al. (2018), and Yaghmaei (2018). Transition from an initial emphasis on macro-social level benefits towards the organisation level mirrors a similar movement in discussions of the impacts of CSR (Carroll & Shabana 2010, p92).

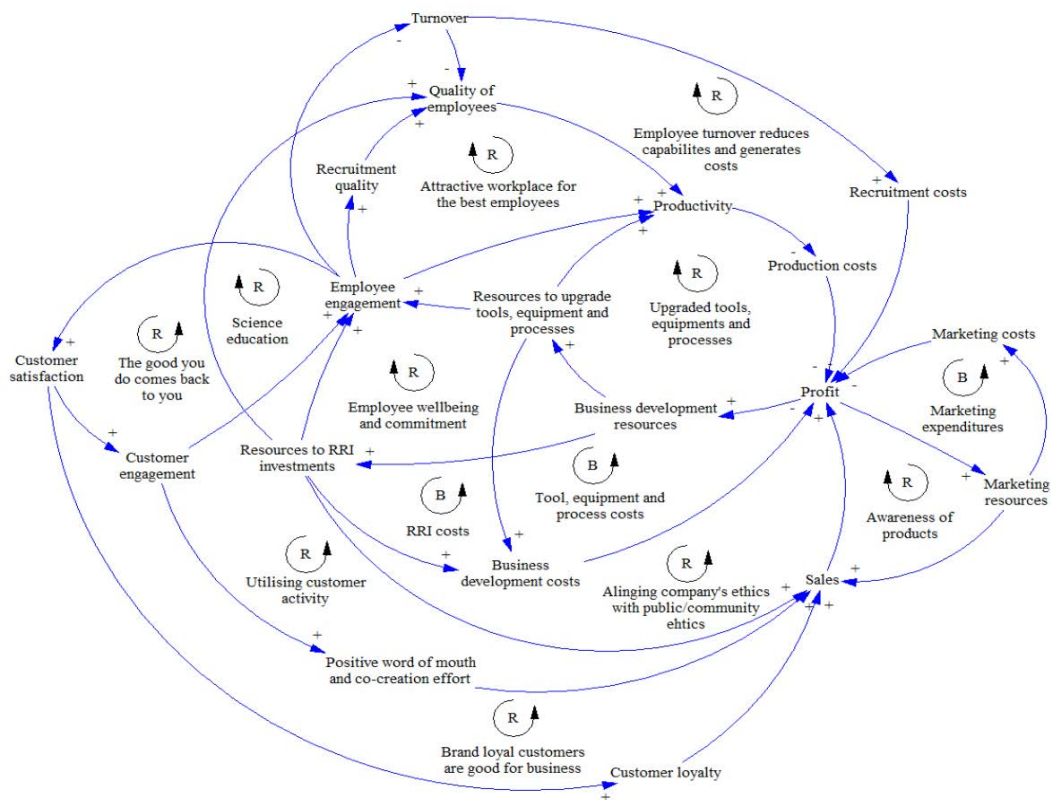
While heterogeneity of approach and shaping to context is an important principle for industry guidance, if we accept the normative premise that encouraging organisations to engage in RRI-related practice is a desirable goal, this idiographic emphasis begs important empirical questions. Which RRI practices are associated with positive business outcomes in different contexts? Beyond this – while practices such as public or employee engagement are associated with positive organisational outcomes, can a 'value-adding' effect for organisations who implement "broad-focus" RRI across the AREA spectrum be observed beyond effects which might be expected from component practices? Within these questions – given that a company's engagement with RRI may be either strategic, or operational (B. C. Stahl et al., 2017; van de Poel et al., 2017) - to what extent are benefits evidenced when RRI is adopted at a company, rather than project level?

The quantitative, empirical study of RRI at the organisation level these questions imply involves defining RRI and its impacts in observable and measurable terms. This is inherently challenging due to the broad scope of potentially relevant activities across different types of organisation as well as the long-term, complex and mediated nature of potentially relevant impacts. Trade-offs are likely to be needed – for example only a limited time horizon is available for tracking impacts, not every stakeholder perspective may be accounted for, and correlation must be interpreted in the context of potentially complex causal relationships.

In considering the outcomes of RRI activity that may be relevant to an organisation, we need to consider indirect as well as direct impacts. Gurzawska et al. (2017) introduce a casual loop model that demonstrates the complexity of potential positive and negative feedback loops mediating RRI activity and outcomes (Figure 1). For example, improved customer engagement may generate positive word-of-mouth that over time generates increased sales.

As highlighted in the CSR literature – for example Carroll & Shabana (2010)'s review - responsibility activities may generate negative impacts (albeit that the weight of evidence in the CSR debate favours net positive impact). For example, engagement can surface tensions between different stakeholders, and delay product development. These activities may have short term disbenefits, and positive longer-term benefits – an understanding of both is necessary for cost-benefit analysis. Consequently, RRI impact need to be considered on a 'two-tailed' basis.

Figure 1. Gurzawska et al. (2017) causal loop diagram for internal RRI incentives.



