KAUNAS UNIVERSITY OF TECHNOLOGY

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# IMPLEMENTING RESPONSIBLE INNOVATION AT THE FIRM LEVEL

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KAUNO TECHNOLOGIJOS UNIVERSITETAS

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# ATSAKINGŲJŲ INOVACIJŲ DIEGIMAS ĮMONĖS LYGMENIU

Daktaro disertacija
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2019, Kaunas

*Reason is the pace,
increase of science the way
and the benefit of man-kind the end.*

(Hobbes, *Leviathan*, 1651)


*The greatest danger in times of turbulence is not the turbulence;
it is to act with yesterday's logic.*

(Peter Drucker, 1991)

## ACKNOWLEDGMENTS

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**AISTIS** – a research project entitled "Open innovation ecosystems: enabling interactions of technological, institutional and social constituents". Research funded by Lithuanian science council under the "Welfare society" program GER2015/001
**CB SEM** – Covariance-based Structural Equation Modeling
**CE** – Circular Economy
**CEO** – Chief Executive Officer
**CSR** – Corporate Social Responsibility
**CTA** – Constructive Technology Assessment
**DMN** – Decision-making norm
**EC** – European Commission
**ELSA** – Ethical, Legal and Social Aspects
**EU** – European Union
**eTA** – Ethical Technology Assessment
**Ex-post** – Before the event
**ICT** – Information and Communications Technology
**n.d.** – no date
**OECD** – The Organization for Economic Co-operation and Development
**PLS-SEM** – Partial Least Squares Structural Equation Modeling
**R&D** – Research and Development
**RI** (Responsible Innovation) – The term used in the business sector
**RRI** (Responsible Research and Innovation) – The term used in the public sector
**RTA** – Real-Time Technology Assessment
**STS** – Science and Technology Studies
**TA** – Technology Assessment

**INTRODUCTION**

**Relevance of the research.** Innovation is highly promoted and integrated into the structure of many societies because of its capability to generate dual value – both for customers and organizations (Tidd, Bessant, 2009). Therefore, it is presumed that innovation is inherently good (Godin, 2015). However, recently, organizations increasingly face the current paradox of demand for efficiency and responsibility of innovation at the same time (Pavie, Scholten, and Carthy, 2014). The rise of awareness regarding societal and ethical issues addressed by the society and institutions forces firms to integrate the issues of responsibility into the innovation process more explicitly in order to sustain long-term competitive advantage and social legitimacy (Garst et al., 2017). Recent events of firms (like Volkswagen and Facebook) reputation crises regarding unaddressed responsibility issues during the innovation process caused unintended consequences of innovation and demonstrated a lack of understanding and, accordingly, required processes to manage innovation implementation in a more responsible manner. In order to address responsibility issues during the innovation process more effectively, firms could apply the solutions suggested by the concept of Responsible Innovation.

Responsible Innovation (RI) is a new concept aimed at mitigating possible negative consequences of innovation by considering ethical and societal concerns and including a wider range of firm's stakeholders into the innovation implementation (Stilgoe, Owen, and Macnaghten, 2013). Responsible Innovation is defined 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 social desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)" (Von Schomberg, 2013, p. 9).

According to Ribeiro, Smith and Millar (2016), the concept of RI was developed on a basis of two lines of argumentation: 1) technology development involves numerous risks that can have detrimental effects on the environment and society, thus it is crucial to anticipate potential negative consequences of innovation beforehand, and 2) improvement of the innovation process by making it proactive instead of reactive and thus seek for better alignment with societal expectations and needs. Hence, RI as a concept calls *for a transformation of values and the actual behavior of societal members towards the socio-ethical issues* (Sutcliffe, 2013). Although ideas about responsibility in the innovation process are not new, "the major novelty and practical relevance of RI is in integrating existing approaches and in making an explicit link between innovation and responsibility" (Genus, Iskandarova, 2017, p. 2).

RI is viewed as a social license for business to operate (Garst et al., 2017), thus increasing a firm's legitimacy and acceptance in society. The results of the project RRI Tools for Business express the benefit of RI in relation to a firm's profitability and social responsibility which can increase the competitiveness of a firm. Involving new stakeholders into the innovation process can lead to new and creative solutions and use the firm's potential in new ways. The positive impact of RI on firm's

innovation performance and success in the market was also supported empirically (Hin et al., 2015; Garst et al., 2017).

**Scientific problem and the extent of its investigation.** RI in the business sector plays a strategic role in various policy documents of the European Union (EU), however, the way in which RI could be translated in the business sector is lacking. Firms can and should contribute to mitigating the Grand Challenges, but, first and foremost, a firm has the need to survive. This is not yet fully reflected in the Responsible Innovation research community, which creates distance and exclusion of the business sector. In addition, among policymakers (Responsible Research and Innovation Tools), RI is promoted among firms that develop both research and innovation, meaning that innovative firms without R&D are not encouraged to apply RI, although the positive effect could be reached both for the firm and society. Although it is expressed that RI is an attempt to articulate economic efficiency with socio-ethical concern (Von Schomberg, 2013), it is unclear how firms could manage their innovation processes in a more responsible manner and how to shape organizational activities towards it (Dreyer et al., 2017; Inzelt, Csonka, 2017).

Moreover, RI theory is mostly normative (prescriptive) and leaves behind a firm's economic need to compete in the market (Garst et al., 2017). Consequently, such normative imperatives cause several scientific and practical problems. The main problem is that, so far, RI is mostly considered as a normative concept that lacks a behavioral approach to realize the actual implementation of RI and its main constructs at the firm level. RI as a concept was firstly developed by the researchers and policymakers making it normative and not differentiating between different contexts like the public (non-commercial) and private (commercial) contexts (Pelle, Reber, 2017). This resulted in ignoring the economic motives and traditional innovation logic in RI studies (Garst et al., 2017; Lubberink et al., 2017). In real practice, firms mostly evaluate innovation impact *ex-post* or at the closing stages of innovation development (Blok, Hoffmans, and Wubben, 2015). As a consequence, there is a lack of how RI could be understood in the business sector as well as RI as a framework lacks concrete practices in firm's networked settings, where different aspects of a firm's internal and external environment affect the firm's application of RI practices.

RI research emerged from different research fields, such as Science and Technology Studies (STS), Corporate Social Responsibility (CSR), etc. RI dimensions determined by Stilgoe, Owen, and Macnaghten (2013), for example, anticipation, inclusion, reflexivity, and responsiveness, contain different organizational activities combined from foresight studies, stakeholder theory, and business ethics research. This means that organizations to some extent already apply activities that are now conceptualized as RI. This causes various opinions and a lack of agreement on and application of RI activities in the industry. As Dreyer et al. (2017, p. 2) point out, "<…> the efforts by most companies to redirect their activities towards more sustainable and positive societal impact are not properly understood by the research community, and the research on RRI is not adopted by industry."

Thus, it is crucial to gain a behavioral understanding of why firms behave in a more responsible manner by applying RI-related elements in the innovation process. It resonates with Long and Blok (2018) that the focus should be not on the execution of methodologies itself but on seeking for an in-depth understanding of why firms behave in a more responsible way and how RI could be further promoted. In order to benefit from the opportunities that the emerging concept of RI provides, the concept should be more aligned with private sector interests and behavior (Blok, Lemmens, 2015), so the more inclusive, anticipatory, reflexive and responsive innovation management would be implemented in the private sector.

In addition, major importance is devoted to guiding a science policy thus causing a lack of managerial knowledge on RI (Ribeiro et al., 2016). The concept of RI is still relatively new and primarily emerged in the public sector (Van den Hoven, Lokhorst, and Van de Poel, 2012; Stilgoe et al., 2013; Pelle, Reber, 2015) and in the academic context (Van der Burg, Swierstra, 2013; Scholten, Van der Duin, 2015). Meanwhile research on RI in the business sector remains less examined: RI was examined in a general innovation context of the firms (Halme, Korpela, 2014; Blok et al., 2015; Dreyer et al., 2017) or by integrating theoretical solutions from the scientific fields such as corporate social responsibility (CSR) or sustainable development (Pavie, Scholten, and Carthy, 2015; Garst et al., 2017). Several quantitative studies were done focusing on start-ups in the academic sector (Scholten, van der Duin, 2015) and on firms in research and development (R&D) context (Flipse et al., 2015). Thus, there is a lack of empirical research of RI in the business sector and operationalization of theoretical RI constructs at the firm level (Blok, Lemmens, 2015).

To summarize the level of scientific problem exploration it can be stated that although responsible innovation gained a lot of attention, there is still a lack of knowledge required to answer the research question raised in this study: what are the main elements (and their interrelationships) constituting the implementation of responsible innovation at the firm level and how it could be fostered?

**The object of the research** is the implementation of responsible innovation at the firm level.

**The research aim** is to substantiate a conceptual framework of Responsible Innovation as implemented by firms.

In order to achieve the aim, the following **research objectives** were set:
1. To discuss the concept of Responsible Innovation at the firm level identifying its main characteristics and conceptual dimensions.
2. To argue for the application of behavioral norms perspective in responsible innovation implementation.
3. To conceptualize the key elements and their interrelationship depicting the implementation of Responsible Innovation at the firm level.
4. To develop a conceptual framework for the implementation of Responsible Innovation at the firm level based on the behavioral norms

approach and the networked nature of the firm's internal and external environments.

5. To empirically test the framework revealing the implementation of Responsible Innovation at the firm level in Lithuania.

**Research methods and logic of the dissertation.** The dissertation was completed in the following stages. First, literature analysis was performed in order to construct a conceptual framework for the implementation of Responsible Innovation at the firm level from behavioral norms perspective. Second, the methodology for empirical research was developed based on the research problem and theoretical analysis. Third, qualitative and quantitative research methods were used. Semi-structured interviews were performed 1) to uncover the phenomenon of implementing responsible innovation at the firm level, specifically focusing on the firm's networked nature and external stakeholders in order to validate related aspects of conceptual framework for implementing responsible innovation at the firm level, and 2) to operationalize the structure of quantitative instrument constructs for RI implementation and adjust it to the business context. Quantitative research was performed in order to collect a primary data set via a questionnaire survey method. The collected data was used to test the validity of the research model and to identify relationships between the constructs of the model. The statistical data of the empirical research was processed using the Statistical Data Processing Package SPSS 21.0. In order to test the hypotheses, a partial least squares structural equation modelling method (PLS-SEM) using SmartPLS 3.0 software was applied.

**Scientific novelty and theoretical significance** of the dissertation reveal in such aspects:

- Based on the results of the systematic and comparative scientific literature analysis, the main characteristics and conceptual elements of Responsible Innovation in the business context were identified. Previous studies have focused on the macro level of RI by examining the governance of RI from the public governance perspective. This study thus challenges the dominant research tradition and extends research focus on the micro level (firms) of RI in the business sector.
- The study introduces a new approach of behavioral norms for the analysis of RI implementation at the firm level that combines both normative and processual approaches of Responsible Innovation.
- A newly conceptualized and theoretically grounded conceptual framework for Responsible Innovation implementation occurring in the networked nature of the firm that highlights the role of firm's external stakeholders and integrates relations between innovation orientation towards Grand Challenges, decision-making, and responsible innovation activities was developed.
- The methodological novelty of the research is related to the applied pragmatism approach in the development of research methodology

that is based on the original mixed method research strategy with the purpose of complementarity.
- To the author's knowledge, this thesis is one of the first quantitative studies that examines RI implementation at the firm level. So far, the public sector and academia gained most of RI scholars' attention, while the business sector was less examined.
- This study also contributes to the operationalization of RI activities at the firm level. The thesis challenges traditional RI activities originally called as dimensions, i.e. anticipation, inclusion, reflexivity, and responsiveness, established by Stilgoe et al. (2013) and after careful deliberation adopts only anticipation, reflexivity and responsiveness in the business sector. The inclusion activity was not eliminated but rather understood as an integrative part of anticipation, reflexivity, and responsiveness. Finally, according to the quantitative results, RI activities (anticipation, reflexivity, and responsiveness) are highly interrelated and should be understood as a unidimensional construct.

**Practical significance** of the research results manifest in the following points:
- The research instrument can be applied in empirical research seeking a deeper understanding of the phenomenon of implementing responsible innovation at the firm level, as well as reasoning practical solutions for managers in innovative firms.
- The prepared research methodology of implementing responsible innovation could be used as a background for innovative firms to learn about the implementation of responsible innovation and to scale up their innovative activities towards RI implementation.
- On the basis of empirical qualitative and quantitative research results, explicit managerial and policy recommendations are proposed to foster responsible innovation implementation in firms.

**Dissemination of the research results** was performed while presenting theoretical and empirical results related to the dissertation research and publishing research articles in national and international scientific conferences, journals and books (see below).

**ARTICLES**
*Articles indexed in the Web of Science and Scopus with Impact Factor / SNIP International Publishers:*
1. **Ceicyte, Jolita**; Petraite, Monika. Networked responsibility approach for responsible innovation: perspective of the firm // Sustainability. Basel: MDPI AG. eISSN 2071-1050. 2018, vol. 10, iss. 6, art. no. 1720, p. 1-15. DOI: 10.3390/su10061720. [Scopus; Social Sciences Citation Index (Web of Science)] [IF: 2,075; AIF: 2,573; IF/AIF: 0,806; quartile: Q2 (2017, InCites JCR SSCI)] [CiteScore: 2.37, SNIP: 1.030, SJR: 0.537 (2017, Scopus Sources)] [FOR: 03S] [Contribution: 0,500]

*Articles indexed in the Web of Science and Scopus without Impact Factor / SNIP International Publishers:*

1. Petraitė, Monika; **Čeičytė, Jolita**. Conceptual model for responsible innovation management in business organizations // Procedia social and behavioral sciences: 19th international scientific conference economics and management 2014, ICEM-2014, 23-25 April 2014, Riga, Latvia. Amsterdam: Elsevier. ISSN 1877-0428. 2014, vol. 156, p. 121-124. DOI: 10.1016/j.sbspro.2014.11.132. [Conference Proceedings Citation Index - Social Science & Humanities (Web of Science)] [FOR: 03S] [Contribution: 0,500]

*National Publishers:*

1. **Čeičytė, Jolita**; Petraitė, Monika. Atsakingųjų inovacijų koncepcija = The concept of responsible innovation // Viešoji politika ir administravimas = Public policy and administration / Kauno technologijos universitetas, Mykolo Romerio universitetas. Kaunas: KTU. ISSN 1648-2603. 2014, T. 13, nr. 3, p. 400-413. DOI: 10.5755/j01.ppaa.13.3.8302. [Academic Search Complete; Central & Eastern European Academic Source (CEEAS); Scopus; IndexCopernicus] [FOR: 03S] [Contribution: 0,500]

*Articles in other peer reviewed research publications (Articles in periodicals, serials, collections of articles, etc.), National Publishers:*

1. **Čeičytė, Jolita**; Petraitė, Monika. Self-organisation perspective to responsible innovation in industry = Saviorganizacijos perspektyva atsakingosioms inovacijoms industrijoje // Organizacijų vadyba: sisteminiai tyrimai = Management of organizations: systematic research. Kaunas; Varšuva: Vytauto Didžiojo universitetas; De Gruyter Open. ISSN 1392-1142. eISSN 2335-8750. 2017, Nr. 78, p. 21-32. [CEEOL – Central and Eastern European Online Library; Business Source Complete] [FOR: 03S] [Contribution: 0,500]

2. **Čeičytė, Jolita**; Petraitė, Monika. Socialinis tinklas kaip savireguliacinis instrumentas atsakingų inovacijų valdyme = Social network as self-regulating instrument in responsible innovation management // Organizacijų vadyba: sisteminiai tyrimai = Management of organizations: systematic research. Kaunas: Vytauto Didžiojo universitetas. ISSN 1392-1142. eISSN 2335-8750. 2016, Nr. 76, p. 7-24. DOI: 10.7220/MOSR.2335.8750.2016.76.1. [CEEOL – Central and Eastern European Online Library; Business Source Complete] [FOR: 06S] [Contribution: 0,500]

3. **Čeičytė, Jolita**; Petraitė, Monika. Socialinis tinklas kaip savireguliacinis instrumentas atsakingųjų inovacijų valdyme = Social network as self-regulating instrument in responsible innovation management // Organizacijų vadyba: sisteminiai tyrimai = Management of organizations: systematic research. Kaunas; Varšuva: Vytauto Didžiojo universitetas; De Gruyter Open. ISSN 1392-1142. eISSN 2335-8750. 2016, Nr. 76, p. 7-24. DOI: 10.7220/MOSR.2335.8750.2016.76.1. [CEEOL – Central and Eastern European Online Library; Business Source Complete] [FOR: 03S] [Contribution: 0,500]

*Articles in conference proceedings, International Publishers:*

1. **Čeičytė, Jolita**; Petraitė, Monika; Pavie, Xavier. Responsible innovation process in healthcare firms // Proceedings of the ISPIM Innovation Forum, 25-28 March 2018, Boston, USA. Boston: ISPIM, 2018. ISBN 9789523352179. p. 1-14. [FOR: 03S] [Contribution: 0,334]

2. **Čeičytė, Jolita**; Rauleckas, Rimantas; Blok, Vincent; Von Zedtwitz, Maximilian Joachim; Petraitė, Monika. Network formation for responsible innovation practices: are grand challenges the driver? // EURAM 2017: making knowledge work, 21-24, June, Glasgow, Scotland: programme book. Glasgow: University of Strathclyde. ISSN 2466-7498. 2017, p. 1-35. [FOR: 03S] [Contribution: 0,200]

**REVIEWS**

*Reviews in other peer reviewed research publications, International Publishers:*

1. **Čeičytė, Jolita**. Responsible innovation: book review // Journal of responsible innovation. Abingdon, Oxon: Taylor & Francis group. ISSN 2329-9460. eISSN 2329-9037. 2015, vol. 2, iss. 2, p. 237-241. DOI: 10.1080/23299460.2015.1059010. [FOR: 03S] [Contribution: 1,000]

**RESEARCH MONOGRAPHS, STUDIES AND CHAPTERS**

*Other International and National Publishers:*

1. Petraitė, Monika; Janiūnaitė, Brigita; Sekliuckienė, Jurgita; **Čeičytė, Jolita**; Dlugoborskytė, Vytautė; Sedziniauskienė, Rimantė; Užienė, Lina. (2018). Atvirųjų inovacijų ekosistema Lietuvoje: mokslo studija. Kaunas: Technologija. 260 p. ISBN 9786090215104. eISBN 9786090215111. DOI: 10.5755/e01.9786090215111. [FOR: 07S, 03S] [Contribution in quires: 2,637]

**OTHER BOOKS AND CHAPTERS**

*International Publisher from the Institutional List:*

1. Petraite, Monika; Pavie, Xavier; **Ceicyte, Jolita**; Janiunaite, Brigita; Carthy, Daphne. Managing innovation in multicultural environments: an imperative of responsibility within interorganizational networks // Intercultural interactions in the multicultural workplace: traditional and positive organizational scholarship / editors: Rozkwitalska, Małgorzata, Sułkowski, Łukasz, Magala, Slawomir. Cham: Springer, 2017. ISBN 9783319397702. eISBN 9783319397719. p. 137-415. (Contributions to management science, ISSN 1431-1941, eISSN 2197-716X). DOI: 10.1007/978-3-319-39771-9. [SpringerLink] [FOR: 03S] [Contribution in quires: 3,986]

**RESEARCH CONFERENCES**

1. *ISPIM Innovation Forum: "The innovation game – base hits, not home runs"*, Čeičytė, J., Petraitė, M., Pavie, X. Presentation title: „Responsible innovation process in Health-tech firms", 25-28 March 2018, Boston, USA.

2. *National Research Conference AIM-MeD*: "Open innovation models for transforming medical engineering: enabling interactions of R&D and user communities for health challenges", Čeičytė J. Presentation title: "Responsible Innovation Profiles in HealthTech: Effects of International Orientation", 08 December 2017, Kaunas University of Technology, Lithuania.

3. *European Academy of Management (EURAM) Conference*: "Making Knowledge Work", Čeičytė, J., Rauleckas, R., Blok, V., Von Zedtwitz, M. J., Petraitė, M., Presentation title: "Network formation for Responsible Innovation practices: are Grand Challenges the driver?", University of Strathclyde, 21-24 July 2017, Glasgow, Scotland, UK.

4. *Conference of UCL Centre for Comparative Studies of Emerging Economies* 2017: "Exploring technology upgrading in emerging and transition economies: from 'shifting wealth I' to 'shifting wealth II'?", Čeičytė, J., Rauleckas, R., Blok, V., Petraitė, M., Presentation title: "Societal Challenges Oriented Innovation: The Mediating Role of Responsible Innovation Practices in Stakeholders' Integration", 26-27 June 2017, University College London, London, UK.

5. *National research conference AISTIS*: "Open innovation ecosystems: Enabling interactions of technological, institutional and social constituents", Čeičytė, J., Rauleckas, R., Blok, V., Petraitė, M., Presentation title: "Network formation behavior for Responsible Innovation practices: are Grand Challenges the driver?", 08 December 2016, Kaunas University of Technology, Kaunas, Lithuania.

6. *EBEN Research Conference:* "Ethical behavior and ethical disclosure", Čeičytė, J., Petraitė, M., Blok, V. Presentation title: "Distributing Responsibility in Business Networks and Open Innovation: An Actor-Network perspective on Responsible Innovation", 08-09 September 2016, Palermo, Italy.

7. *4s/EASST Research Conference:* "Science & technology by other means: Exploring collectives, spaces and futures", Čeičytė, J., Petraitė, M., Blok, V. Presentation title: "Dynamics of Responsible Innovation Constituents along Innovation Processes: Explaining the Variations from a Network Theory Perspective", 31 August– 3 September 2016, Barcelona, Spain.

8. *R&D Management Research Conference:* "From Science to Society: Innovation and Value Creation", Čeičytė, J., Petraitė, M., Blok, V. Presentation title: "Responsible open innovation management within R&D intensive network settings: are Grand Challenges the driver?", 3-6 July 2016, Cambridge, UK.

9. *Philosophy of Management Research conference*, Čeičytė, J., Petraitė, M., Pavie, X. Presentation title: "The integration of responsibility dimensions in innovation process: conceptual model", 9-12 July 2015, St Anne's College, Oxford, UK.

10. *EGOS Research Conference*, Čeičytė, J., Petraitė, M., Pavie, X. Presentation title: "The conceptual model for integration of responsibility dimensions and principles into the process of innovation management", 02-04 July 2015, ALBA Graduate Business School at The American College of Greece, Athens, Greece.