Drawing these strands together, this study will use the activity framework proposed by Lubberink et al. (2017) to provide a lexicon of RRI practices at organisation level, and the industry impacts in Porcari et al.'s (2019) PRISMA summary to frame organisational RRI impacts. The framework advanced by van de Poel et al. (2017) provides an underpinning theoretical principle for these definitions in establishing that organisational processes not specifically aligned to responsibility aims may constitute activity relevant to RRI themes. The framework proposed by Fraaije & Flipse (2019) offers alternative 'qualifiers' for assessing RRI in processes, but while offering a holistic synthesis constitutes a normative, rather than descriptive assessment of RRI activity in an organisation - many of the identifiers used would need further qualitative enquiry within organisations to assess (for example to assess the terms 'meaningful contributions', 'transparently', 'empower' and 'include stakeholders for substantive not instrumental reasons' from appropriate stakeholder perspectives).

1.7. Limitations of empirical RRI studies to date

Studies of RRI to date have mainly used qualitative designs. Lubberink et al.'s (2017) review identifies "few scholars who empirically investigated responsible innovation practices in commercial R&D settings", and that more than two-thirds of empirical RRI articles were case study research. While predating recent studies this:

1. indicates that RRI has until recently focussed on empirical exploration and description;
2. highlights a need for larger-scale and quantitative empirical testing, and;

3. as managerial decision-making is frequently based in quantifiable evidence, signals more quantitative research is essential for future development of the RRI field (Martinuzzi et al. 2018).

The availability of studies will be re-assessed through this article – beyond this it is relevant to note that exploration of the potential business benefits of RRI activity is arguably not just essential for the development of the RRI field, but for increasingly urgent efforts to encourage companies (including technology companies) to innovate responsibly – that is, to make the normative case for RRI to a range of stakeholders above and beyond the academic community.

1.8. Rationale and aims of this study

The proliferation of relatively high quality RRI case studies, in many cases products of EU Horizon projects as noted above, is an opportunity to synthesise findings through meta-review, to explore generalised relationships between RRI implementation and outcomes.

This study aims for a novel contribution to quantitative and empirical evidence in relation to industry engagement with RRI, through a meta-analysis of these case studies that explores the relationships between reported activities and outcomes for organisations. The scope of enquiry includes whether degree of engagement with RRI predicts scope of impacts reported, whether some categories or types of activity are associated with particular outcomes, and the mediating role of characteristics such as sector and organisation type.

This will allow for flexibility in interpretation of RRI in terms of its implementation and impacts within an organisation's operating context.

A meta-review methodology offers the opportunity to identify then synthesise a range of RRI case studies (Moher et al., 2009). The systematic literature review principles of Tranfield et al. (2003) will be used to identify relevant studies. Features of the RRI implementation context such as organisation type and sector will be included in the analysis. The resulting data will be assessed to identify patterns and relationships between context, implementation practices, and outcomes.

Table 1 summarises the specific questions that will be explored, based on the overall research question of 'what is the relationship between RRI implementation practices and outcomes for firms, taking into account contextual variables such as company size and sector?'. Additional detail is provided in the method section below.

Table 1. Detailed research questions.

Question
1. Does the scope of positive RRI outcomes increase as the scope of reported RRI-related activity increases?
2. Does engaging in a full scope of RRI activity increase the likelihood of reporting a wider scope of positive RRI outcomes?
3. Is engaging in some specified types of RRI activity associated with particular types of organisational outcome?
4. Is engaging in some specified types of RRI activity associated with a broader scope of positive organisational outcomes?

5. Is engaging in some specified RRI activities associated with particular organisational outcomes?
6. Is engaging in a certain combination of RRI activities associated with a broader scope of positive organisational outcomes in specific contexts?
7. For some organisation types/sectors/ages/implementation types, is a certain set of RRI activities associated with particular organisational outcomes?

2. METHOD

The principles set out in Moher et al. (2009) were applied to carry out a meta-analysis of published RRI case studies.

A literature search of peer-reviewed English-language papers in the Web of Science, Scopus and ABI/Inform databases was conducted in order to draw in RRI research across a range of disciplines, including business-focussed journals, with reference to the research question set out in the abstract, and the systematic literature review procedure set out in Tranfield et al. (2003). Papers were extracted using the following search phrases in the title, author keywords and abstract: 'responsible research and innovation' and 'responsible research & innovation', from the period 2000-2019. All papers from the Journal of Responsible Innovation and Orbit Journal (publications with a specific RRI focus) were then included for analysis.

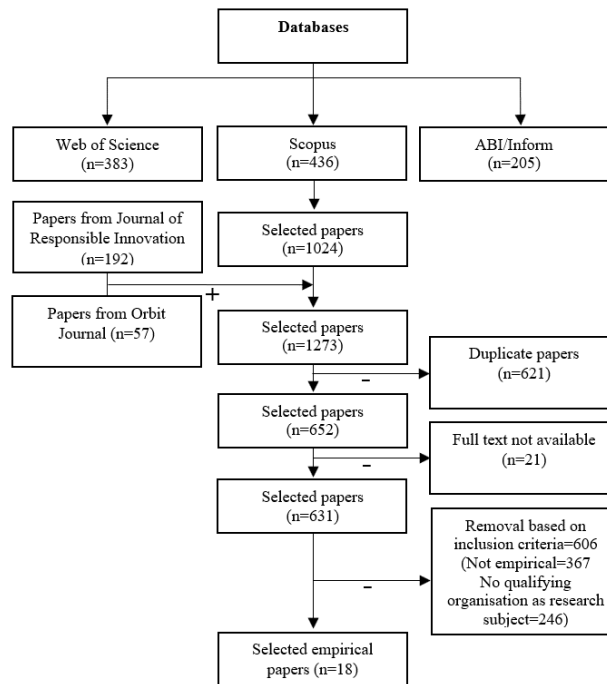
Duplicate papers were identified and removed, and papers for which only abstracts were available were excluded. Papers were then assessed based on the content of their abstract and full text as to whether they constituted an empirical case study with details of RRI-related activities and impacts, with one or more non-HE organisations as the research subject.

A top-down coding schema was applied. 'RRI-related activities' were defined as any of those in a list of activities based on Lubberink et al.'s (2017, p14) taxonomy. 'RRI-related impacts' was defined as any of those in the list of activities proposed in Porcari et al. (2019, p30), with the addition of a code for 'other RRI negative impacts'. These are listed with working definitions at Appendix 1.

'Case study' was defined as "An empirical enquiry that investigates a contemporary phenomenon within its real-life context" based on Yin (2011, p13). 'Empirical' was assessed on the basis of the Oxford Dictionary of Science (Daintith & Martin, 2010) definition of "a result that is obtained by experiment or observation rather than from theory". Editorial or conceptual studies were excluded. 'Organisation' was defined in a broad sense, without reference to funding source, but excluding examples which purely assessed Higher Education institution research teams or state level policies.

This process is summarised as Figure 2 (below). 18 papers which met the criteria for review were imported into Nvivo 12 for analysis, providing 20 organisation case studies.

Figure 2. Flow chart of SLR process.



The lists of RRI-related and impacts in Appendix 1 was used as a top-down coding scheme. Descriptive features (type, sector, region, dates examined, age of organisation) were captured, and studies were defined as ‘strategic’ or ‘operational’ based on the concept in Stahl et al. (2017) – in short, whether they described features of the organisation’s overall work processes, or features that were applied by an organisation to a specific project or programme.

Four additional variables were assigned to each study: ‘scopeofactivity’ (number of distinct RRI-related activity nodes coded), ‘fullscopeactivity’ (true if at least one activity within the top-level categories was present), ‘scopeofimpacts’ (number of distinct RRI-related impact nodes coded), and ‘casestudylength’ (word count of the text within each publication that referred to the case study organisation).

SPSS Statistics 26 and Gephi were used to explore relationships between activity, impacts, and case study metadata.

3. RESULTS

3.1. Study characteristics

Metadata are provided in Appendix 2. While a range of organisation types were included, most were EU based (12 out of 20 - 60%), and in the Healthcare (8 out of 20 - 40%) or Agriculture (6 out of 20 - 30%) sectors. 13 of 20 cases (85%) were assessed as ‘strategic’ implementations. The most frequent organisation types were social enterprises (7 out of 20 - 35%) and joint ventures (4 out of 20 - 20%), with only one assessed as a public body.

Figure 3 shows the proportion of cases coded for each RRI related activity category, which varied from 95% (inclusion) to 10% (reflexiveness). Only two cases were coded against five or more RRI activity categories (Figure 4), and only one against all categories.

Figure 3. Percentage of cases studies coded against different RRI activity categories.

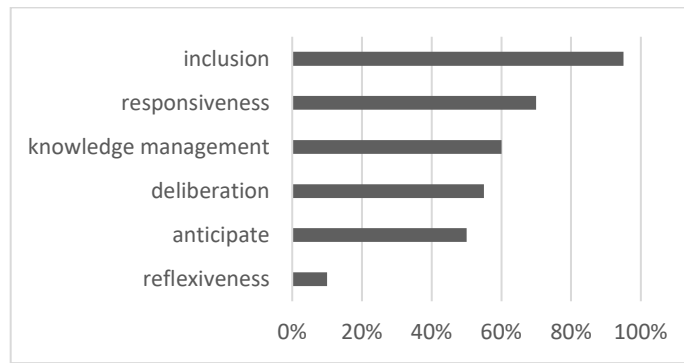
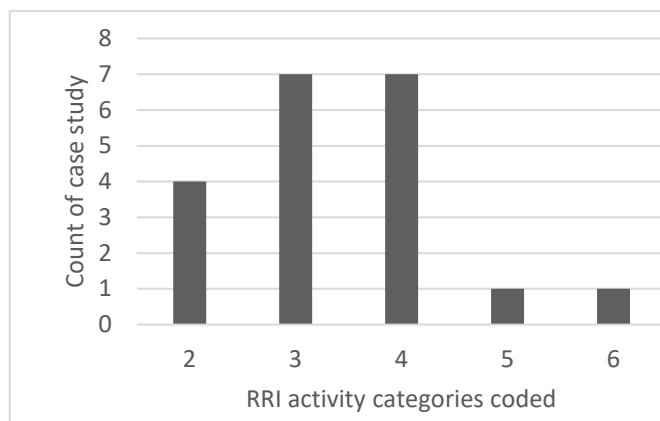


Figure 4. Number of RRI activity categories coded by count of case study.



Ethical and societal benefits were the most frequently cited impacts and appeared in 85% of cases, with the majority relating to 'Meeting user needs and rights' and 'Product acceptability' (Figure 5). Strategic benefits were assessed in 60% of cases, in particular to 'Partner and supplier relations' and 'Customer satisfaction' codes. 'Organisational' type benefits were reported in 55% of cases, most frequently relating to 'Risk management' and 'Employee engagement' impacts. 30% of cases noted costs of RRI practice, in nearly all cases indirect (for example delays to product development).