11. *European Academy of Management (EURAM) Conference*, Čeičytė, J., Petraitė, M., Pavie, X. Presentation title: "The integration of responsibility

dimensions into the open innovation: conceptual model", 17-20 June 2015, Kozminski University, Poland.

**The dissertation was developed** during research internships and projects:

1. *Erasmus long-term research internship* at Hamburg University of Technology (TUHH), Hamburg (Germany), supervisor prof. dr. Cornelius Herstatt, Jan – May 2018.

2. *Erasmus long-term research internship* at Wageningen University, Wageningen (The Netherlands), supervisor assoc. prof. dr. Vincent Blok, Oct – Dec 2015.

3. *Erasmus long-term research internship* at ESSEC Business School, Paris (France), supervisor prof. dr. Xavier Pavie, Mar – May 2015.

4. *Short-term research internship* supported by Research Council of Lithuania at ESSEC Business School, Paris (France), supervisor prof. dr. Xavier Pavie, 04-15 Dec 2014.

5. *Junior researcher at the institutional research project* "Health innovation development in holistic communities: creating open educational environments for knowledge integration" supported by the Association of "Santaka Valley" (KTU), supervisors prof. dr. Monika Petraite (KTU), Ruta Nadisauskiene (LSMU), Lina Kaminskiene (VDU), March – December 2018.

6. *Junior researcher at the institutional research project* „Open innovation models for transforming medical engineering: enabling interactions of R&D and user communities for health challenges" supported by the Research, Development and Innovation Fund of Kaunas University of Technology, supervisor prof. dr. Monika Petraite (KTU), April – December 2017.

7. *Junior researcher at the national research project* „Open innovation ecosystems: enabling interactions of technological, institutional and social constituents", supported by the Research Council of Lithuania, supervisor prof. dr. Monika Petraite (KTU), July 2015 – December 2016.

8. *Junior researcher at the national research project* „Enabling self-organization based management in modern innovation ecosystems: context of so-called "delayed" economic", supported by the Research Council of Lithuania, supervisor prof. dr. Giedrius Jucevičius (KTU), March 2015 – April 2018.

**Structure and volume of the dissertation.** The dissertation includes lists of figures, tables, abbreviations and terms, and consists of an introduction, four main parts, conclusions, a list of references, and appendices. The volume of the dissertation is 140 pages with appendices. The dissertation contains 28 tables, 11 figures, 214 references, and three appendices.

# 1. THEORETICAL REASONING OF IMPLEMENTING RESPONSIBLE INNOVATION IN A FIRM

## 1.1. Conceptual foundation of Responsible Innovation

*1.1.1. Conceptual development of Responsible Innovation*

The conceptual development of Responsible Research and Innovation (RRI) started from questioning the "inherently good" progress of innovation (Godin, 2015). In general, it was accepted that innovation is the main driver of economic growth and competitiveness, thus it was highly promoted and supported by governments across different societies (Tidd, Bessant, 2009; Adams et al., 2016). The GMO permission in Europe demonstrated the case when a higher level of responsibility had to be involved in order to avoid negative consequences that it had after. This was the case when the negative consequences of innovation were witnessed due to a lack of detailed analysis on the holistic impact of GMO (Sutcliffe, 2013; Zwart, Landeweerd, and van Rooij, 2014). Innovation can have short-term benefits, but in the long-term, ethical or social dilemmas and unforeseen consequences of innovation can arise due to irresponsible application of innovation (Ribeiro et al., 2016). Similar cases inspired researchers under the EU Commission and in the academia to question possible positive and negative consequences that emerging technologies, like nanotechnologies, e-mobility, stem cell research, online social networks, biotechnology, dual-use robotics, nuclear technology, military and security technologies (Van den Hoven, 2013a) could have on society and the environment. Thus, the RRI concept is considered to be of crucial importance, since looking from "<…> the technological determinist view, emerging technologies will materialize anyhow, independent of what people think, deliberate and decide." (Swierstra, Rip, 2007, p. 7).

There is a wide range of RRI definitions but the most widely cited is by von Schomberg (2013), who defined 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 social desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)" (p. 9). Other popular definitions that bring together the most prominent perspectives on RI and the main elements are synthetically presented in Table 1.

On the basis of the presented RI definitions, the main characteristics of RI phenomenon are summarized in Table 2. The analysis of the most popular definitions suggests that one of the main distinctions of RI is its orientation *to mitigate the Grand Challenges* by collaborative initiatives (Von Schomberg, 2013). The concept of Responsible Innovation was driven by the need to mitigate the so-called "Grand Challenges" of our time, like water pollution, social inequality and discrimination, sustainable development, climate change, resource depletion, etc. (Lund Declaration, 2009, Von Schomberg, 2013). The Grand Challenges are caused by multiple and complex actions by different societal members. Since these global

problems are difficult to manage and mitigate, Grand Challenges are also referred to as "wicked problems" (Rittel, Weber, 1973). Grand Challenges demand "coordinated and sustained effort from multiple and diverse stakeholders toward a clearly articulated problem or goal" (George et al., 2016, p. 1881). This shift of innovation orientation towards Grand Challenges was reflected at the European level in the most important research programs like Horizon 2020 (European Commission, 2011).

**Table 1.** Definitions of Responsible (Research and) Innovation

| Author | Definition | Key elements |
|---|---|---|
| Sutcliffe (2011, p. 3) | *"1. The deliberate focus of research and the products of innovation to achieve a social or environmental benefit. 2. The consistent, ongoing involvement of society, from beginning to end of the innovation process, including the public and non-governmental groups, who are themselves mindful of the public good. 3. Assessing and effectively prioritizing social, ethical and environmental impacts, risks and opportunities, both now and in the future, alongside the technical and commercial. 4. Where oversight mechanisms are better able to anticipate and manage problems and opportunities and which are also able to adapt and respond quickly to changing knowledge and circumstances. 5. Where openness and transparency are an integral component of the research and innovation process."* | ▪ Social or environmental benefit of innovation<br>▪ Ongoing involvement of society<br>▪ Long-term assessment and prioritization of social, ethical and environmental impacts<br>▪ Openness and transparency |
| Von Schomberg (2011, p. 9) | *"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)."* | ▪ Mutual responsibility of societal actors and innovators<br>▪ (Ethical) acceptability, sustainability and societal desirability |
| Geoghegan-Quinn, (2012, p. 3) | *"Responsible Research and Innovation means that societal actors work together during the whole research and innovation process in order to better align both the process and its outcomes, with the values, needs and expectations of European society."* | ▪ An alignment of societal values, needs and expectations with research and innovation |
| Grunwald (2011, p. 26) | *"RRI is an 'umbrella term' characterized by:*<br>*- involving ethical and social issues more directly in the innovation process by integrative approaches to development and innovation,* | ▪ An integration of ethical and social issues in the innovation process<br>▪ Responsibility reflection regarding |

| | | |
|---|---|---|
| | *- bridging the gap between innovation practice, engineering ethics, technology assessment, governance research and social sciences (STS)*<br>*- giving a new shape to innovation processes and to technology governance according to responsibility reflections in all of its three dimensions [governance, moral and epistemic],*<br>*- in particular, making the distribution of responsibility among the involved actors as transparent as possible, supporting "constructive paths" of co-evolution of technology and the regulatory frameworks of society."* | all levels of innovation process<br>■ Distribution of responsibility among the involved actors |
| Van den Hoven (2013b, p. 82) | *"Responsible Innovation is an activity or process which may give rise to previously unknown designs either pertaining to the physical world (e.g. designs of buildings and infrastructure), the conceptual world (e.g. conceptual frameworks, mathematics, logic, theory, software), the institutional world (social and legal institutions, procedures and organization) or combinations of these, which when implemented expand the set of relevant feasible options regarding solving a set of moral problems."* | ■ New solutions to solve moral problems |
| Stilgoe et al. (2013, p. 1570) | *"Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present."* | ■ Collective responsibility towards the future |
| Stahl (2013, p. 5) | *"RRI is a higher-level responsibility or meta-responsibility that aims to shape, maintain, develop, coordinate and align existing and novel research and innovation-related processes, actors and responsibilities with a view to ensuring desirable and acceptable research outcomes."* | ■ Higher-level responsibility regarding research and innovation |
| Wilford (2015, p. 348) | *"RRI creates a step-change in the way that those who are engaged in research and innovation should consider the impact of what they do."* | ■ Researchers' and innovators' reflection regarding their actions. |

A *more responsible innovation process* is another emphasized characteristic in the main course of definitions (Sutcliffe, 2011; Von Schomberg, 2011; Van den Hoven, 2013a). Responsibility is expressed by openness and transparency that "are an integral component of the research and innovation process" (Sutcliffe, 2011, p. 3), interaction and inclusion of a wider range of stakeholders with whom actors are "taking care of the future through collective stewardship of science and innovation in the present" (Stilgoe et al., 2013, p. 1570).

Another important element of RI in the presented definitions is the dimension of *norms* expressed by "assessing and effectively prioritizing social, ethical and

environmental impacts" (Sutcliffe, 2011, p. 3), thus making both the innovation process and products (ethically) acceptable, sustainable and socially desirable (Von Schomberg, 2011).

In fact, *responsibility* is one of the main characteristics that distinguishes the RI concept from other similar concepts (Grunwald, 2014), such as sustainable innovation and social innovation (Lubberink et al., 2017[1]). Although ideas about responsibility in the innovation process are not new, "the major novelty and practical relevance of RI is in integrating existing approaches and in making an explicit link between innovation and responsibility" (Genus, Iskandarova, 2017, p. 2). Responsibility mostly refers to the need to mitigate the Grand Challenges so that the future generations can live in a better world (Von Schomberg, 2013; Burget, Bardone, and Pedaste, 2017) and assess the uncertainty of an innovation and its possible (negative) consequences for society and the environment (Stilgoe et al., 2013; Von Schomberg, 2013).

**Table 2.** Main characteristics of RI phenomenon (Authors own elaboration)

| Characteristic | Description | Authors |
|---|---|---|
| *Grand Challenges* | Address the Grand Challenges (water pollution, social exclusion, health issues, ageing society, etc.) *during the innovation process* | Owen et al. (2013); Von Schomberg (2013); Sutcliffe (2013); European Commission (2012) |
| *Socio-ethical issues* | Socio-ethical issues *throughout the innovation process* in a way that enhances the societal embeddedness of innovations | Sutcliffe (2011); Von Schomberg (2011); Laroche (2013); Owen et al. (2013); Van den Hoven (2013b) |
| *Democratic innovation process* | More inclusive, democratic, transparent and reflexive *innovation process* that engages with "questions of intent" in research and innovation | Von Schomberg (2011); Sutcliffe (2013); Ribeiro et al. (2016) |
| *Stakeholder engagement* | Inclusion of all the related stakeholders from the ideation phase of an *innovation process* to ensure plural perspectives | Geoghegan-Quinn (2012); Von Schomberg (2013); Guston (2013); Owen et al. (2013) |
| *Mutual/collective responsibility* | Collective commitment and efforts to take care of the future | Von Schomberg (2011); Grunwald (2012); Stilgoe et al. (2013); Grinbaum and Groves (2013) |
| *Meta-responsibility* | Encouraging innovators to take additional steps and actions during *the innovation process* | Stahl et al. (2013); Owen et al. (2013); Grinbaum and Groves (2014) |
| *Positive innovation process and its outcomes* | (Ethically) acceptable, sustainable and socially desirable *innovation process and its outcomes* | Von Schomberg (2013); Stahl (2013); Wilford (2015) |

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[1] For a detailed overview of conceptual overlaps and differences between the concepts, see Lubberink et al. (2017)

Specifically, *socio-ethical responsibility* in research and innovation development is emphasized. As Von Schomberg (2013) notes, the socio-ethical responsibility should be understood in a positive manner, meaning that responsibility should be understood not as a constraint, but rather as "an incentive to open up alternative research and development trajectories" (p. 19). Thus, the central axis of the concept of RI is responsibility and potential activities that would lead to maximum positive and minimum negative outcomes of innovation.

Furthermore, from the literature analysis on RI, it could be stated that there are two dominant approaches towards achieving RI: the first approach emphasizes the role of norms required in order to achieve RI (Von Schomberg, 2013), and second approach is related to the emphasis on the "right" innovation process, assuming that the responsible innovation process will lead to more responsible outcomes (Stilgoe et al., 2013; Ribeiro et al., 2016).

In conclusion, a systematic and comparative literature analysis revealed that the concept of *Responsible Innovation is understood as a democratic, inclusive and transparent innovation process during which organizations address issues related to Grand Challenges, engage with their stakeholders and collectively seek to come up with innovations that have a positive added value for the society and environment*.

### 1.1.2. *Responsible Research Innovation and Responsible Innovation*

As it could be noted in the literature, "Responsible Research and Innovation" (RRI) and "Responsible Innovation" (RI) are used interchangeably. However, there should be a clear distinction between the two terms. It is important to separate *research* and *innovation* since these concepts mean different processes with different actors involved (Long, Blok, 2018).

Regarding *RRI* and related processes, *research* is focused on generating new knowledge, whereas innovation is mostly focused on commercializing new/existing knowledge or inventions. Moreover, there are differences regarding the aim of the research itself. According to Pelle and Reber (2013), the research could be focused on 1) making innovative processes or products available on the market or 2) assessing the potential impacts of innovative process or products. Regarding the involvement of stakeholders in research, the laboratories and research centers of universities/institutions are usually the main actors who drive research. In general, research is mostly financed by governments (Dreyer et al., 2017) and it takes a longer time to do research than innovation. Eventually, the level of responsibility differs in relation to whether the research was behind the innovation processes or whether it was done in order to assess medium and long-term consequences of innovation (Pelle, Reber, 2013).

With regards to *RI*, the focus should be shifted to *innovation* and its commercialization aspects. According to the Organization for Economic Co-operation and Development (OECD, 2015), innovation is defined as "the implementation of new or significantly improved goods or services, or a process, a new marketing method, or a new organizational method in business practices, workplace organization, or external relations" (p. 46). It is important to add that innovation has to create a value for which customers are willing to pay. Thus,

innovation is usually driven by for-profit organizations in the industry. As Owen et al. (2013) note, innovation should be regarded as a non-linear process which involves different or even loosely-connected actors. Thus, Responsible Innovation concerns decision making and behavior during innovation process in commercial settings, where socio-ethical issues should be taken into account from the very ideation phase of innovation and a wider range of stakeholders should be integrated into the decision-making during innovation development. *Thus, the focus of this study is on Responsible Innovation in relation to innovation implementation in business contexts*.

### 1.1.3. *Evolution of Responsible Innovation and Related Concepts*

RI draws on a variety of existing disciplines like science and technology studies (STS), Corporate Social Responsibility, Sustainable Development, etc., but RI mainly evolved from STS and its approaches to Constructive Technology Assessment (CTA) (Schot, Rip, 1997), Ethical, legal and social aspects (ELSA); and engineering ethics (Value sensitive design) (Van de Poel, 2009; Van den Hoven, 2014). However, the exponential growth of interest in RI shows that the concept goes beyond the aforementioned concepts by adding valuable elements (Timmermans, Stahl, 2013). A summary of the relative concepts to RI and main aspects lacking with a view to Responsible Innovation are presented (Table 3).

Coming from STS, there were few methods established to assess technology: Constructive Technology Assessment (CTA), Real-Time Technology Assessment (RTA), value sensitive design and risk assessment tools. The basis for all these TA approaches is impact assessment, forecasting, scenario development and consensus conferences with the related stakeholders (Pelle, Reber, 2013). The problem of these approaches lies in the selection of the stakeholders involved in the process of monitoring science and technology (Ladikas, 2009). In general, most of the studies related to the responsibility in research and innovation in STS are focused on the governance of science and research at the macro level.

Thus, the concept of RI "furthers the tradition which originated in bioethics, in ethical committees focused on various technologies (biomedicine, ICT) and in technology assessment (TA) practices." (Pelle, Reber, 2013, p. 5). In comparison with STS, RI adds an explicit link between innovation and responsibility expressed by ethical reflection (Grunwald, 2011, 2014; Grinbaum, Groves, 2013) meaning that RI is framed as "a responsibility for society at large, with closer attention to societal context and a broader spectrum of actors capable of reflecting on their own values and research and innovation-related responsibilities" (Genus, Iskandarova, 2017, p. 2).

Corporate Social Responsibility is another concept closely related to RI. On the contrary than RI, CSR was a broad definition and remains the object of a good image of a company that is mostly related to financial performance. Also, CSR has been criticized for "greenwashing", thus there is an opinion in society that CSR is related to outside activities of the firm like tree-planting, visiting children houses, etc.

**Table 3.** Comparison of RI and related concepts

| Concept | Reason of origin | Shortcomings | Authors |
|---|---|---|---|
| *CSR* | *Social* responsibility of a businessman | ▪ Understood in a consequentialist way<br>▪ Overly optimistic vision of knowledge and rationality<br>▪ Reduced compliance with existing norms<br>▪ Co-construction in relation to the context is missing | Timmermans and Stahl (2013); Pelle and Reber (2013) |
| *Sustainable development* | Preservation of *natural resources* | ▪ Focus on ecological aspects mostly<br>▪ Too conformist in a sense that rests on the idea to preserve nature instead of questioning the existing norms<br>▪ Seen as an economic opportunity for a business to develop sustainable solutions<br>▪ Lack of orientation towards the future generation | Pelle and Reber (2013); Franceschini, Faria, and Jurowetzki (2016) |
| *Social Innovation* | Solve *social* problems | ▪ Focus on social problems only | Lubberink et al. (2017) |
| *Technology Assessment* | To scientifically assess *new technologies* | ▪ A dominant role of experts in consensus conferences<br>▪ The problem of efficiency of the norms settled during the process and with the conditions for enabling the required changes | Pearson et al. (2016); Pelle and Reber (2013) |
| *ELSA* | Ethical, legal and social aspects of *emerging sciences and technologies* | ▪ Refers to the research only | Pelle and Reber (2013); Zwart et al. (2014) |
| *Open Innovation* | To use external ideas in order to *enhance technology* | ▪ An insufficient degree of transparency during the innovation process and the breadth of stakeholder inclusion<br>▪ A lack of orientation towards sustainable and socio-ethical innovation outcomes | Blok and Lemmens, (2015); Long and Blok (2018) |

RI goes beyond CSR in encouraging to integrate societal expectations and needs into the innovation process; whereas CSR considers general societal impacts and it is not necessarily integrated into the innovation process (Iatridis, Schroeder, 2016; Lubberink et al., 2017). In the case of innovation, CSR only requires firms to comply with the existing standards, i.e. reactive action is satisfactory. In the case of

RI, firms are encouraged to anticipate possible negative consequences of innovation thus promoting the proactive reaction of a firm regarding innovation (Groves et al., 2011). In conclusion, CSR is regarded as the basis for RI, but it does not cover all other aspects that RI involves (Pelle, Reber, 2013).

Other concepts related to RI are Social Innovation and Sustainable Development. Social innovation mostly focuses on social needs and problems that are not met by governments (Mulgan et al., 2007). Sustainable innovation is mostly related to climate issues and is usually seen as a business profit opportunity to develop sustainable solutions (Franceschini, Faria, and Jurowetzki, 2016). Also, according to Pelle and Reber (2013), "sustainability relies on existing norms of preservation, [while] RRI aims at shaping the way we innovate and create new things and new ideas, taking into account the ways norms are considered and assessed" (p. 6, addendum by author).

Circular economy (CE) is another related concept oriented towards sustainability, where materials circulate in a closed-loop (Geissdoerfer et al., 2017). However, CE represents an innovation system and can be thus a very useful context for RI, as well as for Cradle-to-Cradle (C2C). C2C offers a new perspective to the design and development of innovation by rethinking materials and processes leading to more sustainable solutions (Drabe, Herstatt, 2016). The exact connection of RI (as well as C2C) and CE is that RI can provide responsible innovation management at the actor level, which can then be elaborated at a systemic level thus facilitating CE.

Ethical, legal and social aspects (ELSA) and RI share similar terminology and goals in the political project (Zwart et al., 2014); however, ELSA is directed to examine ethical, legal and social aspects of research only. In addition, ELSA was mostly concerned with the public sector (Pelle, Reber, 2013).

Open innovation (OI) is another concept related to RI. Open innovation is defined as "<…> a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology." (Chesbrough, 2003, p. xxiv). OI and RI share the integration of stakeholders into the co-construction of innovation thus requiring transparency towards knowledge sharing with stakeholders. According to the literature review in relation to overlaps and differences between RI and OI by Long and Blok (2018), OI differs from RI in terms of "transparency present in the innovation process, the breadth of stakeholder inclusion, and in the outcomes sought." (p. 8). The issue of OI is that firms follow the common business network logic and tend to involve supply chain actors, based on their value added in innovation processes (both, public and private), while non-economic stakeholders remain to be of lower importance in responsible innovation processes (Blok, Lemmens, 2015). A similar tendency can be seen in the innovation process, where mainly technological and commercial issues are considered in order to gain competitiveness, and socio-ethical aspects are given less importance.

In summary, RI contains most of the main features of related concepts thus making RI a very broad concept. However, the main distinction of RI compared to other related concepts are the responsibility aspect and the major role of norms playing at different levels of RI. As a concept, RI is inherently normative (Lindner

et al., 2016) and oriented to mitigate the Grand Challenges together with stakeholders during the democratic, inclusive and transparent innovation process.

### 1.1.4. *Analysis of responsibility approach for Responsible Innovation*

The initial motive for the development of RI concept started out of "irresponsible" cases such as GMO or rapid emergence of nanotechnologies. Irresponsibility in these cases was frequently seen as "organized irresponsibility" (Beck, 1992), meaning that responsibility is shared among different societal actors responsible for research and innovation development. Such shared responsibility is understood as fragmented responsibility (Beck, 1992), where in the case of a failure, no particular person would be blamed for it (Bovens, 1998).

In the business sector, irresponsible innovation would be considered as "a product, service or business model that causes a new social or environmental problem or worsens an existing one." (Halme, Korpela, 2014, p. 548). For example, Space tourism due to high energy consumption or a touch-phone screen development using scarce raw materials is considered as irresponsible innovations (Halme, Korpela, 2014). A detailed example of irresponsible innovation is given by Inzelt and Csonka (2017, p. 64):

> "A relevant example is the Volkswagen diesel scandal, which illustrates perfectly why responsible research and innovation (RRI) is a concern for the business sector. The company had used a software code to mislead US testing procedures for nitrogen oxide simply to achieve more turnover and profit on the US market.1 The cars incorporated serious technical knowledge and had many innovative elements, but unresolved technical problems were disguised by software designed to deceive. So, the product as a whole epitomized irresponsible innovation."

Thus, the analysis of irresponsibility requires to define responsibility in the business sector. To start with, "responsible" comes from a Latin word *respondere* and means "to account for decisions" (Pavie et al., 2014, p. 8). According to Groves and Grinbaum (2012), responsibility consists of accountability, answerability and liability.

In RI literature, responsibility has a broad meaning. According to the literature review done by Lindner et al. (2016), RI scholars (Von Schomberg, 2013; Van den Hoven, 2013b; Owen, 2014; Forsberg et al., 2015) share a similar understanding of responsibility via the following aspects:

- *Prospective responsibility*. RI is oriented to not only sanction or prevent the negative consequences of innovation but also to manage the innovation process in accordance with societal values.
- *Proactive responsibility*. The aim of RI is to go beyond the existing legal regulations and anticipate the possible consequences of innovation and to use it as a positive driver for developing new innovative solutions that can better serve societal needs.
- *Collective responsibility*. The research and innovation development is understood as a process with shared roles and functions of different

stakeholders. The collective research and innovation governance process should lead to more ethically acceptable, socially desirable and sustainable outcomes.

- ▪ *Plural responsibility*. In RI, responsibility takes place in different dimensions, such as political, legal, ethical, and economic.

The analysis of responsibility dimensions suggests that responsibilities in RI go beyond the standard understanding of individual responsibility. In their empirical research, Timmermans et al. (2017) show that "traditional theories of responsibility tend to focus on individual instances of responsibility. While valuable for understanding responsibility, such individualistic theories fail to reflect the complex and multifaceted reality of modern research and innovation ecosystems." (p. 2). Thus, a holistic or networked responsibility approach to RI is required, since the very nature of RI concept is towards mutual responsibility (Von Schomberg, 2013). In this regard, Stahl et al. (2017) suggest the concept of *meta-responsibility* "that aims to shape, maintain, develop, coordinate and align existing and novel research and innovation-related processes, actors and responsibilities with a view to ensuring desirable and acceptable research outcomes." (p. 708). On the basis of meta-responsibility, Timmermans et al. (2017) developed a theoretical model of "networks of responsibility" defined as "sociotechnical ensembles that are enacted by a multitude of actors" (p. 8). In their research, the interconnected nature of different actors with regard to RI is reflected and the notion of networked responsibility is used to describe the multiple, reciprocal, or overlapping responsibilities between different actors of society.

**Responsibility in the business sector.** Since the aforementioned responsibilities and the concept of meta-responsibility were suggested in the public sector, there is a need for responsibility analysis in the business sector and to see how meta-responsibility could be understood in the business sector. In the context of RI at the firm level, responsibility is being studied in the following dimensions: *legal, contractual and moral* (Wickson, Carew, 2014; Iatridis, Schroeder, 2016; Dreyer et al., 2017).

*Legal responsibilities* are "based on laws and a jurisprudence providing a framework of obligations, but which is dependent on the laws applicable within a specific jurisdiction, e.g., a particular country." (Dreyer et al., 2017, 11). Pavie, Scholten and Carthy (2014) define legal responsibilities as a first (the establishment of firm and legal relationships with its stakeholders like employees, managers, suppliers, etc. at the same time) and second level of responsibility in the business context. The second level of legal responsibilities concern the relationship with society, like paying taxes. Legal responsibilities also consist of product liability aspects such as negligence, various defects, warranty, etc., as well as being transparent regarding the product and its possible negative impacts (Dreyer et al., 2017; Iatridis, Schroeder, 2016).

*Contractual responsibilities* in industrial contexts concern mutual obligations that depend on the agreement of two or more parties. According to Pavie et al. (2014), contractual responsibilities are regarded as third-level responsibilities that include interactions with external stakeholders (like suppliers, subcontractors,

institutions). At this responsibility level, a firm faces responsibility towards commitments, contractual and legislative relationships (Pavie et al., 2014). There is more room for interpretations regarding the contractual responsibilities, but still, the responsibilities of the parties are quite clear and can end up with penalties where a breach occurs (Dreyer et al., 2017).

*Moral responsibilities* are based on the value system and mostly depend on a cultural context. Moral responsibilities are open to interpretations since they are embedded in different societal contexts and norms, industries, etc. (Dreyer et al., 2017). Moral responsibilities could be regarded as fourth-level responsibility towards future generations (Pavie et al., 2014) in relation to mitigating the Grand Challenges. In RI studies, the analysis of moral responsibilities is dominating.

However, in RI studies legal and contractual responsibilities are mostly excluded. RI scholars seem to focus on the importance and elaboration of moral responsibility, thus excluding other types of responsibilities, i.e. legal and contractual that are of high importance in the business context. The theorization and application of moral norms were mostly focused on research and emerging technologies, i.e. in the contexts of academia and the public sector. According to Garst et al. (2017), this could be due the non-commercial research and innovation as a main field of research by RI scholars.

In the literature on RI in public, there are some attempts to combine all levels of responsibility due to the growing interest in practical evaluation of RI. Wickson and Carew (2014), for example, made a typology of RI by classifying it into four levels: 1) exemplary, 2) great, 3) good, and 4) routine. Every level consists of processes and practices that indicate a certain level of RI. Although the criteria mapping for RI is oriented towards the evaluation and funding of projects in the context of public policy, the classification itself combines different types of responsibilities, such as legal, contractual and moral, in order to achieve an exemplary level regarding RI. The need to integrate both legally prescribed procedures and informal interactions for stakeholder inclusion in the public policy context is also emphasized in Cuppen's et al. (2015) research. This confirms the need to integrate different types of responsibilities when understanding RI.

Inspiration also comes from CSR studies that tend to integrate various responsibilities in the industrial context (Garst et al., 2017), where "being socially responsible means operating in a way that meets or exceeds society's ethical, legal, and public expectations" (Gómez-Bezares, Przychodzen, and Przychodzen, 2016, p. 4). Another reason for integrating legal and contractual responsibilities into the whole RI concept is that sometimes legal and contractual responsibilities can be of a lower level in emerging markets compared to developed countries (Hadengue et al., 2017). In this case, firms have different legal and contractual responsibilities in different societal contexts.

In order to employ the networked responsibility approach, there is a need to integrate all levels of responsibility in the business context. From the networked responsibility perspective, a firm has to approach the responsibility criteria from various stakeholders' perspectives, include internal and external stakeholders, and execute innovation in a mutually responsible way.

## 1.2. Conceptual dimensions of Responsible Innovation

On the basis of the analysis of RI concept and its key elements conducted in section 1.1.1., two main dimensions of RI for further analysis are distinguished: 1) *RI as a normative goal* and 2) *RI as a normative innovation process* (see Figure 1) and each dimension is analyzed in further sections.
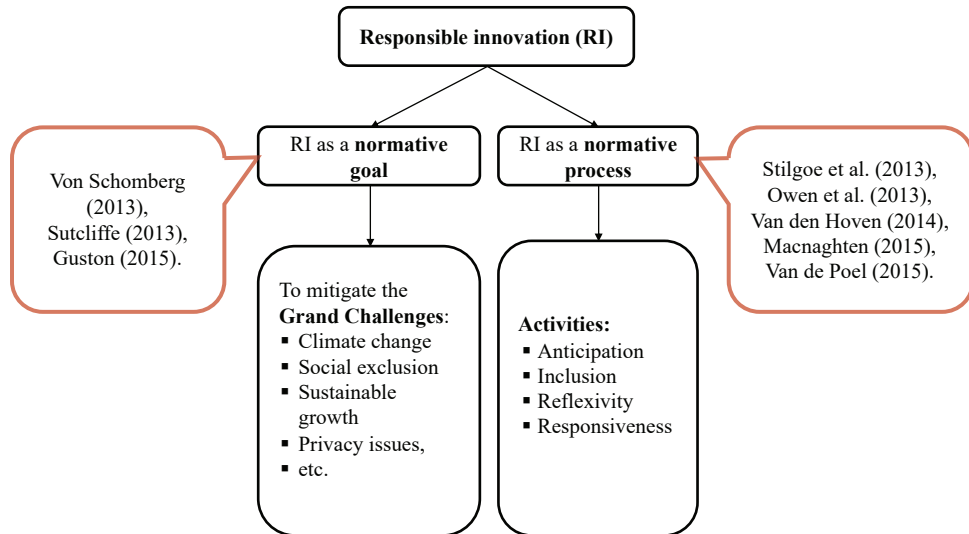


**Figure 1.** The conceptual distinction in research on Responsible Innovation

### 1.2.1. *Responsible innovation as a normative goal*

RI as a normative goal is associated with the assumption that the incorporation of right values and norms leads to responsible outcomes of innovation. Normative goal is mostly related *to mitigate the Grand Challenges*, but it is also complemented with the *compliance with existing formal norms* like standards, institutional regulations and laws. The main idea here is that the establishment of a normative goal in the ideation phase of innovation leads to more responsible outcomes of innovation.

Although Grand Challenges play a key role in defining the normative orientation of innovation (Von Schomberg, 2013), the importance of compliance with the legal responsibilities and integration of established values in policy documents remains. In fact, RI scholars agree that the first step towards RI is compliance with the existing standards and laws (Von Schomberg, 2013; Owen et al., 2013). Some scholars put emphasis on the compliance with normative values that are grounded in policy documents like EU Treaties, Human Rights declaration (Von Schomberg, 2013), meaning that norms are defined by the geographical location like EU. Thus, the legal responsibility of the organization is the basis for further development of RI (Pavie et al., 2014; Petraite et al., 2017) and compliance with the defined norms in the EU continent.

However, since direct integration of norms could be enforced via standards or institutional regulations, the problematic aspect of formal norms and laws is that when new knowledge occurs, institutional regulations must be adapted (Grunwald,

2011). Usually, institutional actions take longer time. Thus, in some cases formal norms and institutional regulations are inefficient as it takes time to change them, thus it is important to come up with common values that would lead the innovation process. Thus, there is a need to find other ways to understand and reinforce norms that define the behavior of the firm regarding RI.

The normative approach to RI is mostly associated with the research from STS, business ethics and philosophy of management. There is a distinctive emphasis on norms coming from STS scholars, who also shaped the concept of RI conducting research projects on RI development. Researchers from STS mostly focus on the importance of ethics specifically in the development of emerging technologies.

### 1.2.2. *Responsible innovation as a normative process*[2]

*RI as a normative process* stresses the importance of normative innovation process itself and states that it leads to responsible outcomes (Owen et al., 2013). In RI literature, the normative process of RI consists of *activities* like anticipation, the inclusion of and deliberation with stakeholders, reflection, and responsiveness (Owen et al., 2013) as well as tools applied during the innovation process. Stakeholder inclusion is considered to be one of the key features of the normative process leading to RI (Stilgoe et al., 2013).

*Norms associated with the innovation process and routine activities*. The normative approach towards responsible innovation process is expressed via ethical acceptability, social desirability and sustainability (Von Schomberg, 2013). The innovation process itself should "right" by being democratic, transparent, interactive, responsive to actors (Von Schomberg, 2013). STS scholars suggest embedding ethics in innovation development (Grunwald, 2011). *Routine activities* in an organization are expressed via anticipation, reflexivity, inclusion (and deliberation), and responsiveness (Stilgoe et al., 2013; Owen et al., 2013) and are analyzed in further sections.

*Norms associated with the application of tools.* In RI literature, the application of specific tools is considered as a way to achieve the normative goals of RI. There were attempts to transfer existing tools into RI, for example, Risk Assessment (Owen, Goldberg, 2010; Van den Hoven, 2013a), Technology Assessment (TA) (Grunwald, 2014; Schot, Rip, 1997), Ethical-constructive technology assessment (Kiran et al., 2015), Foresight activities in addressing Grand Challenges (Cagnin, Amanatidou, and Keenan, 2012), Traditional Ethical, Legal, Societal Implications (ELSI) evaluation (Van den Hoven, 2013a), Value sensitive design (Van den Hoven, 2013b), design thinking (Pavie, Carthy, 2015), Early (upstream) engagement (Fisher, Mahajan, and Mitcham, 2006), Multi-stakeholder involvement (Von Schomberg, 2013), Stakeholder engagement (Blok et al., 2015), Codes of conducts (Grunwald, 2011; Van den Hoven, 2013a; Von Schomberg, 2013).

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Most of the tools are incorporated into the main RI activities developed by Stilgoe et al. (2013), thus there is an overlap between activities and tools (see Figure 2). Furthermore, there are fundamental differences in relation to sectors: in the public sector there is an innovation governance perspective, whereas in a business context, innovation is an individual process (Dreyer et al., 2017). Due to differences in sectors, there is a need to operationalize the innovation process and RI activities for the business sector. In the following sections, the approach for innovation process in this study is presented, followed by examining the application of RI activities in the firm's innovation process.

**Innovation process at the firm level.** Most of the practices or activities suggested for developing RI were developed by researchers and policymakers (Burget et al., 2017) who did not differentiate between research, development and commercialization (Lubberink et al., 2017). Hence, there is a need to firstly analyze the innovation process in the business sector and adapt the existing RI activities within the business sector accordingly. The role of norms is discussed in each RI activity.

There are several possibilities to conceptualize the innovation process, but mostly the terminology depends upon the industry (Dreyer et al., 2017). Considering the New product development process, innovation funnel (Hayes, Wheelwright, and Clarke, 1988; Tidd, Bessant, and Pavitt, 2001) is an adopted practice. In specific sectors like pharmaceuticals and medical engineering, the innovation process is differentiated into pre-clinical research, clinical development, regulatory review, and post-market safety monitoring (FDA, 2015).

Innovation stage gate model (Cooper, 2008) is also being used to conceptualize the RI process. RI studies in public (Macnaghten, Owen, 2011) and private (Blok et al., 2015) contexts applied the stage gate model because of the "gates" that highlight the specifics of decision-making in every stage including innovation launch with regard to the progress made and actual work on innovation to be done. Blok et al. (2015) applied a three-stage framework in the study of RI in the private sector: first phase (discovery and scoping stages), middle phase (business case and development stages), and third phase (testing and validation, and launch stages). Similarly, in this study, input, throughput, and output are used for RI analysis in the business context. This approach allows to minimize possible deviations caused by the individual innovation process design within a single firm.

*Input*, also called the innovation idea generation phase. During this stage, the identification of the issue and exploration of potential solutions are made. The uncertainty and various unknown aspects regarding the project idea are dominant in this stage. Therefore, this stage can also lead to developing or killing the project idea (Dreyer et al., 2017). According to RI literature (Von Schomberg, 2013), during this stage, all related stakeholders should be integrated into the firm's ideation stage in order to anticipate the possible risks of innovation. In reality, however, the wider society is usually integrated into the very last stage before the commercialization of innovation (Blok et al., 2015), thus stakeholders usually do not have any possibilities to express their opinion towards innovation by approving or contesting the innovation idea.

**Anticipation** is used to reduce the uncertainty of innovation by asking the questions "what if?", trying to forecast what possible (negative) consequences innovation could have. The anticipation when including stakeholders could help to forecast the future risks, benefits, side effects, and other issues of innovation.

*Tools*: foresight, technology assessment, horizon scanning, scenario development, vision assessment, socio-literary techniques.

**Inclusion** is about including different stakeholders representing different groups of society into the innovation process. The purpose of inclusion as a principle is not a single, but a consistent process of participation in the whole development of innovation.

*Tools*: citizen's juries and panels, brainstorm events, focus groups, partnerships, co-creation or crowd-sourcing initiatives, user-centered design, open innovation.

**Reflexivity** is crucial from the very beginning of new product development by reflecting on innovation activities in order to avoid detrimental impacts of innovation.

*Tools*: multidisciplinary collaboration and training, ethical technology assessment, codes of conduct, moratoriums.

**Responsiveness** is understood as a necessity to respond to new knowledge and norms.

*Tools*: regulation, standards, niche management, feedback system, value-sensitive design moratoriums, stage-gates.

**Figure 2.** Overview of the overlap of the original RI activities and tools (Adapted from Stilgoe et al., 2013)

The *throughput* stage includes research, development, and engineering (Tushman, 1977). During this phase risk management plays a key role, thus benefits, risks and value both for the company and society have to be clearly stated at the end of this process (Dreyer et al., 2017). In parallel with RI, the need to include wider society into the development phase is required in order to align innovation with the society's expectations.

The *output* phase consists of R&D, manufacturing, market tooling up, coordination, and administration of the new product (Tushman, 1977). During this stage, it is important to focus on the value for the society. Compliance with regulations and standards of the product must be ensured during the implementation stage. At the end of this stage, a product is usually launched (Dreyer et al., 2017). Regarding RI, the feedback from the stakeholders is important in the way that if the

innovation violates any socio-ethical and/or environmental aspects, it should be considered for modification or eliminated from the market.

**Responsible Innovation activities at the firm level.** According to the literature review done by Burget et al. (2017), the most dominant framework defining the conceptual dimensions related to RI activities is the one established by Stilgoe et al. (2013). Based on the geoengineering project in the public sector, Stilgoe et al. (2013) crystallized four activities that were originally called dimensions: anticipation, reflexivity, inclusion (and deliberation), and responsiveness. Each activity raises its own specific questions that could help to assure those innovative ideas are examined in a broader and a more responsible manner. These activities are being used in RI literature as the main dimensions of activities to achieve more responsible innovation (Burget et al., 2017). This thesis presents each activity and operationalizes them for the business sector. On the basis of this analysis, the main RI activities, their descriptions and advantages for firms are presented below (see Table 4).

*Anticipation* is defined as involving "systematic thinking aimed at increasing resilience while revealing new opportunities for innovation and the shaping of agendas for socially-robust risk research" (Stilgoe et al., 2013: 1570). Anticipation is regarded as a starting point to begin with the RI process (Owen et al., 2013; Van den Hoven, 2013a), while Sutcliffe considers the whole concept of RRI as "trying to get better at anticipating problems" (p. 5).

**Table 4.** RI activities, their descriptions and advantages in the business context

| RI activities | Description | Advantage | References |
|---|---|---|---|
| *Anticipation* | • anticipating possible (negative) consequences of innovation<br>• scenario thinking with the firm's stakeholders | ➢ awareness of possible future legislation<br>➢ first mover advantage | Stilgoe et al. (2013); Pavie et al. (2014); Wiek et al. (2016); Timmermans et al. (2017) |
| *Reflexivity* | • reflecting on innovation activities<br>• formal evaluations<br>• third-party critical appraisals<br>• informal (self-) assessment culture | ➢ increased quality and success of an innovation | Long and Blok (2018); Lubberink et al. (2017) |
| *Responsiveness* | • respond to new information and knowledge<br>• change innovation upon the stakeholders' feedback | ➢ increased trust and corporate image regarding stakeholders | Lubberink et al. (2017); Long and Blok (2018) |

By investigating various scenarios of what consequences innovation can have, the uncertainty of innovation reduces (Barben et al., 2008; Owen, Macnaghten, and Stilgoe, 2012). The main aim of anticipation is to shape innovation to the right direction while forecasting possible scenarios of (possible negative) outcomes of innovation (Lubberink, et al., 2017). Anticipation is used to reduce the uncertainty of innovation by asking the questions "what if?", trying to forecast what possible (negative) consequences innovation could have after commercialization, and apply scenario thinking (Stilgoe et al., 2013; Long, Blok, 2018). The anticipation with the stakeholders included could help to forecast the future risks, benefits, side effects, and other issues of innovation (Wiek et al., 2016). This is regarded as a useful tool for managers to anticipate the possible consequences of innovation, although it is sometimes difficult to do this in a comprehensive way (Pavie et al., 2014). In their empirical study, Timmermans et al. (2017) found that anticipation together with the involvement of stakeholders helps firms "to anticipate and influence the contents of future standards but even may prevent standards from becoming mandatory, for example, by becoming (part of) formal regulation." (2017, p. 19). This can lead a firm to gain a first-mover advantage by adjusting the innovation to the future market.

*Reflexivity* is determined as an institutional and scientific practice, which is "holding a mirror up to one's own activities, commitments and assumptions, being aware of the limits of knowledge and being mindful that a particular framing of an issue may not be universally held" (Stilgoe et al., 2013, p. 1753). In RI literature, reflexivity consists of first and second order reflexivity. First-order reflexivity is regarded when "responsible actors are supposed to identify key ethical issues as a list of problems to be watched and/or answered." (Pelle, Reber, 2013). First-order reflexivity reflects the collective understanding of a problem and possible solutions applied (Pelle, Reber, 2013). Although researchers in RI claim first-order reflexivity is not sufficient for RI, nevertheless, first-order reflexivity raises the issues of innovation and this is a first required step towards second-order reflexivity, where those issues are assessed (Grunwald, 2012, Guston, 2013). Second-order reflexivity is considered as "the capacity of actors to identify the various effective possibilities on which the operation of the selection of the norm will be carried out" (Pelle, Reber, 2013). Reflexivity is an activity, during which innovators scrutinize their own activities, commitments and assumptions, being aware of the limits of knowledge and that their own reality could be not universally held (Stilgoe et al., 2013). Reflexivity is crucial from the very beginning of the new product development by reflecting on innovation activities, compliance with the standards, etc. in order to avoid detrimental impacts of an innovation (Laroche, 2011).

In the public sector, reflexivity is increased via public dialogue with a wide range of stakeholders (Flipse et al., 2013). Regarding the academia, collaboration between scientists and society is considered to be the key component of reflexivity (Ribeiro et al., 2016): integrated stakeholders may foster researchers to reflect on socio-ethical aspects of science (Ribeiro et al., 2016) thus leading to active reflexivity (Stilgoe et al., 2013).

Reflexivity in the business context usually takes place after the product's launch. However, in the case of RI, reflexivity should be applied from the very

ideation phase and thus could reduce the possible failure of the new product (Lubberink et al., 2017). Reflexivity in the firm could be supported by applying formal evaluations, third-party critical appraisal, informal (self-) assessment culture, and so forth (Long, Blok, 2018).

*Inclusion* as an RI activity is about including different stakeholders representing different groups of society into the innovation process (Stilgoe et al., 2013). Stakeholders are groups or individuals that are affected or can make an impact on the organization's activities (Freeman, 1984). Stakeholder inclusion is one of the most frequently applied concepts in RI studies (Ribeiro et al., 2016). Due to a highly linked nature of RI to stakeholders, the analysis of stakeholders and their inclusion methods into the innovation process was widely examined.