Figure 5. Percentage of cases studies coded against different RRI impact categories.

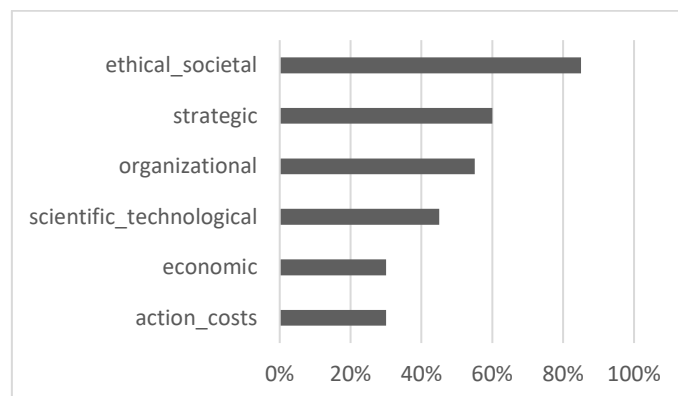
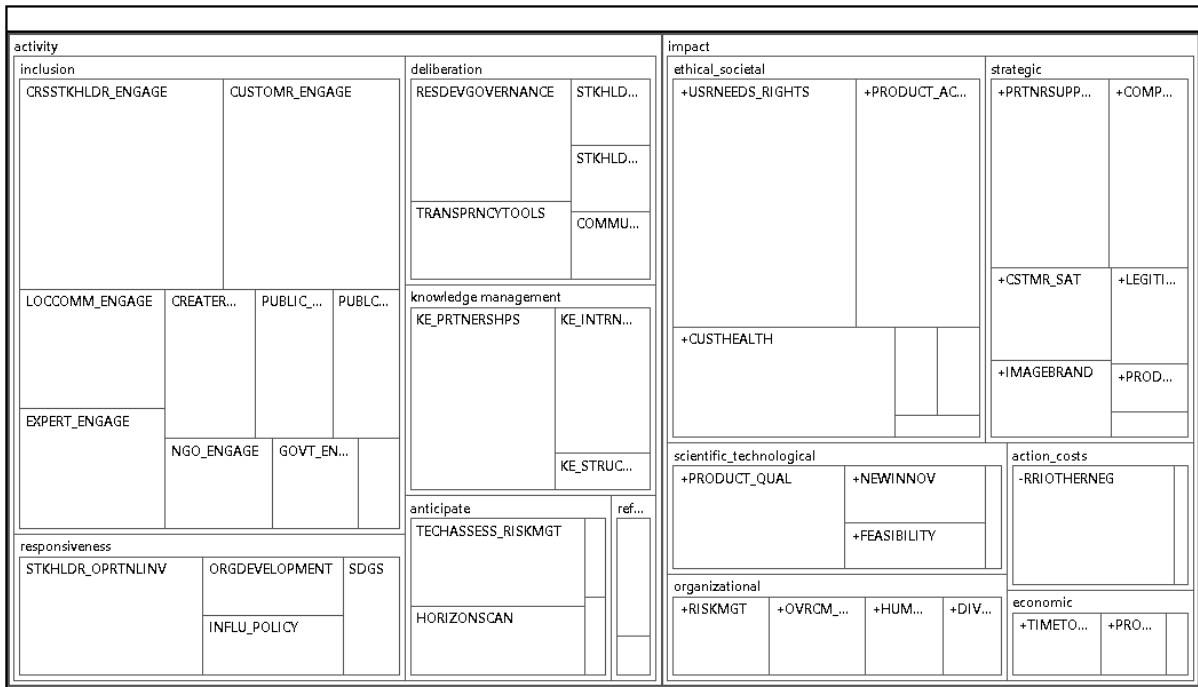


Figure 6 summarises total references to activities and impacts by code (see Appendix 1 for a list of codes and definitions). This highlights that at the detail level, the most frequently referenced items were ‘Cross-stakeholder engagement’, ‘Customer engagement’ and ‘Knowledge exchange partnerships’, and the most frequently coded impacts were ‘User needs and rights’, ‘Product acceptability’ and ‘Customer health’.

Figure 6. RRI-related activity and impacts across case studies by frequency of coding references.



3.2. Relationships between activities and outcomes

Statistical methods were applied to explore the research questions in Table 1 above and determine whether the data indicated any significant relationships between activity and impact coding, with the choice of test determined by the type of variable (‘scopeofimpacts’ is continuous and the presence of absence of an activity for a study is dichotomous).

Although a paired-samples T-test identified a significant relationship between number of reported RRI activities (M=6.75, SD=2.97) and number of reported RRI impacts (M=4.85, SD=2.72); $t(19)=-2.81, p=.011$, when the effect of case study length was controlled for no significant result was obtained.

No test was carried out for full scope of RRI activity against scope of impacts reported due to limitations in the data, as only one case study recorded activities in all categories.