Stakeholder inclusion is primarily focused to anticipate and evaluate different ways of how emerging technology could be "socially embedded" in society. Inclusion of various stakeholders is important in offering more opportunities to solutions in dealing with the Grand Challenges (Cagnin et al., 2012) while exposing different or even opposing opinions and combining contrasting interests. RI literature emphasizes the need for related stakeholders and wider public involvement in innovation development from the very ideation phase (Stilgoe et al., 2013). The purpose of inclusion as a principle is not a single, but a consistent process of participation in the whole development of innovation (Stilgoe et al., 2013). The main argument is that in most of the cases, society does not have an opportunity to participate in real-time innovation development (Laroche, 2011). According to Stahl et al. (2013), systematic inclusion is the right approach to integrate various actors of society with different contexts and knowledge, or sometimes even opposing opinions, when seeking the common consensus regarding the new innovation.

The literature review on stakeholder inclusion suggests that there should be a differentiation between public and private sectors. This relates to the discussion of the needed distinction between "responsible research and innovation" and "responsible innovation". Due to differing formal and informal norms, socio-cultural contexts play a major role in evaluating potential societal challenges of technologies (Douglas, Stemerding, 2013). The sector plays a major role in stakeholder inclusion due to different logic and responsibilities of each sector.

In the public sector context, stakeholder engagement is seen as a way to co-construct technology together with stakeholders in accordance to their expressed values, thus leading to positive outcomes of new emerging technologies (Te Kulve, Rip, 2011).

In the business sector, research shows that the inclusion of stakeholders into the innovation process facilitates learning and the creation of new knowledge within organizations and increases technical and commercial capabilities of innovation (Van de Vrande, Lemmens, and Vanhaverbeke, 2006). Integration of stakeholders enables more efficient penetration into the market and is likely to be more successful (Cagnin et al., 2012), as well as to gain an economic advantage in a rapid pace and volume competition (Vanhaverbeke, Cloodt, and Van de Vrande, 2008).

Despite the possible positive effect of stakeholder inclusion on innovation performance, there are difficulties in employing the strategy of stakeholders'

inclusion within a company. It requires additional costs and time to coordinate the processes of inclusion, to establish information systems for the inclusion, manage different or even opposing views of the stakeholders with the company, to be aware and manage cultural and contextual differences, etc. (Gasiūnaitė, Petraitė, 2011; Beringer, Jonas, and Kock, 2013).

Moreover, the imperative of a democratic innovation process (via transparency towards included stakeholders) is problematic. In an ideal situation, firms should include a wide range of stakeholders and disclose information regarding innovation at the ideation phase. However, this is hardly possible, since a firm can sustain competitive advantage due to the advantage of information asymmetry, i.e. "additional knowledge which enables companies to identify business opportunities in the market" (Blok, Lemmens, 2015, p. 24). In addition, information asymmetry implies possibilities for the firm to exploit innovative solutions based on new knowledge that could provide the first-mover advantage. Thus, the quest for full transparency towards the included stakeholders into the firm's innovation process seems to be difficult to apply in the firm's routines.

In the public sector, it is possible to demand full inclusion of stakeholders and transparency of information for them. However, in the business sector firms have different responsibilities and goals where full transparency is available only to a certain degree (Blok, Lemmens, 2015). Thus, a direct conceptual transfer of the concept "stakeholder inclusion" from the public to the private sector is highly questionable and requires adaptation for business context (Gurzawska et al., 2017).

Inclusion as a separate RI activity is more relevant for the public sector due to a moral obligation to be fulfilled (Ribeiro et al., 2016) for the following reasons: 1) to meet society's needs and define socially desirable outcomes (Stahl et al., 2014), 2) to gain social acceptability (Sutcliffe, 2011, Van den Hoven, 2013a); 3) to enhance society's trust in research and shape technologies or policy frameworks in accordance with societal values (Grunwald, 2011).

In the business sector, inclusion seems to be not a separate, but an integrative part of anticipation, reflexivity, and responsiveness. When examining each RI activity in business contexts that were operationalized by Lubberink et al. (2017), the *inclusion* aspect is found in every other dimension: anticipation, reflexivity, and responsiveness. Because firms should include different stakeholders during the whole innovation process, almost every other activity contains the required element of inclusion of internal or external stakeholders. With regard to anticipation, for example, Lubberink et al. (2017) mention that "it is important that actors develop the roadmaps consisting of alternative ways in which the desired impact can be achieved" (p. 11). Regarding the reflexivity, Lubberink et al. (2017) state that "also, activities that encourage [the] reframing of problems and/or solutions, or that encourage involved stakeholders to challenge their own and the firm's approaches, can help the firm to reflect on their thoughts and practices" (p. 12). With a view to responsiveness, "companies can also benefit from collaboration with other firms or stakeholders, for example, to keep up with information flows, changes in the innovation system, and to be able to respond to them" (Lubberink et al., 2017, p. 16). Sutcliffe also emphasizes that inclusion has to be led by the feedback about the

process of innovation to included stakeholders (2011). Hence, RI activities should be designed in a way that would require including inner or (more preferably) external stakeholders.

Since stakeholder inclusion is also mostly examined in the context of the public sector, it is important to understand what type of stakeholders are important for the firm and how they could be included or engaged with. In the business context, the stakeholders in relation to RI are divided into internal and external (Gurzawska et al., 2017). This division is based on a theory of the firm and defines the locus of control and influence in innovation decision-making.

*Internal stakeholders*. The firm's internal stakeholders are employees or teams who work within an organization. Internal stakeholders work in various areas within the organization, such as in the departments of management, marketing, manufacturing, sales, and so forth (Blyler, Coff, 2003). In order for the firm to achieve better results with regard to socially responsible outcomes of a firm's innovation, it is essential to motivate and engage with internal stakeholders. Since internal stakeholders play a key role with regard to RI, it is important to educate them about the benefits that RI could bring (Gurzawska et al., 2017). RI principles such as the integration of "ethical thinking into [the] design/production process, advocating and encouraging employees to maintain a responsible attitude and discouraging/stigmatizing unethical behavior" (Gurzawska et al., 2017, p. 15) should be employed along the whole value chain. With regard to co-responsibility, the degree of involving internal stakeholders into the innovation process should be of a higher level.

*External stakeholders*. The firm's external stakeholders shape the RI framework and form the networked environment of multiple interactions in the innovation decision-making process. External stakeholders can both be affected or can affect the firm. Usually, the firm's external stakeholders are value-chain-based actors, that is, customers, distributors, suppliers, creditors, user communities, and so forth. In the case of high industries, external stakeholders, especially innovation and supply chain partners, are highly important since there are many collaborations and alliances formed for common innovation projects (Stuart, 2000). However, interactive learning for innovation requires intensive trust-based interaction (Vinding, 2006), therefore, in order to maintain collaboration with external stakeholders, it is important to build trust and cognitive understanding. This forces firms to behave in a more responsible manner towards their external stakeholders in order to ensure long-term relationships. Corporate reputation is also increased while applying RI practices. Hence, this way of improving corporate reputation causes both investors and potential consumers to be more attracted (Gurzawska et al., 2017). Regarding co-responsibility with external stakeholders during the innovation process, the degree is of a lower level due to the uncertainty and possibility of knowledge leakages.

**Responsiveness** is defined as "the coupling of reflection and deliberation to action that has a material influence on the direction and trajectory of innovation itself" (Owen et al., 2013, p. 2). Responsiveness is understood as an adaptive way of innovating (Owen et al., 2012) and as a capacity to respond to the socio-ethical

values expressed by society and adapt research and innovation processes accordingly. In the public sector, responsiveness plays the main role in the case of emerging technologies, for instance, nanotechnology. The crucial aspect here is that responsiveness should take place during the whole life-cycle process of the research and technology development and application (Pelle, Reber, 2013).

In the business context, innovators should be capable of shaping and adjusting innovation in response to the values of stakeholders and the wider public. Thus, if a firm includes stakeholders in the innovation process, it has to be able to actually change innovation according to their feedback (Long, Blok, 2018). Responsiveness is a process that not only allows firms to strengthen their network ties with internal and external stakeholders but also the ties between them. The consolidation process that also takes place, as various dimensions and aspects of RI represented by various stakeholders, is integrated into the common innovation effort and response of the firm.

Thus, having an assumption that the inclusion of stakeholders is an integrative part of anticipation, reflexivity, and responsiveness, the following RI activities are considered as the main activities required for RI implementation in a firm.

According to the literature review on RI activities in relation to norms, *three main activities (anticipation, reflexivity, and responsiveness) are considered suitable for further analysis in the business sector.*

### 1.2.3. *Defining the Research Gap*

Despite the amount of attention the concept of RI has gained, there are some research gaps remaining in relation to RI. A literature review of the Responsible Innovation research indicates the breadth of a quite recent field and attempts to apply different kind of frameworks and theories in order to develop the concept of RI. In fact, regarding RI in a commercial context, there is a situation of an oxymoron – responsibility and innovation, where responsibility implies long and deliberative process, while innovation implies a rapid progress (Schumpeter, 1998; Pavie, Carthy, 2013; Blok, Lemmens, 2015). Thus, looking from the perspective of innovation theory, the quest for responsibility via slowing down the process of innovation by deliberative analysis of sustainability and socio-ethical issues with regard to innovation as well as early inclusion of a wider range of stakeholders (Von Schomberg, 2013) are problematic areas for the business sector. In other words, responsibility here implies additional costs of time and resources that slow down the progress of innovation and the firm at the same time.

First, there is a gap in combining the normative and processual dimensions in RI in order to holistically understand the RI implementation. In the literature on responsible innovation, two separate perspectives on RI are dominant: 1) normative and 2) procedural approach. The normative substantial approach is related to the norms in the innovation input phase in order to come with responsible outcomes of innovation. Grand Challenges play a key role that defines the normative orientation of innovation (Von Schomberg, 2013). The procedural approach focuses on responsible ways and activities during the innovation process. In RI literature, the dominant activities of RI process are as follows: anticipation, the inclusion of

stakeholders, reflection, and responsiveness (Owen et al., 2013). In addition, the normative approach could be associated with *moral overload* (Van den Hoven, 2013b), "when one is burdened by conflicting obligations or conflicting values, which cannot be realized at the same time" (Van den Hoven, 2013b, p. 77). A purely procedural approach is criticized due to the lack of integration of normative aspects. The normative aspects of RI are mostly studied by 1) STS scholars in the research and innovation governance at the national level in the public sector with a specific focus on research and emerging technologies or 2) by scholars of business ethics and philosophy of management, where prescriptive research towards norms in business organizations dominates. Thus, there is a need to search for a suitable perspective of how to combine normative and procedural approaches and analyze the RI implementation in a holistic way, since norms and procedures are highly interrelated during the innovation development process.

STS scholars go further and state that norms of different levels of RI are interrelated and should be analyzed simultaneously. The process of innovation development requires deliberate attention as it constructs norms at the same time (Grunwald, 2011). According to Grunwald (2011, 2012), in RI research, the emphasis should be on the interrelationship between ethics/norms, decisions and actions that are not yet conceptualized.

Second, RI as a concept calls for a transformation of values and the actual behavior of societal members towards mitigating the Grand Challenges (Sutcliffe, 2013; Von Schomberg, 2013). However, both theoretical and empirical analysis on the behavior during the responsible innovation implementation of organizations, specifically, in the business sector, is scarce. Thus, there is a need to understand the current state of the "business as usual" in order to understand how RI could be fostered at the firm level:

> The great majority of technology-relevant decisions can be classified as "business as usual" or "standard situation in moral respect" in the following sense (Grunwald, 2000; Grunwald, 2012): the normative aspects of the basis for the decision including assumptions about responsibility are not made the object of special reflection, but accepted as *given* in the respective situation, thereby also accepting the elements of the normative framework this entails. (Grunwald, 2014, p. 24)

In conclusion, it could be summarized that RI research in the business context lacks a theoretical and practically applied framework that could reveal the firm's behavior towards RI. On the basis of the identified gaps, the focus of this study is on the following research questions: *what are the main elements (and their interrelationships) constituting responsible innovation implementation at the firm level? How is responsible innovation implemented in innovative firms? What supportive factors to innovate more responsibly at the firm level exists?*

According to the identified research gaps and research aim, the main research focus of this study is summarized in Table 5.

**Table 5.** A summary of the research focus of the dissertation

| Responsible Innovation | | | |
|---|---|---|---|
| *Research field* | Public Governance | Philosophy of Management | Business Ethics | Innovation Management |
| *System Level* | Micro (Organization) | | Meso (Groups of organizations) | Macro |
| *Sector* | Business sector | | Public Institutions | Academia (Research) |
| *Organizational level* | Micro (individuals in an organization) | | Meso (workgroups) | Macro (organization) |
| *Focus in the innovation process* | Input | | Throughput | Output |
| *Type of innovation* | Emerging/contested technologies | | Any kind of innovative product | |

## 1.3. Towards a conceptual framework for RI implementation in the firm

On the basis of literature analysis and presented research gaps, this sub-chapter firstly presents the decision-making as a missing concept required for the whole understanding of implementing responsible innovation. Secondly, the behavioral norms approach is presented as the most suitable to bridge the gap between normative and processual approach in order to analyze a firm's behavior in relation to responsible innovation implementation. Thirdly, the elements (and their interrelationships) of responsible innovation implementation are presented. Finally, the networked nature of responsible innovation is presented in order to understand the context of responsible innovation implementation.

### 1.3.1. *Decision-making dimension of Responsible Innovation*

The analysis of RI literature explored the dimension of *decision-making* as a combining link between two mostly separated RI dimensions: norms and processes. However, decision-making is evidently a not yet explicitly studied concept among RI researchers, except for the empirical study by Flipse et al. (2015) on the identification of key performance indicators (KPIs) in earlier successful innovation projects that could make a positive contribution to decision-making in relation to responsible innovation.

Decision-making is mentioned by most of the scholars who shaped RI concept like von Schomberg (2012, 2013), Owen et al. (2012), Grunwald (2011, 2014), etc. Decision-making is frequently emphasized in the public sector as well as the academic contexts. Although decision-making does not appear in the RI definitions, however, it has significant importance in fostering RI. Decision-making varies in exact positions regarding the process and norms of RI. Conceptual links between decision-making and RI elements are summarized in Table 6 and Table 7.

In relation to decision-making and responsible innovation process (Table 6), decision-making is regarded as an important part of RI activity, i.e. responsiveness (Owen et al., 2012):

It is the institutionalised coupling of such integrated processes of anticipation, reflection and inclusive deliberation to policy and decision-making processes – i.e. the dimension of responsiveness – that is an important, if evolutionary, contribution that RRI makes, and one to which the EC [European Commission] aspires to embed more systematically across the ERA. (Owen et al., 2012, p. 755; addendum by author)

**Table 6.** An analysis of the importance and relationship of decision-making and RI Process

| RI author | Quote | Relation to RI dimension |
|---|---|---|
| Von Schomberg (2012, p. 7) | *"Public engagement projects such as the Nanofutures or the Nanosec project adopts both foresight and a deliberative approach, which is to be welcomed. It is, however, important to note that the reason for this approach is not limited to the normative rationale of a more democratic and transparent **decision making** process. The deliberative foresight approach can also improve the quality of the **decision making** process and help to identify knowledge gaps for which we would need to go back to science." (Emphasis added)* | Process |
| Von Schomberg (2013, p. 19) | *"I will not here elaborate in too much detail on the negative (anticipated or not) consequences of innovation as they are well described by many others, including those in that particular report. Nonetheless, a framework for RRI needs to address these consequences, as well as build on the work of these authors. The lessons learned from these 12 cases mainly relate to **decision making** under scientific uncertainty and scientific ignorance." (Emphasis added)* | Process |
| Owen et al. (2012, p. 751) | *"Further roots [of RI] include, but are not limited to, integrated approaches such as technology assessment in its various forms (e.g. Schot and Rip, 1996; Guston and Sarewitz, 2002) and anticipatory governance (e.g. Karinen and Guston, 2010), some of which have been formalized within **decision making** processes, (of which the so-called 'Danish model' for technology assessment based on public participation and deliberation (e.g. through consensus conferences) is one notable European example." (Addendum by author, emphasis added)* | Process |
| Owen et al. (2012, p. 755) | *"It is the institutionalised coupling of such integrated processes of anticipation, reflection and inclusive deliberation to policy and **decision-making** processes – i.e. the dimension of responsiveness – that is an important, if evolutionary, contribution that RRI makes, and one to which the EC aspires to embed more systematically across the ERA.*"| Process: RI activities |
| Van Oudheusden (2014, p. 73) | *"From a concern with instigating sociotechnical change, RI proponents seek to bring multiple publics and their 'knowledges' into science and technology **decision-making**. Hence, they call for 'transparent, interactive processes' and for 'the involvement of all stakeholders' in sociotechnical governance." (Emphasis added)* | Process |

| Van Oudheusden (2014, p. 74) | *"While it is acknowledged that deliberative processes can in some instances impact on traditional, representative **decision-making**, elected representatives are publicly mandated to enforce policy **decisions**; whereas, deliberative democrats lack an official **decision-making** mandate. In the case of RI specifically, it remains to be seen how grand responsibility principles, such as gender, equality, responsibility, and so on, which are, for instance, invoked in von Schomberg's voluntary codes of conduct, can effectively be enforced." (Emphasis added)* | Process |
|---|---|---|
| Taebi et al. (2014, p. 120) | *"We have argued that an ideal approach to responsible innovation requires a timely and continuous inclusion of stakeholders' values in the process of technological design. The relevant public values can be extracted from the always-rich public debate, and the potential value conflicts need to be identified. The insights of this interdisciplinary research should then inform technological design, the associated institutions and the **decision-making** process." (Emphasis added)* | Process |

The relationships of decision-making and norms are summarized in Table 7. Von Schomberg (2012) regards decision-making as situated between RI norms and process:

> Public engagement projects such as the Nanofutures or the Nanosec project adopts both foresight and a deliberative approach, which is to be welcomed. It is, however, important to note that the reason for this approach is not limited to the normative rationale of a more democratic and transparent decision making process. (Von Schomberg, 2012, p. 7)

Grunwald (2011), for example, makes a link between responsibility and decision-making.

> It [responsibility] associates ethical questions regarding the justifiability of decisions in and on science and technology with the actions and decisions of concrete persons and groups and resulting accountabilities, and it is faced with the challenges posed by uncertain knowledge of the consequences of those decisions. (Grunwald, 2011, p. 10; addendum by author)

**Table 7.** An analysis of the importance and relationship of decision-making and RI Norms

| RI author | Quote | Relation to RI dimension |
|---|---|---|
| Owen et al. (2012, p. 756) | *"Von Schomberg (2007) considers that collective responsibility is supported by public debate (i.e. that 'upon everyone's shoulders rests a particular moral obligation to engage in the collective debate that shapes the context for collective **decision making**'), technology assessment, foresight/ knowledge assessment and constitutional change, dimensions which have strong synergies with the dimensions of anticipation, reflection, deliberation and responsiveness we have highlighted above."* (Emphasis added) | Norms: Collective responsibility |
| Grunwald (2011, p. 10) | *"The concept of responsibility has been used widely in connection with scientific and technological progress in the past two to three decades (Durbin, Lenk, 1987). It [responsibility] associates ethical questions regarding the justifiability of **decisions** in and on science and technology with the actions and **decisions** of concrete persons and groups and resulting accountabilities, and it is faced with the challenges posed by uncertain knowledge of the consequences of those **decisions**."* (Addendum by author, emphasis added) | Norms: Ethical aspect of RI |
| Grunwald (2011, p. 11) | *"The moral dimension of responsibility is addressed by the question whether actions and **decisions** should be regarded responsible relative to the body of rules. Insofar as normative uncertainties arise (Grunwald, 2011a, Ch. 3), e.g., because of moral conflicts or indifference, ethical reflection on these rules is needed. Relevant questions are: What criteria allow distinguishing between responsible and irresponsible actions and **decisions**? Which traditions such as Kantian or utilitarian ethics should be involved and what would follow? Is there consensus or controversy on these criteria among the relevant actors? Can the actions and **decisions** in question be justified with respect to the rules, values and ethical principles?"* (Emphasis added) | Norms: Responsibility |
| Grunwald (2011, p. 21) | *"Responsibility inquiry into technology aims to influence the further course of development or, in short, to make an impact rather than being a mere ornament. Therefore, it has to be clarified how responsibility deliberations could take place and upon what grounds they could be founded but also how their results could enter **decision-making** processes."* (Emphasis added) | Norms: Responsibility |
| Grunwald (2014, p. 18) | *"**Decisions** concerning the pursual or abandonment of various technological paths, regulations and innovation programs, new development plans, or the phasing-out of lines of technology often have far-reaching consequences for further development."* (Emphasis added) | Norms |

Furthermore, from the presented conceptual links, it could be summarized that decision-making could be institutional, ethical and techno-economic. *Institutional decision-making* can be based on institutional regulations and formal procedures that innovators must take into account while developing innovation:

> Further roots [of RI] include, but are not limited to, integrated approaches such as technology assessment in its various forms (e.g. Schot and Rip, 1996; Guston and Sarewitz, 2002) and anticipatory governance (e.g. Karinen and Guston, 2010), some of which have been formalized within decision making processes, (of which the so-called 'Danish model' for technology assessment based on public participation and deliberation (e.g. through consensus conferences) is one notable European example. (Owen et al., 2012, p. 751; addendum by author).

From other statements, ethical values are reflected towards decision-making in responsible innovation implementation. For example, Grunwald (2011) argues that decisions during innovation implementation should be responsible: "The moral dimension of responsibility is addressed by the question whether actions and decisions should be regarded responsible relative to the body of rules." (p. 11).

Techno-economic decision-making is also found in relation to responsible innovation implementation. It is argued that during the implementation of responsible innovation, knowledge is required to develop it: "RI proponents seek to bring multiple publics and their 'knowledges' into science and technology decision-making" (Van Oudheusden, 2014, p. 73).

Having argued decision-making to be a missing dimension in responsible innovation implementation, further sections conducts a theoretical analysis of decision-making.

A classic definition of a decision is considered as "a conclusion arrived at after consideration" (Longman New Universal Dictionary, 1982). The definition of Hatch (1997) states that "Decisions take place endlessly, so it is also possible at a given point in time to interpret an organization as the product of its decisional history" (p. 270). Butler, Bezant-Niblett and Caine (2011) note that this definition emphasizes the processual dimension of decision-making and that it could be influenced.