A chi-square test of independence was performed to examine the relation between each activity category and impact category variable in turn, controlling for case study length. The following relations were identified as significant, supporting the supposition that engaging in some specified types of RRI activity is associated with particular types of organisational outcome:

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- Organisations performing activities in the Anticipate category were more likely to report impacts in the Organizational category $X^2 (17, N = 20) = .675, p = .002$
- Organisations performing activities in the Inclusion category were more likely to report impacts in the Ethical and Societal category $X^2 (17, N = 20) = .511, p = .025$

A multiple regression was run to predict scope of impacts from RRI-related activity categories. Although activity category variables statistically significantly predicted scope of impacts, $F(6, 20) = 3.027, p = .044, R^2 = .583$ indicating that engaging in some specified types of RRI activity is associated with a broader scope of positive organisational outcomes, when controlling for case study length this effect was no longer visible.

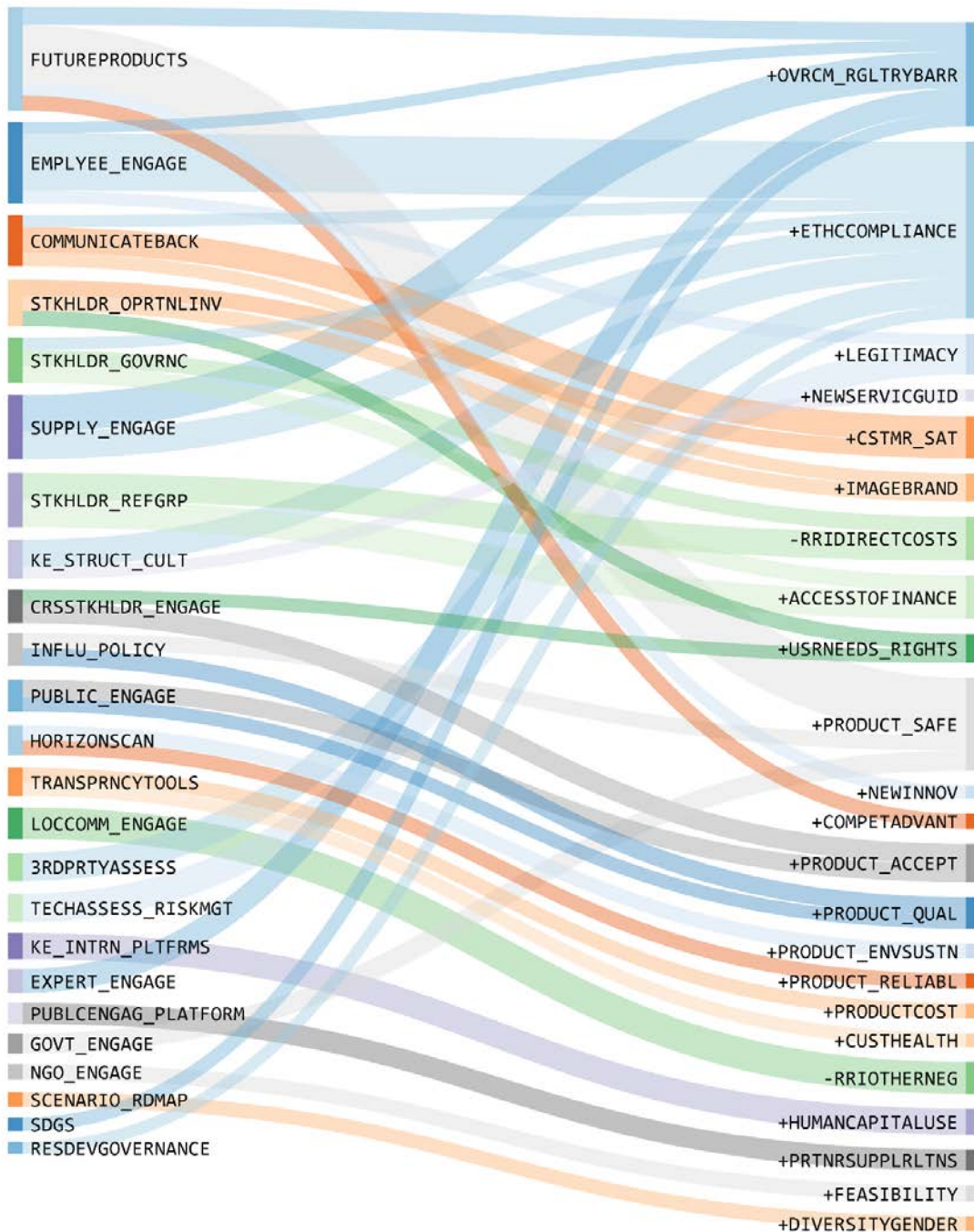
A further chi-square test of independence was performed to examine the relation between detailed activity and impact codes (controlling for case study length). A number of relations were identified as significant. Nine results which related to a single occurrence of an impact code were excluded. The strongest relationships ($p < 0.01$, two-tailed) are summarised in Table 2 below.

Table 2. Activity-impact relationships significant at the 0.01 level.

Activity	Impact	$X^2 (17, N=20)$
Supplier engagement	Overcome regulatory barriers	0.799
Local community engagement	Other negative impact	0.743
Technology assessment / Risk management	Improvement in perceived legitimacy	0.702
Knowledge exchange internal platforms	Human capital use	0.671
Communicate back to stakeholders	Customer satisfaction	0.670
Expert engagement	Overcome regulatory barriers	0.649
Public engagement platforms	Partner / supplier relations	0.605
Stakeholder reference group	Partner / supplier relations	-0.600
Cross-stakeholder engagement	Product acceptance	0.591

This indicates that engaging in some specified RRI activities is associated with particular organisational outcomes. Figure 7 summarises relationships between activities and impacts in the data significant at the $p=0.05$ level. Size of line indicates correlation strength (X^2). Code definitions are provided in Appendix 1.

Figure 7. Significant activity-impact relationships.



Hierarchical multiple regression was run to predict likelihood of product acceptability, product quality, competitive advantage and negative RRI impacts from certain combinations of RRI-related activities, separately and together with organisational metadata (sector, age, type) and implementation type. No statistically significant result was found.

4. DISCUSSION

While statistically significant associations were found between RRI-related practices and impacts, it is important to emphasise that this is a limited study of a small sample of

organisations and results should not be over-generalised. A number of qualifying comments apply.

Firstly, the selection of case study organisations was a limited sample. It was not neutral, consisting of entities selected as case studies for publications in many cases because they are seen as positive exemplars of organisations applying RRI practices. In some cases, subject organisations may have been in receipt of EU funding or were participating in EU-funded projects, which may create demand characteristics or the conditions for 'acquiescence bias' that could influence the reporting of impacts. In any case, this was a study of RRI-practicing organisations, rather than a comparison of those practicing 'RRI activity' against 'not-RRI activity'. The sample was small, particularly with respect to any intent to generalise. Although the study included organisations of different types from different regions and sectors, it would not be statistically appropriate to conclude that the relationships identified in this study necessarily exist in other regions or organisation types.

It was noteworthy from the literature search carried out that within RRI literature, a high proportion of papers were non-empirical (367 of 621, 59%) and within empirical studies a high proportion took higher education research teams as a subject, assessed higher education RRI teaching methods, reported on 'work in progress' RRI elements of research programmes, or were 'snapshot' surveys of attitudes to RRI themes. This reinforces Martinuzzi et al.'s (2018) assessment that there is a need for more empirical studies of industry engagement with RRI. At the same time, a number of studies focussed on perceived RRI 'drivers' and 'barriers', so a meta-study of these aspects would be likely to yield a larger sample size.

Setting wider parameters for the initial literature search might increase the number of case studies for analysis. Fuzzier literature search terms could overcome the issue that RRI-related activity may be reported under different conceptualisations such as 'CSR' and 'responsibility' in connection with 'R&D' or 'product development' keywords, as in the literature review by Lubberink et al., (2017) but carries the risk of including activity that can't be meaningfully differentiated from 'not-RRI' activity (as noted in Thapa, Iakovleva, & Foss, 2019). This assumes that activity can still be categorised as constituting RRI even if does not necessarily involve an explicit commitment to engage with RRI, a position taken by the Stahl et al. (2017) maturity model (Level 1 - 'unconscious engagement'). Additional cases may also exist in the 'grey literature', for example in unreported outputs of a wider range of EU RRI projects to those featured in this study at the expense of including non-peer reviewed data, and inclusion of non-English publications could yield further studies.

Secondly, while small, the sample of organisations and the types of impact assessed may have been too fuzzy. The subject case studies were not developed with a standardised methodology and varied in duration and level of detail. Although effort was taken to mitigate this by considering case study duration and wordcount as independent variables and the use of well-defined criteria for inclusion, it is possible that the effects observed may relate in part to factors such as the methodology used for particular types of enquiry, for example the extent to which evidence on impact of RRI engagement was gathered, the stakeholders whose inputs were gained, and the relative ability of different types of organisation to assess activity outcomes. It is also relevant to note that the activities list used was developed on an explicit premise that the practices are based on organisations in the global North (Lubberink et al., 2017, p2-3).

In terms of activities and impacts, although the indicator lists were selected on the basis of measurability, some indicators were very broad and articulated in a qualitative rather than easily

measurable manner (for example 'improved image/brand'). This was partly mitigated in the current study by use of working definitions for analysis, but the measurability of these could be developed further, and criteria could be developed for assessing what counts as valid evidence of an impact associated with the RRI activity – for example in some cases, impacts were coded based on interviews with a small number of stakeholders within organisations. The inter-rater reliability of assessments could also be enhanced by involving co-authors in the process. Beyond this, the inclusion of some RRI-related impacts could be said to presume a Corporate Shared Value (CSV) perspective – from some industry perspectives, 'improved customer health' may be assessed as an indirect and societal, rather than direct organisational benefit. This could be accounted for in analysis by distinguishing direct, and indirect impacts to organisations.

A third issue is that with a mean average of 2 years for the case studies' duration, with several constituting 'snapshot' descriptions of organisations at a specific point in time, limited time horizons may not reflect the lead time for all benefits arising from engagement in RRI activities. While the complex processes that mediate engagement in the context of RRI with organisational outcomes are challenging to map and measure and the lead time for benefits may vary significantly by organisation type and sector, Gurzawska et al.'s (2017) indicative causal model highlights the fact that benefits may accrue over a longer time period as a result of intermediate impacts. Similarly, intermediate benefits that precede more measurable outcomes may be harder to measure. While the Porcari et al. (2019) list of impacts used for this study was broad enough to cover a wide range of potential impacts, this issue could be addressed by either measuring broader aspects of (for example) brand perceptions, net promoter score and improvements in social and intellectual capital as a result of engagement with RRI activities, or more formal measures to gain organisational perspectives on outcomes of RRI engagement that organisations assess will drive measurable outcomes over a longer timescale. Focussing on a particular sector and/or organisation type could allow for more accurate quantification of benefits and broader time horizons for analysis.