A firm-level analysis requests a deeper look into decision-making factors that are available and could be executed by the firm. Decision-making is usually analyzed from psychological, cognitive, managerial and normative perspectives. Decision-making research often focuses on how decisions are ordinarily made.

Decision-making can be rational or influenced by "bounded rationality". Rational decision-making was mostly influenced by the Industrial Revolution when it was believed that with a series of logical decisions it was possible to achieve the right solutions (Butler, Bezant-Niblett, and Caine, 2011). It is assumed that with a deliberative analysis of data and logical thinking one would make a good decision.

March and Simon (1958) coined the term "bounded rationality" in decision-making. Based on research from evolutionary psychology, Butler et al. (2011) summarized the following limitations for making a good decision: complexity and quality of information, disagreement (between peoples' opinions), error, different

perceptions, politics, lack of time, too much focus by overlooking other information, tendency to notice sharp differences instead of gradual ones, failure to seek information, influence by the success and not seeing possible problems, looking internally instead of at competitors, failure to share information. These limitations are due to human inability to consider every possible aspect related to decision-making, thus sometimes causing humans to use short-cuts (Butler et al., 2011)

Studies of decision-making in the commercial innovation context show that decisions along the innovation development in many cases are taken on the basis of bounded rationality (Gutierrez et al., 2008) due to the complexity of multiple considerations in innovative activities (Flipse et al., 2015). Thus, the assumption of this study is that a firm's decisions are made under bounded rationality.

The innovation process consists of many different decisions (Monahan, 2000) that could be separated into two groups: macro decisions and micro decisions. From the management perspective, macro decisions are understood as those involving a decision to start a project, new innovation development, etc. (Gaynor, 2015). After the macro decision has been taken, micro decisions in everyday innovation processes take place:

> Performance can be enhanced by understanding the actions and processes required to implement the decision, prior to making the macro decision. While that first macro decision initiates a project or some action, successful performance depends on how the organization manages the thousands and often millions of subsidiary decisions. (Gaynor, 2015, p. xiv)

In fact, micro decisions should be deliberated even before accepting the macro decision, for example, a decision to start a new innovation development in order to avoid unintended consequences (Gaynor, 2015). "<…> to pursue up-front work with greater diligence prior to making commitments" (Gaynor, 2015, p. xv).

The managerial perspective acknowledges the important role of not only internal but external factors in decision-making. Concerning the external factors of decision-making, according to Gaynor (2015): "Decision-makers must also be guided by competitive forces that may govern their particular industry, government rules and regulations from the local to national to international requirements that impose restrictions on operations, the economy from local to national to international, and the changes in social mores and structure" (p. 46). In parallel to RI, decision-making literature (Gaynor, 2015) also reflects on the challenges of complexities regarding different layers influencing decisions at the firm in today's global economy. In fact, uncertainty is regarded as one of the main issues in efficient decision-making in the firm (Monahan, 2000). According to Gaynor (2015), "Successful execution of any major decision depends on resolving the unknown, unpredictable, and uncontrollable issues and continually verifying the known, predictable, and controllable issues based on changing requirements and conditions." (p. xvi).

However, the main focus of this study is the accepted informal norm for decision-making in certain situations during innovation development. In this study, a firm is understood as a normative reference group (Buffalo, Rodgers, 1971), which

provides an employee "with a guide to action by explicitly setting norms and espousing values. <…> Their [normative reference group] principal function is to direct the individual into conformity with the basic cultural patterns. (Kemper, 1968, p. 32; p. 35; addendum by author).

Thus, decision-making is regarded as a missing element in the whole responsible innovation implementation understanding. In this study, *decision-making* is defined as *bounded rationality behavior in a firm's daily activities requiring taking action in a certain situation and where the decision is made based on informal norms accepted in the boundaries of the organization.*

*1.3.2. Behavioral norms perspective for Responsible Innovation Implementation*

This study uses elements of Behavioral theory of the firm (Cyert, March, 1963) to understand RI implementation in the firm. The behavioral theory of the firm, therefore, is useful in offering a suitable perspective to understand RI as a process consisting of a variety of decisions.

The behavioral theory of the firm was introduced by Cyert and March (1963). They were inspired by H. A. Simon, who coined the term "bounded rationality" in the 1950s, which argued that people behave with bounded rationality in uncertain situations. The theory emphasizes the explanation of decisions made within the firm: "Focus on a small number of key economic decisions made by the firm." (Cyert, March, 1963, p. 2).

The behavioral theory of the firm also emphasizes the need to understand the process itself: "Develop process-oriented models of the firm. That is, we viewed decisions of the firm as the result of a well-defined sequence of behaviors in that firm; we wished to study the decisions by studying the process." (Cyert, March, 1963, p. 2).

Thus, using the perspective of the behavioral theory of a firm (Cyert, March, 1963; Argote, Greve, 2007), it is understood that the implementation of RI consists of small everyday economic decisions. The sum of a variety of decisions made and manifesting via the firm's behavior increases the understanding of how the firm operates. This is in accordance with Stahl (2013), who states that organizations should have their fundamental normative principles in evaluating whether the developing innovation is acceptable for the society and environment. However, since the decision-making is embedded into the every-day innovation activities, it manifests with bounded rationality in accordance with the accepted behaviors in the firm.

The behavioral theory of the firm would suggest that internal stakeholders of the firm behave on the basis of organizational norms and procedures and thus, their behavior can be easily induced by management decisions; while external stakeholders and institutional norms induce the innovation decision-making frameworks to which firms have to adjust in order to survive in the networked nature.

The application of behavioral perspective is seen as beneficial in disclosing the usual firm's behavior in relation to the implementation of RI. When certain informal norms are in place, they manifest through usual and accepted behaviors. Looking from the perspective of bounded rationality, it is believed that the firm's decisions

and behavior are influenced not only by the firm's inner environment and stakeholders but also by the external environment.

The assumption of this study is that every-day decision-making is influenced by the coordinating role of underlying norms. Norms are studied from various fields, such as psychology, sociology, anthropology (Anderson, Dunning, 2014). From Organizational Behavior (OB) perspective, norms are defined as "something that is usual, typical, or standard" (Moerdyk, 2015, p. 53). Another understanding given by OB scholars is that norms are shared attitudes, opinions, feelings, or actions that guide social behavior (Kreitner, Kinicki, 2010). In summary, norms could be understood as rules about behavior (Anderson, Dunning, 2014). In fact, there is an exhaustive list of different kind of norms depending on the studied field (Anderson, Dunning, 2014), however, due to the wide scope, the focus in this work is on two types of norms – moral and behavioral – that essentially differ.

In the context of this study, it is important to understand that norms can be moral and behavioral. According to Buffalo and Rodgers (1971), moral norms "will refer to standards of conduct that are believed to be 'right,' 'just,' or 'ideal' forms of behavior." (p. 102). Moral norms are about "collective beliefs about how people ought to behave that anyone can defend with non-forceful sanctions. At the stricter end, violations of a taboo tend to be met with extreme disgust" (Anderson, Dunning, 2014, p. 723). According to Brennan et al. (2013), moral norms, like truth-telling and promise-keeping, and norms of beneficence forbidding murder, rape, and torture exist in most societies. Thus, moral norms reflect a common societal understanding of what is radically accepted and not.

Behavioral norms "refer to standards of conduct that are deemed the "real pattern", i.e. what people actually do, irrespective of what they are ideally supposed to do, or what they themselves believe should do." (Buffalo, Rodgers, 1971, p. 102). The difference between moral and behavioral norms was examined in an empirical study by Buffalo and Rodgers (1971), where they found essential differences in what respondents thought they should do and what they actually do in a certain situation. Thus, the focus of this study is on the actual behavior (behavioral norm) rather than how it should be (moral norm), because according to the presented empirical study by Buffalo and Rodgers (1971), despite the moral norms a person could have in mind, his behavior can differ in situations.

Hence, a *behavioral norm* in this study is understood as *a usual behavior in a specific situation based on a set of informal norms that are regarded as valid in an organization.* Thus, applying the perspective of behavioral norms in RI implementation is helpful in understanding the interrelationship between the behavior that is accepted as a norm during the RI implementation. In the following section, each conceptual element of responsible innovation implementation is elaborated further.

### 1.3.3. *Main elements of Responsible Innovation Implementation*

*Orientation towards Grand Challenges.* The issues with regard to the Grand Challenges should be integrated into a firm's innovative activity and, therefore,

understood as innovation orientation. According to Siguaw, Simpson, and Enz (2006), innovation orientation is defined as

> a multidimensional knowledge structure composed of a learning philosophy, strategic direction, and trans-functional beliefs that, in turn, guide and direct all organizational strategies and actions, including those embedded in the formal and informal systems, behaviors, competencies, and processes of the firm to promote innovative thinking and facilitate [the] successful development, evolution, and execution of innovations. (Siguaw, Simpson, and Enz, 2006, p. 7)

In this guise, the Grand Challenges could be seen as a normative goal for a firm to move towards while innovating (Yaghmaei, 2015) and as a potential future market for responsible innovative solutions at the same time and organizations should take advantage of being the first movers (Lieberman, Montgomery, 1988) by embedding the Grand Challenges into their innovation orientation. The concept of innovation orientation helps to understand Grand Challenges as innovation orientation of the firm that requires a complex mix of knowledge and competencies in order to be successfully implemented in the innovation.

Institutional aspects in decision-making should be positively influenced because the firm pays attention to societal values. Since the global goal to mitigate the Grand Challenges comes from public institutions (Lund Declaration, 2009; EC 2013), a firm's innovation orientation towards Grand Challenges, in turn, should also contribute to institutional aspects of decision-making during innovation development.

In RI literature, Grand Challenges are understood as the main motivation for ethical aspects of innovation (Von Schomberg, 2013; Stilgoe et al., 2013), thus innovation orientation towards Grand Challenges should have a positive influence on Ethical decision-making in the firm.

Grand Challenges also require technological development of innovation. Innovation orientation towards Grand Challenges can inspire firms to develop new technologies that would solve socio-ethical issues. In this case, techno-economic aspects are important in an efficient innovation development (Bessant, 2013). Techno-economic efficiency of innovation is also considered to be responsibility criteria (Pavie et al., 2014). Thus, a firm's innovation orientation towards Grand Challenges should be also positively influencing techno-economic decision-making.

In sum, if the firm has innovation orientation towards mitigating the Grand Challenges established, it should have a positive influence on the firm's institutional, ethical and techno-economic aspects of decision making during the innovation process. Regarding the literature review, the hypotheses are as follows:

H1a: *Innovation orientation towards Grand Challenges has a positive influence on Institutional decision-making*

H1b: *Innovation orientation towards Grand Challenges has a positive influence on Ethical decision-making*

*H1c: Innovation orientation towards Grand Challenges has a positive influence on Techno-economic decision-making*

*Decision-making in Responsible Innovation Implementation.* According to the analysis and synthesis of the literature review (see section 1.3.1.), in this study, decision-making is distinguished into Institutional, Ethical, and Techno-economic. In the following sections, each determinant for decision-making is elaborated.

*Institutional decision-making.* Looking from the normative institutionalism theory (Paauwe, Boselie, 2003; Bolfíková, Hrehová, and Frenová, 2012), the main goal of a firm is to survive and gain legitimacy from the society, thus firms follow the "logic of appropriateness", which guides their behavior within their institutional environment, which basically consists of a firm's external stakeholders. The formal and informal norms of external stakeholders shape the decisions and actions taken by firms in order to adapt to their environment. Thus, firms scan their environment and make their decision that shapes the innovation process and its outcomes accordingly. A firm has to match the existing formal (institutional standards) and informal (opinion of firm's partners and related stakeholders, the general opinion of the society) norms in order to survive and be accepted by the society. This means that firms are influenced by their stakeholders from external environment: suppliers, competitors, governments, customers, partners, etc. during their RI implementation.

Thus, Institutional decision-making should positively influence a more responsible behavior during the innovation process. Accordingly, the following hypotheses are defined for this study:

*H2a: Institutional decision-making has a positive influence on Anticipation activities during the innovation process*

*H2b: Institutional decision-making has a positive influence on Reflexivity activities during the innovation process*

*H2c: Institutional decision-making has a positive influence on Responsiveness activities during the innovation process*

*Ethical decision-making.* Based on RI studies, ethical decision-making aspects should also be strongly related to RI activities (Santana, Vaccaro, and Wood, 2009; Stilgoe et al., 2013; Von Schomberg, 2013). The added value of ethical decision-making is driven by innovative solutions, which are the perceived responsibility towards society and the environment. Ethical aspects are considered to enhance a firm's innovative activity by increasing organizational foresight, reflexiveness and responsiveness practices (Santana et al., 2009; Fuentelsaz, Garrido, and Maicas, 2015). Since aspects related to Ethical decision-making are emphasized as the main motives for RI (Guston, 2013; Pandza, Ellwood, 2013; Grunwald, 2014), it should lead to a more responsible innovation process. The hypotheses are defined as follows:

*H3a: Ethical decision-making has a positive influence on Anticipation activities during the innovation process*

*H3b: Ethical decision-making has a positive influence on Reflexivity activities during the innovation process*

*H3c: Ethical decision-making has a positive influence on Responsiveness activities during the innovation process*

*Techno-economic decision-making.* Firms are mainly self-interested (Blok, Lemmens, 2015) because they seek to be updated with the newest technological developments and rapidly acquire external knowledge that is altogether an important supplement in the firm's internal innovative activities (Wernerfelt, 1984; Ulrich, Lake, 1991; Conner, Prahalad, 1996). Since firms are forced to keep up the speed and progress of innovation to gain market success, techno-economic aspects during innovation development remain even though firms orient themselves towards RI. In an empirical study of Halme and Korpela (2014), the importance of the resources during responsible innovation was confirmed.

Applying the perspective of the resource-based view (hereafter, RBV), firms seek to be updated with the newest technological developments, rapidly acquire external knowledge that all together are important supplements in the firm's internal innovative activities (Wernefelt, 1984; Conner, Prahalad, 1996). According to the RBV of the firm, resources are "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by the firm" (Barney, 1991, p. 101). In fact, "resources must not be possessed by all competing firms, they must be difficult to imitate or duplicate through other means, and contribute positively to performance" (Barney (1991) cited by Schroeder, Bates and Junttila (2002). The RBV leads us to understand a firm's internal and external stakeholders as a potential resource of specific knowledge and skills, where the resources are distributed among various actors and provide competitive advantage (Barney, 1991).

Looking through the lenses of RBV, the firm's internal and external stakeholders, therefore, are seen as means to obtain complementary resources for the successful innovation development and commercialization. A line of empirical research has shown that organizations tend to establish partnerships with those organizations that have a high level of technical and commercial competence (Kitching, Blackburn 1999; Ahuja, 2000; Bogers, 2011; Dodgson, 2013). Integration of external knowledge and resources help to reduce the penetration into the market and is likely to be more successful (Cagnin et al., 2012), as well as to gain an economic advantage in a rapid pace and volume competition (Vanhaverbeke et al., 2008).

It is empirically confirmed that internal R&D intensity and technological sophistication positively correlate with the number of established collaborative initiatives and partnerships (Freeman, 1991; Powell, Grodal, 2005). When firms start to collaborate with external stakeholders, new processes and routines are established

that transform the firm's internal routines (Adler, Goldoftas, and Levine, 1999). New resources, i.e. knowledge and competencies gained from the network, build up the social construction of knowledge embedded in innovation processes (Schroeder et al., 2002).

Seen from the RBV perspective, the firm's partnerships based on techno-economic aspects facilitate to cope with more complex innovation (Barney, 1991; Van de Vrande et al., 2006). In this case, organizations pursue well-established processes for innovation development as they work towards technological excellence (Clausen, Korneliussen, and Madsen, 2013). A firm's relationship with partners based on techno-economic aspects may increase more responsible innovation development as partners are more dependent on each other in delivering technological innovations. Therefore, it is necessary to integrate the techno-economic decision-making of a firm into the unifying conceptual framework of RI at the firm level. Techno-economic decision-making thus should positively influence RI activities. Consequently, the hypotheses are:

H4a: *Techno-economic decision-making has a positive influence on Anticipation activities during the innovation process*

H4b: *Techno-economic decision-making has a positive influence on Reflexivity activities during the innovation process*

H4c: *Techno-economic decision-making has a positive influence on Responsiveness activities during the innovation process*

*Responsible innovation activities: anticipation, reflexivity and responsiveness*. Applied RI activities should be also understood as behavioral norms that manifest during the innovation process. Such behavioral norms in an organization manifest as routine activities in a firm, and therefore could be understood as informal norms since they are usually not codified (Anderson, Dunning, 2014). However, internally, the firm could have the ISO standards applied that make RI-related activities formal.

Anticipation could be regarded as an activity-related norm because the process of anticipation itself leads to RI and the production of norms (Guston, 2013). Anticipation activities mainly consist of two tools: scenario planning and foresight. Anticipation activities help to acquire knowledge about possible consequences that innovation could have for society and environment, thus revealing the normative conceptions about the innovation (Owen et al., 2013). According to Pelle and Reber (2013), "drawing on the imaginary of individuals (to reveal their vision of the world through narratives) and building different scenarios of development allow for a better understanding of how individuals incorporate technology in their lives and what they expect from it". Moreover, the development of future scenarios leads to the co-construction of desirable ends (Guston, 2013) – one of the main purposes of RI.

Activities rising out of reflexivity are the reflection of existing norms (Pelle, Reber, 2013). During reflexivity activities, norms could be also elaborated while reflecting on them. The normative dimension of a firm is enhanced via reflexivity

activities. Thus, the application of reflexivity activities enhances the innovation process and should lead to the implementation of RI.

Responsiveness could also be regarded as the activity-related norm since it shows the dialogue with stakeholders and reactive behavior in the firm's innovation process. If responsiveness activity is integrated into the firm's innovation processes, it may lead to better insights with regard to innovation and co-construction of innovation that is promoted by RI scholars.

To summarize, based on the hypothesized relationships, the following research model is proposed (Figure 3.)
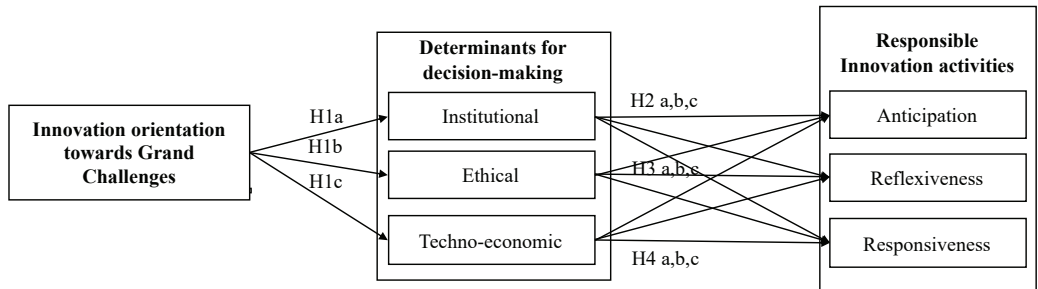


**Figure 3.** Research model

### 1.3.4. *Networked nature of Responsible Innovation Implementation*

The network approach is frequently used to depict the interconnected nature of an innovative firm with its environment. Network approach emphasizes interdependencies between related actors and stimulates new ways of collaboration (Frels, Shervani, and Srivastava, 2003). It offers valuable perspective for the analysis of RI application in firms, as innovation has to be managed in a constantly changing constellation of merging disciplines, levels of analysis, and research methods in the complex technological environments (Dodgson, Gann, and Phillips, 2014).

From the network theory perspective, different actors are interconnected and are analyzed in a systemic manner. As Ritter and Gemünden (2003) note, cutting-edge innovations are developed in collaboration between complementary actors of the network. This is also relevant in RI context because complex problems can only be mitigated by different actors working together by gathering information, resources, activities, and capabilities. It is then possible to achieve a solution that could not be achieved by organizations alone (Bryson, Crosby, 2006). Because firms scan the environment consisting of a wide range of different stakeholders, they notice the changing norms and values that have to also be reflected in a firm's inner environment since firms need to have a social license to operate and be accepted by society (Pavie et al., 2014; Garst et al., 2017). At the firm level, these behavioral norms form the basis for a potential behavioral change in a firm's RI process.

In this study, the egocentric network approach to analyze a firm's behavior towards RI regarding the networked nature of the firm's internal and external environments is applied. An egocentric network is considered to be the primary unit of the social network analysis, which focuses on the focal actor like an individual or organization (Cummings, Cross, 2003). If we look from the firm's behavior

perspective, the main purpose of the firm is to build up an egocentric network and to use it for its own competitive advantage and economic profit. As Laszlo (2013) states, "to focus beyond the bottom line does not imply forgetting about the "profit motive" but transcending it toward a mode of wealth creation that pursues personal, social, and ecological gains in addition to financial results." (pp. 606–607). The question is how to embrace the change towards RI when the firm's corporate logic is understood. However, understanding and accepting the egocentric nature of firms, that is, "how it actually is" rather than "how it should be", is the first step towards affecting a positive change in firms. Thus, there is a need to understand how one unit operates and what its logic is in order to shape the whole socio-technical system, which consists of many different units (Kilduff, Tsai, 2003).

The ego-centric network approach suggests that all actors behave on the basis of their own innovation and organizational and/or societal goals. Within this complex setting, a central coordination role is assigned to behavioral norms during RI implementation that induces the framework for decision-making within the common innovation space, where external stakeholders play an important role in influencing RI implementation in the firm. Based on this, the following propositions are proposed:

P1:   *Innovative firms tend to operate in a networked nature consisting of internal and external environments while implementing RI.*

P2:   *Firm's external stakeholders play an important role in a firm's internal RI implementation.*

A resulting conceptual framework (see Figure 4) suggests that RI in a firm happens in a networked environment, where the firm operates from an egocentric network perspective. Firm's internal and external environments represent the networked nature of the firm and its stakeholders. The external environment marked with the dotted line represents a permeable boundary of the firm which is induced by the existing norms or values that are either institutionalized or impacted upon by existing/emerging as social norms.

The RI implementation occurs as a result of the coordination between the firm's internal and external stakeholders and a constant adjustment of the innovation goals of the firm towards the expectations of external stakeholders. However, these two environments in the proposed model cannot be oversimplified as the stakeholders both internally and externally, and even transcendentally, form networked responsibility that binds the internal and external environment of the firm in such a way as to form a common RI space (Stahl, 2013).
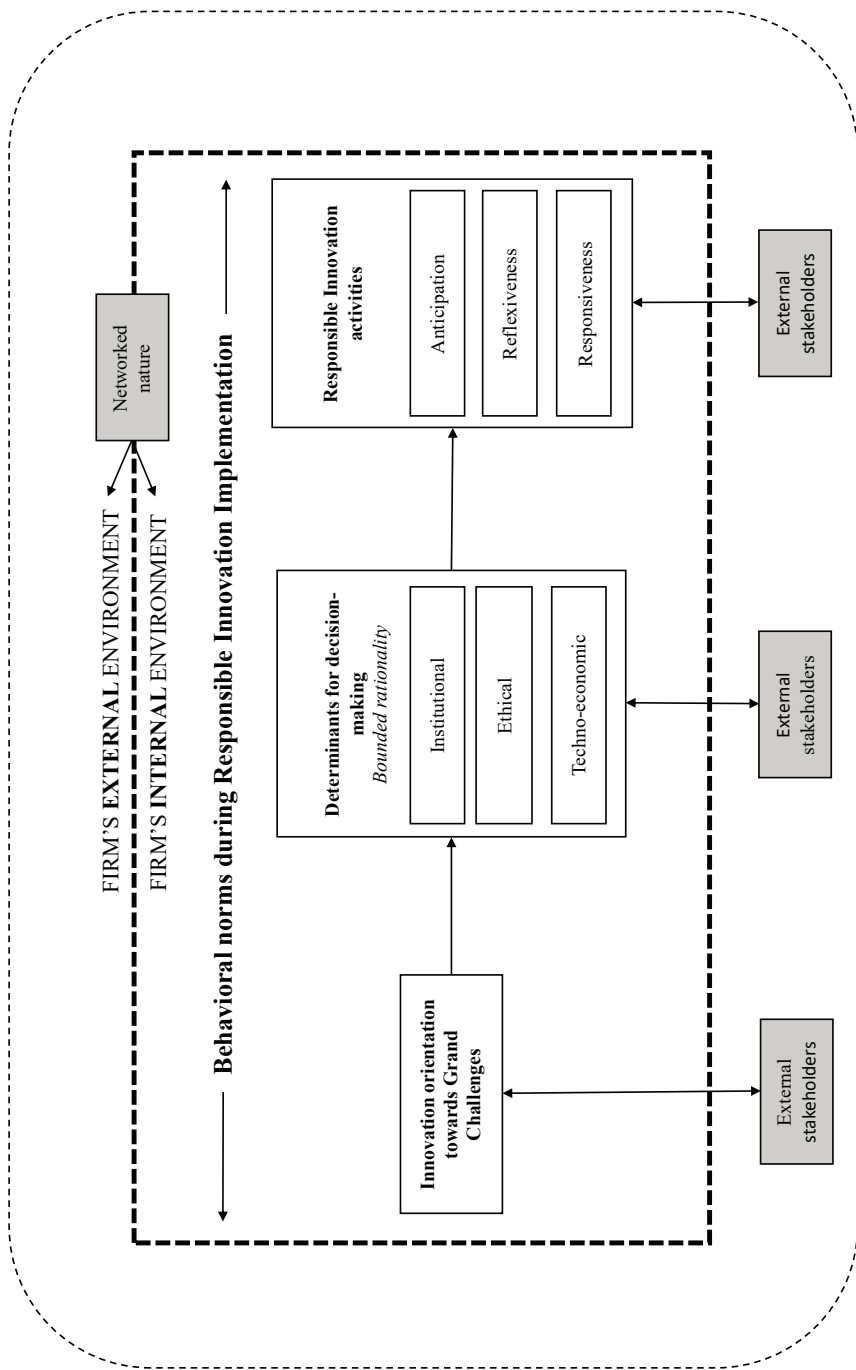
**Figure 4.** The conceptual framework for RI implementation at the firm level

FIRM'S **EXTERNAL** ENVIRONMENT

FIRM'S **INTERNAL** ENVIRONMENT

**Behavioral norms during Responsible Innovation Implementation**

Networked nature

**Responsible Innovation activities**

Anticipation

Reflexiveness

Responsiveness

External stakeholders

**Determinants for decision-making**
*Bounded rationality*

Institutional

Ethical

Techno-economic

External stakeholders

**Innovation orientation towards Grand Challenges**

External stakeholders

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## 2. METHODOLOGY FOR THE ANALYSIS ON THE IMPLEMENTATION OF RESPONSIBLE INNOVATION IN A FIRM

### 2.1. Pragmatism as a research approach

The phenomenon of Responsible Innovation represents an emergent shift in the society, which is rather complex and embedded in different levels. The concept of responsible innovation itself emerged in 2011 (Sutcliffe, 2011; Von Schomberg, 2011), although the literature review shows that there is a lack of empirical research on responsible innovation at the firm level due to the complexity of RI implementation in the firm. Since this study is oriented towards solving an existing problem regarding Responsible Innovation implementation in firms and to gain insights about a real-world practice by suggesting actual solutions, the pragmatism approach is regarded as the most suitable to derive the required knowledge (Patton, 1990) to gain the best understanding of the research problem raised in this dissertation (Creswell, 2003).

The underlying assumption of reality in this study is believed to be both singular and multiple (Creswell, 2003), i.e. there is a single "real world" and the world as interpreted by individuals (Wheeldon, 2010). Also, the pragmatism philosophy is oriented towards problem-solving (Farjoun, Ansell, and Boin, 2015). Since this study seeks better theorizing and practice of organizing in relation to responsible innovation implementation at the firm level, pragmatism is the most suitable philosophy since it adopts an approach situated between rationalist and structural understanding (Farjoun et al., 2015).

Such principles as "<…> a rich and behaviorally plausible model of human nature, an emphasis on the interplay of action and meaning, a strong distrust of dualisms ("means versus ends"), and an appreciation of recursive influences" comprise the main ideas of pragmatism and distinguish it from other approaches (Farjoun et al., 2015, p. 2). Precisely these core principles of pragmatism are believed to potentially lead to a better understanding of the rapidly changing and complex nature that organizations are embedded in (Murmann, 2013; Farjoun et al., 2015). Furthermore, pragmatism has had an influence on the behavioral theory of the firm (Farjoun et al., 2015), which laid the ground for the behavioral assumptions in this thesis.

Pragmatism believes that research occurs in a specific context bounded by social, historical or political aspects (Creswell, 2003). In RI studies, the context is regarded as having an important role in elaborating RI (Owen et al., 2012). Pelle and Reber (2013) state that RI activities are conducted within a specific context that influences the RI process. The authors emphasize that the context merely influences the way of how RI is implemented. Since RI is interrelated with formal (institutional standards, laws, regulations) and informal (social) norms, there will always be aspects specific to the context, which is where lies the networked responsibility, because RI is actually constructed by individuals in a given context. Nevertheless, studies in RI have mainly focused on advanced market economies, such as the United

Kingdom, Germany, the Netherlands, etc. (Van den Hoven, 2013). By focusing on another socio-political context, this study contributes to the literature by enhancing the understanding of RI implementation in non-Western firms.

In line with pragmatism, a *mixed-methods research design* is applied in this study (Tashakkori, Teddlie, 2010; Azorín, Cameron, 2010) by using different methods to reveal differing perspectives in relation to the existing problem and to test different aspects of the conceptual framework (Cameron, 2011).

## 2.2. Mixed methods research design

Following the approach of pragmatism, *mixed methods* were applied as the most suitable for the research questions raised in this dissertation (Tashakkori, Teddlie, 2003).

Mixed methods research is defined "as research in which the investigator collects and analyzes data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or a program of inquiry." (Tashakkori, Creswell, 2007, p. 4). Mixed methods were chosen to both develop a detailed view of the meaning of the phenomenon and generalize the findings to a population (Creswell, 2003).

The choice of research integrating qualitative and quantitative research methods was grounded on the need to view the research topic from different perspectives (DeCuir-Gunby, 2008), to answer mixed research questions and to test different aspects of the conceptual framework (Creswell, 2003). Due to the scarce theoretical and empirical research on RI implementation at the firm level thus far, it is believed that combining the relative strengths of qualitative and quantitative methods serves best to analyze the research questions raised in this study (Greene, Caracelli, and Graham, 1989). Hence, there is a need to uncover some variance which otherwise may have been neglected by single methods.

The rationale behind choosing mixed methods was the purpose of *complementarity* (Greene et al., 1989) in order to measure some overlapping as well as different aspects of the phenomenon of responsible innovation implementation in a firm, and to increase the validity of the constructs. The *qualitative study* was used twofold: 1) to uncover the phenomenon of responsible innovation implementation at the firm level, specifically focusing on the firm's networked nature and external stakeholders in order to validate related aspects of conceptual framework for responsible innovation implementation at the firm level, and 2) to operationalize the structure of the quantitative instrument constructs for RI implementation and adjust it to the business context. Hence, the *quantitative study* was used to study variables and their relationships with a large sample. The main purpose of a conducted survey was to test the hypotheses and validate the conceptual framework of RI implementation. The logic of the research design is presented in Figure 5.

Since two complementary studies were performed, the logic and methods of qualitative and quantitative studies are presented separately in the further sections (see 2.2.1. and 2.2.2.).
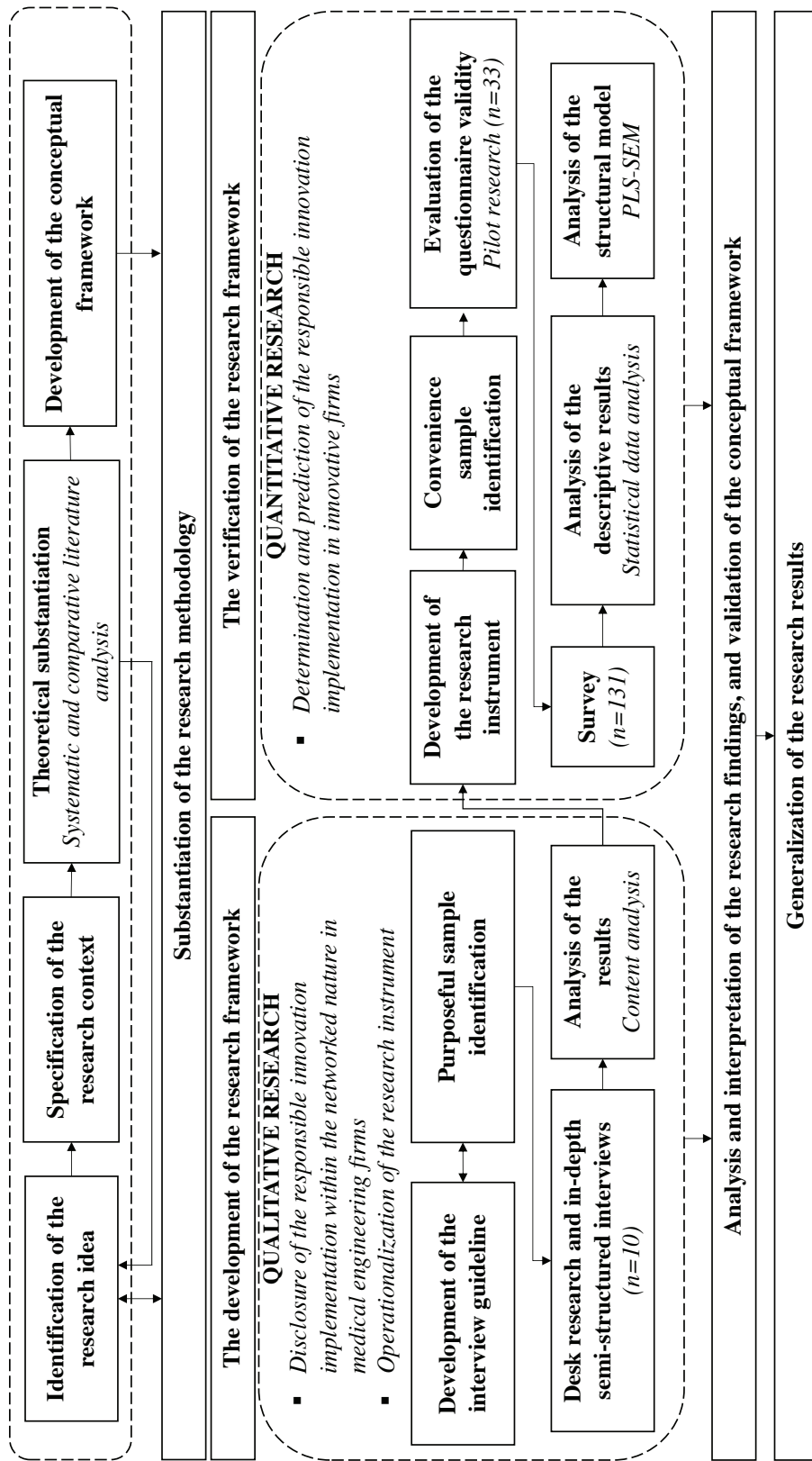
**Figure 5.** The logic of the research design structure

*2.2.1.   Qualitative Study*

*The case study* method was used in order to gain detailed information and systematically analyze the dynamics of a particular situation and to find out less obvious aspects compared to the survey (Tellis, 1997; Rahim, Baksh, 2003). *A semi-structured interview* was applied (Frechtling, Sharp, 1997; Kvale, 2007) to gain new insights by revealing different views and opinions of the people with correcting or/and additional questions (Tidikis, 2003; Braun, Clarke, 2013). The interview guideline was based on indicators extracted from literature. Following the suggestions of Gioia, Corley and Hamilton (2013), the interview guideline was prepared in advance in coherence with the research questions (see Appendix 1).

*Case Selection.* The qualitative study is based on the assumption that the majority of innovative companies will be constrained by (some of the) institutional norms in the future. Thus, medical engineering firms are suitable for initial analysis due to their constrained nature via dependence on institutional regulations and standards. Since the concept of RI is yet unexplored in Lithuania, medical engineering firms were selected due to the relation of their innovative activity with some of the Grand Challenges (like health issues, ensuring affordable prices of the devices and drugs for the society, etc.) that should be mitigated or solved via the concept of Responsible Innovation. Medical engineering firms also work in a networked nature – they are depended on internal and external stakeholders (Gelijns, Rosenberg, 1999). At the same time, it is clear that in the future some of the Grand Challenges will be institutionalized and certain firms will have to adopt new standards along their innovation process. Furthermore, medical engineering firms are guided not only by regulations but also by ethical and medical standards. Therefore, it serves as a good practice example regarding Responsible Innovation implementation, where the innovation process is partially regulated. Another important reason for choosing this industry is that medical engineering firms have to combine both social and ethical responsibilities while competing in the market. Thus, these firms experience the paradox of the need to behave in a responsible manner and at the same time to gain economic benefit and competitive advantage. Therefore, medical engineering firms are the most appropriate to analyze RI implementation in Lithuanian context.

In line with the literature, a purposeful sample of 10 case firms was chosen in order to examine the phenomenon thoroughly (Yin, 2003). Following the suggestions in the case study literature (Eisenhardt, 1989; Patton, 2002), a *purposeful sampling* approach under the following criteria was deployed to meet the focus of this study:

1) firms are R&D intensive;
2) some of the Grand Challenges are reflected and integrated into the innovation orientation of the firm;
3) firms are awarded as being successful in innovative activities and being exemplary in sustainability and/or corporate social responsibility by national institutions;
4) firms state their responsible orientation towards innovative activities in firms' strategy, mission or vision;

5) firms' innovative activities are based on standards, regulations, or codes of conducts;
6) firms are open to society and/or cooperating with civil society;
7) firms operate in various types of networks during their innovation implementation;
8) firms collaborate with a variety of external stakeholders during their innovation implementation.

*Selection procedure.* At first, firms that were awarded for their innovative products, sustainability and/or corporate social responsibility aspects applied in their innovative activities were searched in the websites of national agencies organizing such yearly awards like "The most innovative firm", "The most sustainable firm", etc. Firms in medical engineering or pharmacy sectors were chosen for further selection according to the aforementioned selection criteria. The rest of the firms were found on the websites of medical or pharmaceutical associations, clusters, etc.

*Data Collection.* Two data sources were used to triangulate the data (Yin, 2009) – 1) desk research and 2) in-depth semi-structured interviews. To select a representative sample and to get acquainted with the firms' innovative activities and their stakeholders, at first, secondary data was collected from all accessible sources of information about the firms, such as press releases, newsletters, videos from conferences they participated in, financial statements, official reports, and membership in various associations and clusters.

In-depth semi-structured interviews were conducted with the CEOs, technology-, innovation-, quality- or project managers of the case study firms. To ensure the disclosure of the research object, informants with different characteristics, i.e. gender and age were chosen (Bitinas, Rupšienė, and Žydžiūnaitė, 2008). It was important that they have systematic knowledge on innovation implementation at the firm. During interviews the concept of responsible innovation was explained in order to have the required understanding about the topic.

A total of 13 interviews with 15 interviewees from ten different firms were made. All interviews were held in Lithuanian language in a face-to-face manner. The interviews were conducted between September 2015 and October 2017 at the workplace of the case firms. All interviews were recorded upon agreement with the interviewees and lasted from 42 to 75 minutes. Follow up emails and phone calls with some of the interviewees helped to clarify some missing data.

*Data Analysis.* The interview transcripts were transferred to, coded and analyzed with qualitative and mixed methods data analysis software Maxqda12, which was chosen due to its suitability to analyze a large amount of qualitative data: long interviews and different types of information. The software helps to integrate different sets of information into a more holistic perspective. The data were then thematically analyzed. This entailed condensing the data set by assigning codes to the text of varying sizes such as words, sentences, and paragraphs (Miles, Huberman, 1994). The multiple case study analysis was used to deeply understand the implementation of responsible innovation of each case (Eisenhardt, 1989). As the following step, cross-analysis was used to compare these patterns within the cases. Following the guidelines of the case study literature (Eisenhardt, 1989), categories

were checked for differences and similarities across the cases. As the interviews were originally in Lithuanian, significant quotes were then translated to English.

**Ethics Precautions.** In this study, research was conducted in an ethical manner: the free will of the participants to take part in the research (Kardelis, 2007), the research purpose and preliminary questions were introduced before meeting with the interviewees (Žydžiūnaitė, 2007), and the privacy of the firms' names and informants was ensured upon the wish of the interviewees (Rupšienė, 2007).

### 2.2.2. Quantitative Study

**Instrument Development.** The research instrument of the AISTIS project contained 17 large research blocs. A total of 31-question survey instrument with 305 items for the AISTIS project was developed. In the introductory part of the questionnaire, a screening question to select the sector in which organization is operating by NACE Rev. 2 enabled to filter the respondents according to the strata. The control questions to select innovative organizations were the following indicators of the organization: ratio of R&D and the total sales, the share of workers involved in innovative and engineering activities, or in cooperation and partnership activities for innovation, the share of investment in the staff development and training regarding the turnover, the share of new products or services in the total sales, the created new ventures, and the number of patents and licenses. Due to the length of the questionnaire, it was divided into question groups, so that it would be more comfortable for the respondent (Blair, Czaja, and Blair, 2014).

The first part of the questionnaire was dedicated to the demographic questions of an organization: name of an organization (not obligatory question), municipality in the country, the year the organization was established, is an organization foreign- or national-capital based, number of employees, the percentage of employees with higher education, the sex of the head of the organization, the main market of the organization (Business to Business or Business to Customer), and the main sector that the organization is operating in.

The second part of the questionnaire regarding Responsible Innovation implementation at the firm level consists of three diagnostic blocks that cover Innovation orientation towards Grand Challenges, Responsible Innovation activities, and decision-making. For all constructs a reflective specification mode was used since items were interchangeable and highly correlated (Diamantopoulos, Winklhofer, 2001; Hair et al., 2014b). Due to the scope of the survey, it was divided into three parts with a possibility to save the results from the first and second part to gain more results. Thus, it was possible to finish the first and/or second part of the questionnaire without answering to all of the questions.

Due to the newness of RI topic and the lack of empirical research (especially in the business context), it was not possible to find any existing constructs and measures that would investigate RI at the firm level. The measures employed in this study were drawn from the related literature, and in some cases they were operationalized during the qualitative study and adapted to fit the context of the study. In addition, to ensure the validity of the constructs, two researchers working

in the field responsible innovation implementation in the business sector were consulted regarding the development of measures.

   *Innovation orientation towards Grand Challenges.* The items were developed according to RI scholars (Sutcliffe, 2011; Von Schomberg, 2013) and main European documents related to Grand Challenges (Lund Declaration, 2009; European Union, 2010; European Commission, 2012; Van den Hoven, 2013a) (Table 8). The measures were developed on the basis of von Schomberg's (2013) normative anchor points (reflecting the Grand Challenges) that should be addressed when developing an innovation: "high level of protection to the environment and human health, sustainability, and societal desirability" (p. 21). According to these categories, the measures were developed and adapted in relation to the business sector.

**Table 8.** Operationalization of the research model constructs (Innovation orientation towards Grand Challenges)

| [Q20] Innovation orientation towards Grand Challenges construct and items | Authors |
|---|---|
| 1. [During innovation development, we seek] … to contribute to mitigating the global warming | Adapted from Lund Declaration (2009), European Commission (2012), Van den Hoven (2013a), Von Schomberg (2013) |
| 2. …to contribute to solving energy, water and food preservation problems | Adapted from Lund Declaration (2009), Sutcliffe (2011), European Commission (2012), Van den Hoven (2013a), Von Schomberg (2013) |
| 3. …to contribute to solving sustainable economic growth problems | Adapted from European Union (2010), Von Schomberg (2013) |
| 4. …to contribute to solving health issues | Adapted from Lund Declaration (2009), Sutcliffe (2011), Von Schomberg (2013) |
| 5. …to contribute to solving ageing society problems | Adapted from European Commission (2012), Van den Hoven (2013a) |
| 6. …to contribute to solving social exclusion and discrimination problems | Adapted from European Union (2010), Von Schomberg (2013) |
| 7. …to contribute to solving privacy issues of society | Adapted from Lund Declaration (2009), Sutcliffe (2011), Von Schomberg (2013) |

   Following the decision rules of Hair et al. (2014b), Grand Challenges were measured reflectively. The causality is directed from the construct to items. The items and their wording were adopted to the business context. To measure a firm's intention to integrate Grand Challenges into innovation development, a 7-point Likert scale ranged from "strongly disagree" to "strongly agree". The option of "I don't know" was available for every question, however, items with these values were excluded from further analysis.