Fourth, the decision to focus on benefits for specific organisations may not account for the networked nature of innovation processes (Dreyer et al., *ibid*). The resulting analysis may exclude changes to innovation ecosystems as a result of RRI processes, which may impact organisations over a longer period of time. If we accept that RRI activities can operate at a network level, and aims to enhance relations between different stakeholders and embedding scientific advances within social structures (Von Schomberg, *ibid*), the innovation ecosystem could be seen as the most relevant level of analysis for assessing outcomes. For example, new or increased contact between stakeholders as a result of RRI-related activity may develop social and bridging capital that strengthens innovation networks, without immediate or direct benefits to a component organisation, but increasing the likelihood of successful innovations for the future. While complex, this aspect could be assessed by probing benefits to innovation networks alongside benefits to organisations that form part of those networks, and considering the perspective of other actors within innovation networks such as entrepreneurs (Stahl & Brem, 2015). This may also include systematic consideration of different stakeholder perspectives (for example shareholder, management and employee perspectives).

Finally, the case is made in the wider literature and in particular, in the CSR literature that the configuration of responsibility activities most likely to positively impact businesses is likely to relate to other factors such as business strategy, market position and innovation strategy (Carroll & Shabana 2010, p95), the technology readiness level of relevant innovations (Stahl et al., 2017) and a range of other contextual and company-specific factors (van de Poel et al., 2017).

In most cases these data were not available in the case study material so were not included in analysis - their absence limits our ability to infer causation, since extraneous factors such as these could explain both a firm's adoption of a practice, and its achievement of particular outcomes. A future metastudy could include additional data collection for organisations to classify organisation-specific context, strategy and capabilities in more detail. This could be combined with assessment of the RRI maturity level of organisations to assess the effect on outcomes (Stahl et al., *ibid*) - although judging the degree of integration of RRI methods into business processes and strategy is likely to require nuanced assessment of an organisation, for example through some combination of primary data, parsing of sustainability reporting and annual reports, and consideration of other perspectives.

In conclusion,

- [1] This study demonstrates a method to identify business-case-relevant relationships from a heterogeneous sample of RRI case studies. With additional data, this method could provide the basis for statistically-based causal modelling to develop the model developed by Gurzawska et al. (2017), and provide a basis for business improvement tools underpinned by empirical data of practices associated with positive (or negative) RRI-related impacts. It aims to lay the foundation for better empirical evidence to support statements relating to the benefits to industry of engaging with RRI.
- [2] Within the limitations of a small sample, the results indicate that certain RRI activities are significantly associated with specific organisational outcomes (Table 2 and Figure 6 above).
- [3] Further studies may provide opportunities to capture a broader range of case study examples through reframing literature search parameters, inclusion of non-peer reviewed case study material, or a tighter focus on specific regions, sectors or organisation types. This might draw in CSR studies relating to research and development processes, or establishing a living dataset that enables comparison of RRI against non-RRI approaches and RRI maturity level in relation to measures of organisational impact.
- [4] The limitations of the empirical evidence base for industry RRI highlighted by this study imply that future projects seeking to evaluate impacts of RRI should aim to capture benefits realised at the organisation and innovation network as well as national levels, both to develop a full understanding of the effects of RRI-related activity and to facilitate future industry engagement with RRI.
- [5] Further study of the empirical evidence base for the 'business case' for industry engagement with RRI may support broader public policy objectives relating to responsible innovation in industry. This has particular relevance for companies innovating new uses of smart information systems and their stakeholders.

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Appendix 1 – RRI activities and impacts

Based on Lubberink et al. (2017) and Porcari et al. (2019)

code	type	category	definition
HORIZON SCANNING	activity	anticipate	Horizon scanning / monitoring PESTEL trends
FUTURE PRODUCTS	activity	anticipate	Future-focussed product development based on long-term societal/environmental value
TECH ASSESSMENT/RISK MGT	activity	anticipate	Innovation risk management / technology assessment
SCENARIO/ROADMAP	activity	anticipate	Scenario building / roadmap development
3RD PARTY ASSESSMENT	activity	reflexiveness	Formal third party assessment of business strategy and its impact (inc. CSR-related charter marks)
EMPLOYEE ENGAGEMENT	activity	reflexiveness	Employee engagement activities (in relation to roadmap/vision)
PUBLIC ENGAGEMENT	activity	inclusion	Public engagement
SUPPLY CHAIN ENGAGEMENT	activity	inclusion	Supply chain engagement
CUSTOMER ENGAGEMENT	activity	inclusion	End user/customer engagement (inc. crowdsourcing)
NGO ENGAGEMENT	activity	inclusion	NGO engagement
EXPERT ENGAGEMENT	activity	inclusion	Engagement with experts
CROSS-STAKEHOLDER ENGAGEMENT	activity	inclusion	Cross-stakeholder engagement
GOVERNMENT ENGAGEMENT	activity	inclusion	Engagement with Government agencies
LOCAL COMMUNITY ENGAGEMENT	activity	inclusion	Local community engagement
INDIRECT ENGAGEMENT	activity	inclusion	Indirect engagement (e.g. thought experiments, role play, intermediaries)
PUBLIC ENGAGEMENT PLATFORMS	activity	inclusion	Public platforms for engagement (inc. online)
CREATE ROLES	activity	inclusion	Creation of Engagement / inclusion focussed roles
R&D GOVERNANCE PROCESSES	activity	deliberation	Formalised R&D/innovation/product development governance processes
TRANSPARENCY TOOLS	activity	deliberation	Provide transparency tools / reports
STAKEHOLDER REF.GP.	activity	deliberation	Stakeholder reference group
STAKEHOLDER GOVERNANCE ROLES	activity	deliberation	Stakeholders formal involvement in governance (e.g. Board position)
STAKEHOLDER VOTING POWER	activity	deliberation	Stakeholders have voting power
COMMUNICATE BACK	activity	deliberation	Communicate back about action taken based on stakeholder input
OPERATIONAL INVOLVEMENT OF STAKEHOLDERS	activity	responsiveness	Involvement of stakeholders at operational level e.g. project teams
ORG.DEVELOPMENT	activity	responsiveness	Organisational development/change (e.g. structure) to align with societal needs/as result of stakeholder engagement
INFLUENCE BROADER POLICY	activity	responsiveness	Engage with stakeholders to influence the broader policy or business environment
SDGs	activity	responsiveness	Specifically engage with UN SDGs
IMPACT MITIGATION PROCESSES	activity	responsiveness	Formal process(es) for action to mitigate or avoid social, environmental or economic impacts