   *Decision-making.* Based on RI literature, a research gap was found in relation to decision-making during RI implementation. However, due to the specifics of RI context (more specifically – in relation to the business context), no research was found that could be used for operationalization. Thus, after careful deliberation, the constructs of institutional, ethical and techno-economic decision-making during the

RI implementation were elaborated based on different streams of related literature presented in Section 1.3.3. and on the basis of qualitative study (Table 9).

**Table 9**. Operationalization of the research model constructs (Decision-making constructs)

| [Q23] Decision-making constructs and items | Authors |
|---|---|
| ***Institutional decision-making construct***<br>1. [During innovation development] … we take the opinion of our innovation partners and stakeholders into account<br>2. … we take in to account the prevailing opinion of society<br>3. … we take in to account institutional regulations and standards | Adapted from Paauwe, Boselie, (2003); Bolfíková et al. (2012); Von Schomberg (2013); Pavie et al. (2014) |
| ***Ethical decision-making construct***<br>4. … we follow our internal ethical standards in the innovative activities<br>5. … we choose innovation partners by considering their ethical standards of activities | Adapted from Santana, Vaccaro, and Wood (2009); Guston (2013); Stilgoe et al. (2013); Pandza and Ellwood (2013); Von Schomberg (2013); Grunwald (2014); Fuentelsaz, Garrido, and Maicas (2015) |
| ***Technological decision-making construct***<br>6. … we choose innovation partners by considering the competencies that we lack in our organization<br>7. … we choose innovation partners by considering the technological compatibility<br>8. … we choose innovation partners by considering the socio-technological compatibility | Adapted from Wernefelt (1984); Barney (1991); Conner and Prahalad (1996); Ahuja (2000); Powell, Grodal (2005); Schroeder et al. (2002); Vanhaverbeke et al., (2008); Halme and Korpela (2014); Blok and Lemmens (2015) |

The institutional decision-making construct was developed on the basis of formal and informal norms. During interviews, firms emphasized the role of institutional regulations and standards, thus it was included into the instrument. Additionally, firms mentioned the importance of firms' innovation partners and other stakeholders such as professional colleagues related from the knowledge and technology point of view during responsible innovation implementation. However, according to RI literature (Von Schomberg, 2013; Pavie et al., 2014), it is important to take into account the importance of the prevailing opinion of society, as innovative firms operating in other sectors might be more dependent on the societal opinion. Hence, formal norms are measured with item 1 (we take the opinion of our innovation partners and stakeholders into account) and item 2 (we take in to account the prevailing opinion of society), while formal norms are measured with item 3 (we take in to account institutional regulations and standards).

Regarding the ethical decision-making construct, items were developed on the relevant stream of literature and qualitative study results. The importance of a firm's internal ethical values and standards, and the ethical standards of firms' innovation partners were mentioned as highly important during interviews. Consequently, there were two types derived to measure the ethical decision-making construct: the firm's internal ethical standards were measured with item 4 (we follow our internal ethical

standards in the innovative activities) and the ethical standards applied by the innovation partners were measured with item 5 (we choose innovation partners by considering their ethical standards of activities). During interviews, it was also expressed that in relation to ethical decision-making, firms consider internal ethical standards and ethical standards as applied by the firm's innovation partners.

The measures of techno-economic decision-making were developed by consulting related literature and qualitative study results. During interviews, a particular emphasis was given for techno-economic aspects in relation to innovation partners during responsible innovation implementation. Thus, it was decided to focus on the techno-economic decision-making regarding firm's innovation partners. Hence, techno-economic decision-making were measured with item 6 (we choose innovation partners by considering the competencies that we lack in our organization), item 7 (we choose innovation partners by considering the technological compatibility) and item 8 (we choose innovation partners by considering the socio-technological compatibility).

Following the decision rules of Hair et al. (2014b), the constructs of institutional, ethical and techno-economic decision-making were measured reflectively. The causality is directed from the construct to items. To measure institutional, ethical, or techno-economic decision-making, a 7-point Likert scale ranged from "strongly disagree" to "strongly agree". The option of "I don't know" was available for every question, however, items with these values were excluded from further analysis.

***Responsible Innovation activities.*** Unfortunately, there were also no established measures with regard to responsible innovation activities at the firm level. Originally, Responsible innovation dimensions that describe RI activities were established by Stilgoe et al. (2013). The four original dimensions by Stilgoe et al. (2013) are anticipation, reflexivity, inclusion, and responsiveness. However, there was a need to operationalize these dimensions in the business context, since these dimensions were established in the context of a public project on geoengineering. Responsible innovation dimensions were renamed as RI activities as they relate more to the main principles that those consisting activities of each dimension represent. Literature analysis of RI activities in the business context (Van den Hoven, 2013; Pavie et al., 2014; Blok et al., 2015; Pavie, Carthy, 2015) were used to operationalize the items.

On the basis of argumentation in literature review (see section 1.2.2.) and RI-related literature in business context, RI activities were developed as three constructs: anticipation, reflexivity, and responsiveness (Table 10). Anticipation activities were measured with item 1 (We consider possible consequences of innovation from a long-term perspective (more than 3 years) for the benefit of the society and environment), item 2 (We anticipate possible ethical, ecologic, economic, and social risks of innovation), item 3 (We develop a few possible scenarios of innovation development), and item 4 (We evaluate the whole life-cycle of the innovation with regard to the environment and society). Reflexivity activities were measured with item 5 (We are transparent while evaluating possible risks of innovation), item 6 (We openly discuss the threats and limits of our innovation

within an organization), and item 7 (We are dealing with incompatible values for the benefit of the environment and society). Consequently, responsiveness activities were measured with item 8 (We integrate relevant stakeholders into the innovation process), item 9 (We are transparent towards innovation partners and stakeholders about the content of the innovation), item 10 (We adjust our innovation for the environmental and societal benefit accordingly to the significant information given by the innovation partners and stakeholders), and item 11 (We provide feedback for the innovation partners and stakeholders what is done (or not) with their input during the innovation process).

**Table 10**. Operationalization of the research model constructs (Anticipation, Reflexivity and Responsiveness constructs)

| [Q24] Responsible Innovation activities constructs | Authors |
|---|---|
| *Anticipation activities construct* <br> 1. We consider possible consequences of innovation from a long-term perspective (more than 3 years) for the benefit of the society and environment <br> 2. We anticipate possible ethical, ecologic, economic, and social risks of innovation <br> 3. We develop a few possible scenarios of innovation development <br> 4. We evaluate the whole life-cycle of the innovation with regard to the environment and society | Adapted from Stilgoe et al. (2012); Van den Hoven (2013); Pavie et al. (2014); Blok et al. (2015); Pavie and Carthy (2015) |
| *Reflexivity activities construct* <br> 5. We are transparent while evaluating possible risks of innovation <br> 6. We openly discuss the threats and limits of our innovation within an organization <br> 7. We are dealing with incompatible values for the benefit of the environment and society | |
| *Responsiveness activities construct* <br> 8. We integrate relevant stakeholders into the innovation process <br> 9. We are transparent towards innovation partners and stakeholders about the content of the innovation <br> 10. We adjust our innovation for the environmental and societal benefit accordingly to the significant information given by the innovation partners and stakeholders <br> 11. We provide feedback for the innovation partners and stakeholders what is done (or not) with their input during the innovation process | |

Following the decision rules of Hair et al. (2014b), RI principles were measured reflectively on a 7-point Likert scale ranging from "strongly disagree" to "strongly agree". The option of "I don't know" was available for every question, however, items with these values were excluded from the further analysis.

The resulting items were reviewed to ensure that the meaning was preserved through adoption and translation to Lithuanian. The original language of all the items was English. In order to ensure consistency and to test the translation, the backwards translation method was used (Singh, 1995). At first, the questionnaire was translated

from English into Lithuanian. Secondly, two academic researchers translated it back into English. Eventually, the original items were compared with the two translated English versions and the discrepancies were resolved. A final version of the questionnaire in the Lithuanian language is provided in Appendix 2 and the questionnaire in the English language is provided in Appendix 3.

*Pilot Study.* The pilot study consisted of two steps. After developing the first version of the questionnaire, the research instrument was refined using the evaluation of academic and business experts in order to establish the content validity regarding representativeness, comprehensibility of the questions, suitability of scales, etc. (Blair et al., 2014). The questionnaire was modified according to the feedback of experts when the suggestions improved items without modifying them significantly.

A joint workshop and a focus group organized by UAB Pokyciu valdymas were organized in order to find out the possible issues the respondents might encounter in a self-administered questionnaire. The focus group was asked to fill in the questionnaire on a printed version and note their comments regarding the clarity of instructions, questions and layout. The time needed for the questionnaire to fill in was tracked. After completing the questionnaire, the focus group was asked to share their feedback and possible modifications for the questionnaire were assessed. In general, results indicated that construct definitions for the study variables were well understood, only some minor improvements of the research instrument were made. After modifying the questionnaire, a pilot study was conducted to ensure the validity of items and to see how respondents react to questions (Garson, 2002), and to test and refine the measurement instrument on a convenience sample of 38 innovative organizations. 33 valid responses were acquired (response rate 86%). Research administration and a statistical summary were conducted by experts at UAB Pokyciu valdymas. Final reliability and validity results of the questionnaire are presented in subchapter 3.2.

*Sample.* The quantitative research of this study was a part of a larger research project entitled "Open innovation ecosystems: enabling interactions of technological, institutional and social constituents (AISTIS)" (Research funded by Lithuanian science council under the "Welfare society" program GER2015/001). The goal of the research project was to analyze the relationships of the actors in Lithuanian innovation system and their behaviors within the open innovation ecosystem. To obtain a representative sample, innovative organizations were targeted, covering all the sectors in which the actors of the Lithuanian innovation system might be acting.

*Data collection.* To collect the primary data, probability sampling (the stratified random sampling) was applied. This technique allowed to divide the population based on sector classification according to the statistical classification of economic activities in the European Community (NACE Rev. 2). Since there is no database or list, where all innovative organizations could be found, the list of all registered active organizations was used. A target sample of 500 innovative organizations was set out as a representative regarding the fact that there were 93017 active organizations in Lithuania at the beginning of 2015 (Statistics Lithuania, n.d.). Screening questions in the introductory part of the survey were introduced to ensure

a proportional representation of a statistically reliable sectorial distribution (according to NACE Rev. 2) of the active organizations in Lithuania within the collected sample, and later – within the collected responses from innovative organizations. Hence, the sample was made to be representative in terms of the population.

An online survey was implemented using the method of *Computer-Web-Assisted Personal Interviewing* (WAPI), this type of questionnaire was selected as the most suitable. A self-administered internet survey was used as it is a convenient, rapid and cost-efficient way to reach the respondents (Blair et al., 2014). In order to ensure that the respondent possessed the required knowledge and qualification, a personal email with a detailed information about the survey (and the internet link to the survey) was sent, also noting that the respondent should be at the top-management level within the organization responsible for innovation management.

UAB Pokyciu valdymas also executed the data collection for the main study. The survey was created with the LimeSurvey software package and placed on the servers of the data collection company. Data for the main study was collected in January–March 2016, and the pilot study samples were excluded from the main test.

In total, 1,524 out of 93,017 registered active actors of the Lithuanian innovation ecosystem operating in public or private sectors participated in the survey. A total of 551 entries were collected from innovative organizations after the control questions were selected. This study uses the sample of organizations operating in the private sector. For all the items used in this analysis, items having non-response of 5% and less were selected. Out of 551 organizations, 131 responses from the organizations operating in the business sector were chosen for the final sample after removing outliers and straight lining.

*Data analysis.* Structural equation modelling (SEM) was used in order to simultaneously link latent variables associated with theoretical concepts that were later used as indicators and estimate the relationships among these latent variables. As this research is focused on identifying new relationships of the constructs fostering the implementation of RI activities in firms, it used the PLS-SEM method. SEM PLS was chosen because of the sample size and the difficulty of the survey that integrates different scales of various authors (Hair et al., 2014a).

SEM is multivariate data analysis, which is based on a theoretical model involving unobservable latent variables and a measurement model (Haenlein, Kaplan, 2004). There is a growing use of SEM in social sciences as it provides researchers with a complete resource for assessing theoretical models (Anderson, Gerbing, 1988). To explore the new relationships between constructs that have to be analyzed simultaneously, SEM as a multivariate data analysis method is appropriate for construct validation as it has advantages over other traditional approaches, such as multi regressions (Gefen, Straub, 2000).

Partial least square approach (PLS) was applied since the research model specification cannot be ensured due to a small sample size and little is available of RI theory on application (Fornell, Cha, 1994; Wong, 2013). In general, path analysis allows a better understanding of relationships among constructs which is lacking in regression models. Partial least squares SEM (PLS-SEM) is a counterpart to

covariance-based SEM (CB SEM) with certain advantages coming from its algorithm, the least squares estimation, focus on prediction and not requiring joint normal distribution of manifest variables result in lower sample sizes required, higher numbers of latent and manifest variables in the model and other advantages (Chin, 1998; Hair et al., 2014b). On the methodological side, CB SEM is better for theory testing, while PLS SEM is more suitable for theory development (Hair et al., 2014a).

The PLS-SEM method was also selected as more appropriate for the data and nature of this research as it seeks to reveal new relationships among previously not studied variables (Hair et al., 2014a), such as innovation orientation towards Grand Challenges, decision-making, and RI activities. Furthermore, the use of PLS-SEM in innovation management contexts is increasing (Hair et al., 2012).

## 3. FINDINGS OF THE EMPIRICAL RESEARCH ON RESPONSIBLE INNOVATION IMPLEMENTATION IN A FIRM

### 3.1. A Qualitative Analysis of the Networked Nature of Responsible Innovation Implementation in Medical Engineering Firms

*Overview of the cases*

*Firm 1* is based on the invention of non-invasive intracranial pressure measurement (NCP) device; the company has developed a suite of ultrasound-based devices to non-invasively measure the absolute value of intracranial pressure (ICP), real-time cerebral blood flow auto-regulation (CA), and intracranial volumetric wave monitoring.

*Firm 2* is a biotechnology product development company, developing innovative analytical instruments, lab equipment and specialty diagnostics that provide rapid and accurate results for customers in research, clinical and applied markets.

*Firm 3* spearheads the development, production and marketing of a wide range of specialty medicines, generic products, active pharmaceutical ingredients (API) and novel new therapeutic entities.

*Firm 4* is the largest cosmetics manufacturer in Lithuania that develops beauty nourishment products by innovating and utilizing the best resources of nature and the most innovative ingredients of cosmetics.

*Firm 5* is an innovative Lithuanian company which created a lung health monitoring device for asthma patients.

*Firm 6* is a young and ambitious company consisting of professionals with high competencies in the health sector. The main activity of the company is to organize and perform scientific research and on this basis commercialize innovative products in the health sector.

*Firm 7* is a Lithuania-based provider of cutting-edge robot-supported automation technology for the telecom and healthcare industries.

*Firm 8* manufactures and adjusts prosthetic, orthopedic and occupational therapy products for Lithuanian people after operations, injuries or disabilities. Individually produced and adapted to a variety of orthoses, prostheses, shoe inserts, orthopedic footwear.

*Firm 9* is a company in the molecular biology field. The company develops DNA sequencing technology.

*Firm 10* is creating innovative software-based medical visualizations to improve the quality of patient care.

Details of the case study firms are provided in Table 11. In order to ensure anonymity, codes are given instead of the real names (Gioia, Corley, and Hamilton, 2013).

**Table 11**. Profiles of the case firms

| Case firm | Year | Industry (NACE code) | Size[3] | Number of interviews | Number of informants and position in a firm | Interview duration |
|---|---|---|---|---|---|---|
| Firm 1 | 2009 | MANUFACTURING, 26.60 Irradiation, electromedical and Electrotherapeutic Apparatus Manufacturing | small | 3 | 1 – CEO<br>2 – Quality manager<br>3 – Innovation manager | 42 minutes<br>52 minutes<br>45 minutes |
| Firm 2 | 2010 | MANUFACTURING, 20.13 Other Basic Organic Chemical Manufacturing | large | 1 | 1 – Project manager | 75 minutes |
| Firm 3 | 2004 | MANUFACTURING, 21.20 Pharmaceutical Preparation Manufacturing | medium | 1 | 1 – Technology manager | 65 minutes |
| Firm 4 | 1991 | MANUFACTURING, 20.42 Perfume and Toilet Preparation Manufacturing | medium | 1 | 1 – CEO | 83 minutes |
| Firm 5 | 1993 | MANUFACTURING, 32.50 Medical and odontology equipment, instrument and maintenance manufacturing | medium | 1 | 1 – CEO | 63 minutes |
| Firm 6 | 2011 | PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES, 72.19 Other Scientific Research and Development in Life Sciences and Engineering | micro | 1 | 1 – CEO | 73 minutes |
| Firm 7 | 2009 | PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES, 71.12 Engineering and related technical consulting service | small | 1 | 1 – CEO | 61 minutes |
| Firm 8 | 2016 | PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES, 72.11 Research and Development in Biotechnology | micro | 2 | 1 – CEO | 55 minutes |
| Firm 9 | 2014 | INFORMATION AND RELATIONS, 63.99 All other information services | micro | 1 | 1 – CEO | 62 minutes |
| Firm 10 | 2007 | INFORMATION AND RELATIONS, 62.01 Computer software programming services | small | 1 | 1 – Quality manager | 67 minutes |

[3] Firm's size is defined under Eurostat (n.d.), where *micro* enterprises have less than 10 persons employed; *small* enterprises have 10–49 persons employed; *medium*-sized enterprises have 50–249 persons employed; *large* enterprises have 250 or more persons employed.

*The notion of responsible innovation and its implementation in the case study firms*. Most of the firms were not yet aware of the concept of Responsible innovation. Case study firms were usually confusing the term with the concept of CSR by providing information that was not related to the innovation implementation, but rather to activities outside the work, like taking care of homeless children, planting trees or supporting the local community.

However, after explaining the differences between the concepts, the majority of the theoretically described elements of Responsible Innovation (see section 1.1.1. Table 2) were found in the case firms (Table 12). All of the firms were aware of the main *Grand Challenges* like sustainability, privacy issues, social exclusion and discrimination, and of course, healthy ageing and health issues, and firms were addressing these Grand Challenges with their innovative products. Health issues were certainly the main pillar of the cases firms' innovative activities, and they are trying to address health problems with their innovation. In some cases, firms' (like Firm 2, Firm 8) intentions were not only to provide an innovative product that would solve some specific health issue, but they also try to provide such health products that would be affordable for social groups with lesser income. Furthermore, firms were trying to integrate aspects of sustainability into their innovation activities.

**Table 12**. The main elements of Responsible Innovation manifesting in case study firms

| Category | Sub-category | Significant quotes |
|---|---|---|
| *Grand Challenges* | *Health issues and social exclusion* | "Basically, in every stage of innovation development, we try to think about the life-cycle costs, we integrate sustainability aspects in our innovation development." (Firm 2) |
| | *Sustainability* | "He [the doctor, a colleague of a CEO] wanted to create a solution which could make it possible to heal without operation, especially, for those who could not afford that operation." (Firm 8; addendum by author) |
| *Socio-ethical responsibility* | *Positive input for creativity* | ,,The American government has banned research with babies' stem cells and ethical research suddenly is beginning. Researchers do not do any research with babies' stem cells and it turns out that it is possible to genetically modify any kind of cell and turn it into a stem cell. Therefore, only such a strong limitation has made it possible to discover new ways." (Firm 1) |
| *Democratic innovation process* | *Reflexive and open innovation practice* | "Finally, our New product committee finishes their job by ensuring that this new product is really safe, that the features didn't change during the development process and it functions as it was planned, they evaluate the risks for the environment." (Firm 2) "Maybe it is our sector, but it is very important to stop after each innovation phase and reflect on how the processes are going." (Firm 3) "Rather than asking 'who is guilty', we instead investigate why this happened, what could we do that it would not happen again." (Firm 4) "There are constant ideas about how to improve our product, and this is usually such a condensation of what we've seen at our competitor, |

| | | |
|---|---|---|
| | | what the clients have said, and… If this is possible to implement technologically." (Firm 5) |
| **Stakeholder engagement** | *Inclusion of innovation partners* | "Usually, when we launch a new product, we meet with doctors and discuss about the product, i.e. does it meet the initial idea regarding features and quality, what could be improved, what new functions could be added that are crucial to the doctors." (Firm 10) |
| | *Client's inclusion* | "Clients are included when we need their opinion about the usage of the product, its package." (Firm 4)<br>"If we have positive research results, then we include many people like potential clients in our further product development. Clients' opinion is important for us because they will use our product eventually." (Firm 3) |
| **Mutual/ collective responsibility** | *Mutual responsibility with partners* | "It took about half a year until we found trustworthy partners for our innovation development. We had situations that some partners would disappoint us by disappearing or being not capable of delivering the quality we ask for. I feel quite certain about our current network of partners who I trust, and this is really nice feeling because they can take care of certain things and we can be sure about their quality, and, eventually, about our quality." (Firm 8)<br>"Sometimes there are situations where we are almost done with the product launch, and then, suddenly, some doctor "wakes up" and suggests a new feature to integrate into the product. Sometimes it is feasible, sometimes we postpone to the next version of our product. But we are responsive to our end-users, and they are aware of what and how we develop our innovation." (Firm 10) |
| **Meta-responsibility** | *Additional actions to ensure higher level of responsibility* | "You can have all the formal documents confirming the eligibility of your product, but if you do it [research] for, as I say, not for the documents themselves, but you just have to take additional actions to make yourself clear that this [product] is really effective, it really helps." (Firm 4) |
| **Positive innovation process and its outcomes** | *Long-term anticipation* | "You have to anticipate your possible innovation idea for a few years ahead. Of course, it is quite difficult to do that in the scientific field, but you cannot act against the nature." (Firm 2) |
| | *Institutional feedback system* | "After the launch of a new product, the feedback system is very important. Usually, medical institutions are giving these institutional feedbacks depending on patients' wellbeing due to our products. If there are some negative consequences for patients, we try to find out what and why it happened. However, if some aspects were unanticipated throughout the innovation process, after some negative consequences for patients, our innovation could be eliminated, and we must check our innovation again, including clinical studies." (Firm 1) |
| | *Firm's own feedback system* | "Our administrator works responsibly on the clients' feedbacks. Every feedback is analysed carefully and then we check the negative aspects of our products all together in a company, and we try to come up with the best solutions." (Firm 4)<br>"We have the so-called Quality journal, where we register all the complaints, defects, and other type of feedback, which help us to improve our products. Our clients' feedbacks are very important for our professional development." (Firm 5) |

In relation to *socio-ethical issues*, despite the strict rules in the medical sector, it can actually foster creativity and new solutions, so institutional regulations could lead to positive outcomes. In the case of RI context, there are various environmental, social and ethical issues that have to be mitigated by various actors worldwide, thus new regulations and standards towards sensitive issues foster creativity, new and alternative ways to innovate responsibly.