8. Societal Challenges in the Smart Society

INTERNAL KE PLATFORMS	activity	knowledge management	Internal platforms within the firm for knowledge exchange
FIRM STRUCTURE/CULTURE FOR KE	activity	knowledge management	Firm structure / culture / communication channels aligned to knowledge creation
KE PARTNERSHIPS	activity	knowledge management	Involvement in partnerships (e.g. R&D consortia)
NEW INNOVATIONS	impact	Scientific & Technological	Identify new innovations
FEASIBILITY	impact	Scientific & Technological	Improved feasibility of the technology solution
PRODUCT QUALITY	impact	Scientific & Technological	Improved product quality
PRODUCT RELIABILITY	impact	Scientific & Technological	Improved product reliability
PRODUCT LIFECYCLE	impact	Scientific & Technological	Improved product life cycle
PRODUCT ACCEPTABILITY	impact	Ethical & Societal	Improved product acceptability
PRODUCT SAFETY	impact	Ethical & Societal	Improved product safety
PRODUCT ENV.SUSTAIN.	impact	Ethical & Societal	Improved product environmental sustainability
CUSTOMER HEALTH/QOL	impact	Ethical & Societal	Improved customer health/QOL as a result of product
NEW SERVICES/GUIDANCE	impact	Ethical & Societal	Identify opportunities for improved product related services/guidance
USERS NEEDS/RIGHTS	impact	Ethical & Societal	Identify opportunities to address users' needs and rights (e.g. privacy)
COMPETITIVE ADVANTAGE	impact	Strategic	Achieve competitive advantage
IMAGE/BRAND	impact	Strategic	Improved corporate image/brand
VISIBILITY PRODUCT QUALITIES	impact	Strategic	Improved visibility of product qualities
CUSTOMER SATISFACTION	impact	Strategic	Improved customer satisfaction
CUSTOMER LOYALTY	impact	Strategic	Improved customer loyalty
LEGITIMACY	impact	Strategic	Improvement in perceived legitimacy
PARTNER/SUPPLIER RELATIONS	impact	Strategic	Improved relationships with partners, suppliers and sub-suppliers
ETHICAL COMPLIANCE	impact	Strategic	Demonstrate compliance with ethical/social requirements (e.g. for funding)
USE OF HUM.CAP.	impact	Organizational	Improved use of human resources
EMP.ENGAGEMENT	impact	Organizational	Team/employee engagement and motivation
REGULATORY BARRIERS	impact	Organizational	Address regulatory barriers
RISK MANAGEMENT	impact	Organizational	Improved risk management
GENDER/DIVERSITY	impact	Organizational	Gender and diversity contribution to product development
IRRESPONSIBLE BEHAVIOUR	impact	Organizational	Avoid irresponsible behaviour
PRODUCT COST	impact	Economic	Reduced product cost
TIME TO MARKET	impact	Economic	Reduced time to market
PROFIT/SHARE	impact	Economic	Increased profit or market share
ACCESS TO FINANCE	impact	Economic	Improved access to financial support
RRI DIRECT COSTS	impact	RRI action costs	Increase in costs due to RRI activity
RRI OTHER NEG.IMPACT	impact	RRI action costs	Other negative impact on company due to RRI activity

Appendix 2 – Characteristics of the case study selection

Implementation type	Count
Operational	7
Strategic	13
	20

Organisation type	Count
Social enterprise	7
Joint Venture	4
SME	3
Multinational corporation	3
Limited company	2
Public body	1
	20

Sector	Count
Agriculture/Food Production	6
Education	2
Financial Services	1
Healthcare Technology	8
ICT	2
Nuclear energy	1
	20

Region	Count
EU	12
North America	3
Asia	3
Africa	2
	20

Data used for analysis are provided on a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License here: : https://drive.google.com/drive/folders/1XB0_PeR66wZydXTIQu5-iBa0bZKb5MQL?usp=sharing