In relation to a *democratic innovation process*, most of the firms were applying reflexive and a more inclusive perspective towards innovation implementation, also by raising questions of intent regarding innovation.

With regard to *stakeholder engagement*, it is actually problematic to include the wide society into innovation implementation due to intellectual property issues. Mostly, firms tend involve the related innovation partners during innovation implementation. In other cases, firms open up only when they feel "safe" that they have developed the innovative product and only related questions to packaging, aesthetics, or external aspects of innovation are relevant.

Regarding *mutual/collective responsibility*, the situation is similar as in the case of stakeholders' inclusion. Firms tend to make the collective commitment with trustworthy innovation partners for better (firm's and societal) future.

In relation to *meta-responsibility*, innovative firms certainly take additional actions during innovation implementation. They tend to put in additional thoughts and take additional actions to improve innovation.

In the case of *positive innovation process and its outcomes*, the majority of the case firms also put additional efforts in forecasting the outcomes of innovation but this is related to the field that firms are working in, where there is a direct contact with human health. Therefore, most of the firms invest in a high quality feedback system or get the feedback from doctors when the innovative product is approved and available to use for patients.

*Finding a responsible idea together with external stakeholders, which would solve an existing problem* (Table 13). The case firms tend to make full use of their external stakeholders in the idea generation phase. When searching for an innovative solution that would serve people, external stakeholders, e.g., professional colleagues, researchers and informal knowledge networks, play a major role in all the case firms. Firms seek out new ideas, but it is extremely important that these ideas are coming out of the real need, i.e. would solve an existing health problem. Thus, the innovation orientation towards the Grand Challenges is clearly established in medical engineering firms with the interactions of the external stakeholders.

A very clear example was the case of Firm 5, where their most popular medical innovation was enforced by a professional colleague of the firm's CEO. He came with an idea of how the existing problem could be solved for the benefit of society. Instead of having surgery, the professional colleague suggested technology that would allow more people to get cured with lower costs. The openness of the firm's CEO towards its external stakeholders and the willingness to try new solutions was a success for a company.

**Table 13.** External stakeholders during the responsible idea exploration phase

| Category | Sub-category | Significant quotes |
|---|---|---|
| **External stakeholders** | *Professional colleagues* | "My colleague doctor was raising a question how we could heal the patient without a need to make surgery and make it more available for most of the society. Our most popular innovation for knee joint started when the doctor came to me with his idea, which was patented and could easily save many peoples' health in an affordable way." (Firm 5) |
| | *End-users* | "We ask our end-users, for example: "Would this kind of product help you out in your everyday life? Would it make your illness a bit easier to live with?" (Firm 9) |
| | *Clients* | "Our client is the best hospital in the country. This is a fantastic place to discover ideas and realize them together with them. Because if we create innovation that will fulfil the needs of this hospital, we can be sure that we developed the innovation with the highest potential and best features." (Firm 10) |
| | *Informal knowledge network* | "Ideas for innovation come from informal chats in the professional community, and then suddenly you realize that this idea has potential and can possibly solve the existing problem." (Firm 7) |
| | *Researchers* | "Companies do not search for ideas inside the company in the medical sector. Ideas come from scientists. Pharmacy is a kind of industry that it is necessary to comply with the law and requirements in order to commercialise innovation. Therefore, innovative ideas have to come from outside because it is just impossible to finance such expensive research." (Firm 3) |

Another example of striving to find a responsible and innovative solution was expressed by Firm 9: "We ask our end-users, for example: "Would this kind of product help you out in your everyday life? Would it make your illness a bit easier to live with?"". Such ideas are more reliable and have more potential to be successful, as it brings value for the society. Professional colleagues and end-users (e.g., hospitals) are included in the ideation process because of the experience and knowledge of what innovative idea would be beneficial for society.

However, case firms admit that another reason for searching for potential innovation ideas outside is also based on the economic rationale. For R&D-intensive firms, it is too expensive to develop all ideas inside the company, because they have to invest considerably large amounts in product development, clinical trials, etc. Thus, firms constantly collaborate and meet with the lead users and professional colleagues to find out existing problems and potential solutions: "Ideas for innovation come from informal chats in the professional community, and then you suddenly realise that this idea has potential and can possibly solve an existing problem" (Firm 7).

The competent, high skilled and applying high standards in their activity is another important aspect regarding the choice of external stakeholders. Firm 10 admits that "our client is the biggest hospital in the country. This is a fantastic place

to discover ideas and realise them together with them. Because if we will create innovation that would fulfil the needs of this hospital, we can be sure that we developed the innovation with the highest potential and best features".

*Implementing responsible innovation in a networked nature.* During responsible innovation implementation, medical engineering firms experience the dominating role of institutional standards and regulations (Table 14). Legal requirements are necessary to ensure responsibility in relation to medical innovation, so firms concentrate on compliance with the law at first. It is crucial to develop the prototype and innovation according to the existing regulations and standards in order to pass the accreditation and ethics committees.

**Table 14.** External stakeholders during the responsible innovation implementation phase

| Category | Sub-category | Significant quotes |
|---|---|---|
| *External stakeholders* | *Committee of ethics* | "The new product has to be approved by an ethics committee, too. It is not important to them if I am a Nobel prize winner, or not, because the procedure is very strict." (Firm 1) |
| | *Accreditation committee* | "In this phase, the committee of professors in medicine is involved. They must give me a license for my new product, which confirms that innovation complies with all the needed requirements. If they give me this license, then it is their responsibility for giving me it. However, people in these committees are high ranked professionals. But I must admit that the decision to give a license for a new product depends on their morality and values." (Firm 1) |
| | | "Accreditation committee approves whether my product satisfies all the requirements, and only after this approval it is possible for us to move further with our innovation." (Firm 5) |
| | *Professional experts (colleagues)* | We integrate coaches in the feasibility stage because they know best how our innovation works on and with the people, like how they breathe, feel, how to observe the physical exertion. During the development process, their reflections upon our innovation are the most important." (Firm 6) |
| | | "The experience and expectations of the doctors we collaborate with is the main knowledge source that we seek for when we develop our innovation." (Firm 10) |
| | *Researchers* | "When we decide to develop an innovative idea, we search for partners outside the firm; usually, we purchase scientific research, so, we collaborate with scientists because we seek for the highest quality." (Firm 7) |
| | | "Collaboration with universities and students give us the greatest joy because due to this collaboration we improved our innovation a lot." (Firm 8) |
| | | "In order to proceed with the prototype that we had, we needed certain knowledge, we could not risk by finishing it ourselves. <...> We have a team of professionals in medicine, who consult and help us with our innovation development, so we can be sure that we will achieve the best quality possible." (Firm 9) |

While some medical engineering firms are less restricted by the standards and regulations, they integrate external stakeholders even more actively: "The experience and expectations of the doctors whom we collaborate with is the main knowledge source that we seek when we develop our innovation" (Firm 10). In a long-term perspective, firm's external stakeholders even set the higher innovation management standards to implement responsible innovation. These firms strive to remain embedded in their external stakeholders' networks in order to increase the value of innovation towards society and environment because their external stakeholders are rich in knowledge, experience and competencies that could be used for responsible innovation implementation.

Responsible innovation activities regarding anticipation, reflexivity and responsiveness enhanced by external stakeholders actively are expressed in firms in order to meet the expectations of the future clients. Firms tend to apply reflexivity and responsiveness practices together with their end users: "We integrate coaches because they will work with our product and they know best how our innovation works with the people, like how they breathe, feel, how to observe the physical exertion. During development process, their reflections upon our innovation are the most important" (Firm 6).

*Decision-making aspects during Responsible Innovation implementation.* Institutional, ethical and techno-economic decision-making aspects were mentioned during the interviews. Regarding *institutional decision-making aspects*, the standards and regulations were repeatedly mentioned as the most important factor while making decisions during the implementation of responsible innovation (Table 15). Another finding was the importance of the opinion and discussion from firms' professional colleagues in relation to decision-making aspects during RI implementation. The case firms are embedding themselves into informal (international) professional networks, where they have the possibility to share and discuss potential issues related to innovation and to get complementary knowledge. High relevance of trust among the members provides the possibility to share insights and issues about the potential idea even in the early phase innovation.

**Table 15.** Institutional decision-making aspects during RI implementation

| Category | Sub-category | Significant quotes |
|---|---|---|
| *Institutional decision-making aspects* | *Formal norms as the most important instrument for RI* | „In this phase [innovation ideation phase], standards and regulations are inevitable, because it is the basis for the continuous development of the whole system towards the right way." (Firm 1; addendum by author) |
| | | „At first you feel very much constrained by all those requirements and regulations. But then, when you think about it more deeply, you can understand that this is the only way that influences you to behave in a responsible manner." (Firm 1) |
| | | "In medicine it is different, you can literally kill or injure a human, to harm their health <…>, there are strict regulations. You have to show evidence so that you would be allowed to enter the market. <…> That means there is an idea, that all the risks were assessed then design and architectural solutions are covered; then verifications are created, |

validation plan, all traceability from initial requirements, from business users' requirements to system requirements, design, verification protocol, that the risk were covered, that everything is ready for testing. And all that documentation referred to as a Design Folder has be sent to some kind of [institution] like America's FTA audit, who without your intervention, then analyze your submitted paper and then inform you whether it is good or bad. Otherwise, you have no right to sell it. And because you are engaged in such activities, you are forced to have those processes because you will not proceed otherwise." (Firm 7)

| | Informal norms coming from professional community | "I belong to one informal network, where there is no jealousy, instead, we treat each other as a family member. The very crucial aspect which unites us in this informal network is the comfort of sharing scientific knowledge, ideas and reflections from our innovative activities. All the members of this network are scientists and various professionals, and that gives a lot of valuable insights." (Firm 1) |

During interviews, firms acknowledged the importance of higher standards and ethical standards during responsible innovation implementation (Table 16). Two main ethical decision-making aspects were mentioned: firm's own ethical values and standards and those applied by firms' partners.

Table 16. Ethical decision-making aspects during RI implementation

| Category | Sub-category | Significant quotes |
|---|---|---|
| *Ethical decision-making aspects* | *Internal ethical values and standards* | "We have our own internal ethical standards and values that are crucial for our innovation process." (Firm 7) |
| | | "We feel responsible to our customers. Standards and regulations are mandatory, but you have to do it not for the regulations. It has to be done for the benefit of the human. We have a long-term strategic plan to stay in the market, so we cannot rely just on the standards, we have to exceed it. We can lose the trust very quickly, but to regain it again is almost impossible. My boss once taught me one lesson that I will never forget – better lose money, not confidence. You can't buy confidence." (Firm 4) |
| | *Ethical standards by innovation partners* | "And we take into consideration ethical standards applied of our partners." (Firm 7) |

Although institutional and ethical aspects during responsible innovation implementation are of high relevance for firms, they tend to mention techno-economic decision-making aspects as inseparable during responsible innovation implementation (Table 17). Specifically, techno-economic decision-making aspects are mostly related to firms' innovation partners. For medical engineering firms, it is crucial to have partners who are capable of technological skills. Since techno-economic aspects are also related to such aspects of economic responsibility as efficiency and quality of the innovation, case firms found the need to have technologically skilled partners as a very important resource for implementation of responsible innovation.

**Table 17.** Techno-economic decision-making aspects during RI implementation

| Category | Sub-category | Significant quotes |
|---|---|---|
| *Techno-economic Decision-making aspects* | *The importance of technological skills of innovation partners* | "For example, one detail of our innovation has contact with human skin. Therefore, we need to print this detail in such a way that it would be suitable for the contact with the skin, furthermore, we need this material for the detail tested and approved in a laboratory that it would not cause allergies, etc. Also, it [the printing material for the detail] needs to comply with a certain standard. So, we have found the one we need. Germans produce, and the Dutch print it." (Firm 1) |
| | | "If we were working separately with scientists for a long-term period, we would lose the edge and our competitive advantage because we would have been stuck with old knowledge and technologies, so we could not progress and develop technologies that would help better solve the problems with DNA." (Firm 9) |

Concluding the results of the qualitative study, it could be stated that the majority of the theoretically grounded responsible innovation implementation elements were confirmed during interviews. Regarding the notion of responsible innovation and its implementation in the case study firms, it could be stated that the majority of the theoretically grounded RI elements are applied in the medical engineering firms. Although firms were not familiar with the concept of RI, they applied theoretically grounded activities related to RI. Firms address the Grand Challenges related to health issues and sustainability mostly with their innovative activities. Socio-ethical issues are mostly reflected in institutional restrictions related to the medical field. In relation to the democratic innovation process, most of the firms apply reflexive and a more inclusive perspective towards innovation implementation. Regarding stakeholder engagement, mostly firms' innovation partners are included during the responsible innovation implementation, which is also the case of mutual/collective responsibility, where firms tend to collectively implement responsible innovation with their innovation partners. In the case of meta-responsibility, innovative firms certainly take additional actions beyond the legal requirements. Lastly, in relation to positive innovation implementation and its outcomes, the case firms put additional efforts to ensure the positive outcomes for the society.

In relation to decision-making aspects, it can be stated that firms apply institutional, ethical and techno-economic decision-making aspects while implementing responsible innovation. Regarding institutional decision-making aspects, formal norms like institutional standards and regulations play a major role in firms' decision-making. Regarding informal norms, the opinion of firms' innovation partners and professional colleagues was mentioned among the crucial aspects. In relation to ethical decision-making aspects, firm's internal ethical values and standards were mentioned as of high importance. Lastly, techno-economic decision-making aspects are equally important to firms while implementing responsible innovation. The role of firms' innovation partners and their technological

skills was mentioned repeatedly. As a result, the institutional, ethical and techno-economic decision-making constructs and its measures were adapted according to these qualitative findings.

Qualitative empirical data revealed the networked nature of RI in medical engineering firms. The firms are dependent on their overall network of stakeholders due to external ideas for medical innovation that can better solve societal issues. During the phase of responsible idea exploration, the following external stakeholders play a key role in medical engineering firms: professional colleagues, end-users, clients, informal knowledge network, and researchers. The main reasons to include them are the experience and knowledge of what innovative idea would be beneficial for society, creative solutions, profound market knowledge on the most relevant ideas for innovation.

During the implementation of responsible innovation, the committee of ethics, accreditation committee, professional colleagues, and researchers are of high importance. Legal requirements are necessary to ensure responsibility in relation to medical innovation, so firms concentrate on compliance with the law at first. Other medical engineering firms that are less restricted by the standards and regulations integrate external stakeholders even more actively due to their knowledge, experience, and competencies in order to increase the value of innovation towards society and environment.

Based on these results, it could be stated that all propositions are supported:

| P1: | *Innovative firms tend to operate in a networked nature consisting of internal and external environments while implementing RI.* | *Supported* |
|---|---|---|
| P2: | *Firm's external stakeholders play an important role in the firm's internal RI implementation.* | *Supported* |

## 3.2. An analysis of Quantitative research results on Responsible Innovation Implementation in Innovative Firms in Lithuania

*Data Distribution.* As the first step, *missing data* were identified in this study. The subsample from the survey of firms was drawn such that no more than 5% of cases were missing in order to avoid additional data complexities related to data imputation methods and to take advantage of the recommendation of safely replacing the missing values with the mean values. In addition, the subsample size increased compared to a list-wise subsample. In total, 131 cases representing organizations from the business sector were selected.

*Data characteristics* were checked, although PLS-SEM can handle extremely non-normal data (Hair et al., 2014a). For this matter, skewness and kurtosis were examined. Results show that the data is partially skew (with regard to decision-making norm items), thus supporting the use of PLS-SEM. Next, normal data distribution was also tested by conducting the Kolmogorov-Smirnov Test and the

Shapiro-Wilk Test. Both tests were conducted on the construct level (Hair et al., 2014a) demonstrating the non-normality of several constructs. However, such non-normality does not cause estimation bias in PLS (Hair et al., 2014a). In conclusion, the majority of the data in this study is not normally distributed thus supporting the use of the variance-based approach to estimate the structural equation model.

*Descriptive results.* Regarding the field of the firm, different sectors according to NACE Rev. 2 were represented, with the exception of mining and quarrying (B) and public administration and defense, compulsory social security (O) (Table 18). In general, the mining and quarrying sector constitutes only 0.11% and public administration and defense, compulsory social security sector constitutes 0.56% of all active organizations, thus it could be stated that the general pattern of sectorial distribution in this study's sample remained constant. Regarding the size of the firm, micro firms (with 1 to 9 employees) constitute 27.5%, small firms (with 10 to 49 employees) constitute 23.7%, medium firms (with 50 to 249 employees) constitute 29.8%, and large firms (with more than 250 employees) constitute 19.1%. With regard to the age of the firm, young firms (operating for less than 10 years) constitute 35.9%, and firms that operate from 10 to 25 years constituted 51.9%. Firms having more than 40% of employees with a higher degree constitute 67.9%. Firms with a female CEO constitute 20.6%, whereas firm with a male CEO constitute 79.4%. Consequently, the sample can be considered as representative in an innovation context.

Regarding the contribution to Grand Challenges during innovation development (Figure 6), firms tend to contribute most in mitigating social exclusion and discrimination, in solving energy, water and food preservation problems, and in solving sustainable economic growth problems. Meanwhile, the problems of ageing society and health issues were evaluated as of least importance.
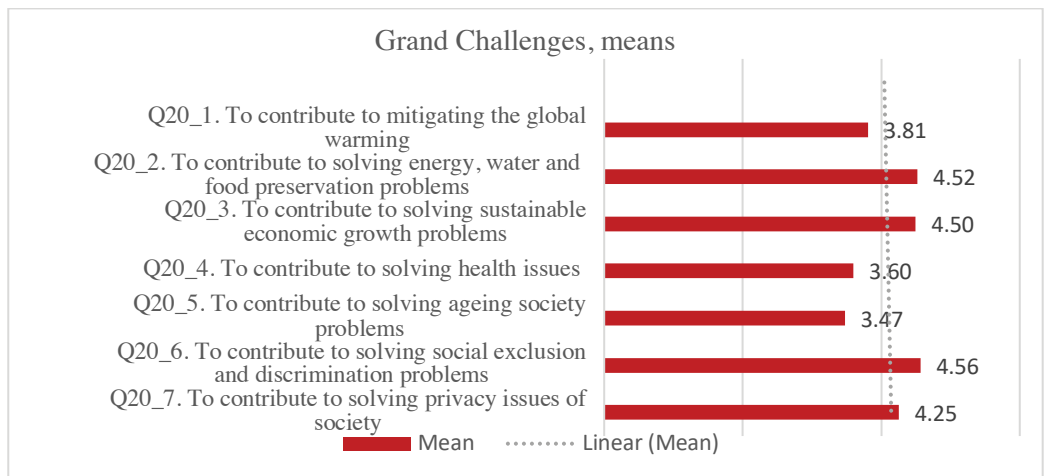


**Figure 6.** Contribution to Grand Challenges during Innovation development, means

Table 18. Representation of sectorial distribution of innovative firms within the sample of the study

| Sector by NACE Rev. 2 | Active organizations at the beginning of 2015* | | Survey participants | | Participants after control questions | | Entries on innovative firms | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| A Agriculture, forestry and fisheries | 2,107 | 2.33 | 34 | 2.23 | 20 | 3.63 | 2 | 1.50 |
| B Mining and quarrying | 106 | 0.11 | 2 | 0.13 | 1 | 0.18 | 0 | 0 |
| C Manufacturing | 7,543 | 8.11 | 118 | 7.74 | 34 | 6.17 | 17 | 13.0 |
| D Electricity, gas, steam and air conditioning supply | 1,021 | 1.10 | 16 | 1.05 | 11 | 2.00 | 4 | 3.10 |
| E Water supply, sewerage waste management and remediation activities | 401 | 0.43 | 8 | 0.52 | 6 | 1.09 | 3 | 2.30 |
| F Construction | 6,987 | 7.51 | 109 | 7.15 | 42 | 7.62 | 15 | 11.50 |
| G Wholesale and retail trade, repair of motor vehicles and motorcycles | 24,352 | 26.18 | 380 | 24.93 | 57 | 10.34 | 22 | 16.80 |
| H Transportation and storage | 7,451 | 8.01 | 116 | 7.16 | 21 | 3.81 | 11 | 8.40 |
| I Accommodation and food service activities | 3,336 | 3.59 | 52 | 3.41 | 4 | 0.73 | 1 | 0.80 |
| J Information and communication | 3,057 | 3.29 | 48 | 3.15 | 30 | 5.44 | 6 | 4.60 |
| K Financial and insurance activities | 745 | 0.80 | 46 | 3.02 | 25 | 4.54 | 5 | 3.80 |
| L Real estate activities | 4,263 | 4.58 | 66 | 4.33 | 2 | 0.36 | 1 | 0.80 |
| M Professional, scientific and technical activities | 9,400 | 10.11 | 147 | 9.65 | 33 | 5.99 | 13 | 9.90 |
| N Administrative and support service activities | 2,968 | 3.19 | 46 | 3.02 | 37 | 6.72 | 3 | 2.30 |
| O Public administration and defense, compulsory social security | 521 | 0.56 | 24 | 1.57 | 21 | 3.81 | 0 | 0 |
| P Education | 3,672 | 3.95 | 77 | 5.05 | 74 | 13.43 | 3 | 2.30 |
| Q Human health and social work activities | 3,048 | 3.28 | 48 | 3.15 | 29 | 5.26 | 3 | 2.30 |
| R Arts, entertainment and recreation | 2,820 | 3.03 | 44 | 2.89 | 26 | 4.72 | 9 | 6.90 |
| S Other service activities | 9,156 | 9.48 | 143 | 9.38 | 78 | 14.16 | 13 | 9.90 |
| Total | 93,017 | 100 | 1,524 | 100 | 551 | 100 | 131 | 100 |

* Data source: Statistics Lithuania (n.d.)

A second descriptive finding concerns the firm's decision-making during innovation development. As can be seen in Figure 7, the most important factors are firms' internal ethical standards and the choice of innovation partners based on their competencies that the firm lacks and technological compatibility. The least important determinant for decision-making during innovation implementation is the prevailing opinion of society.
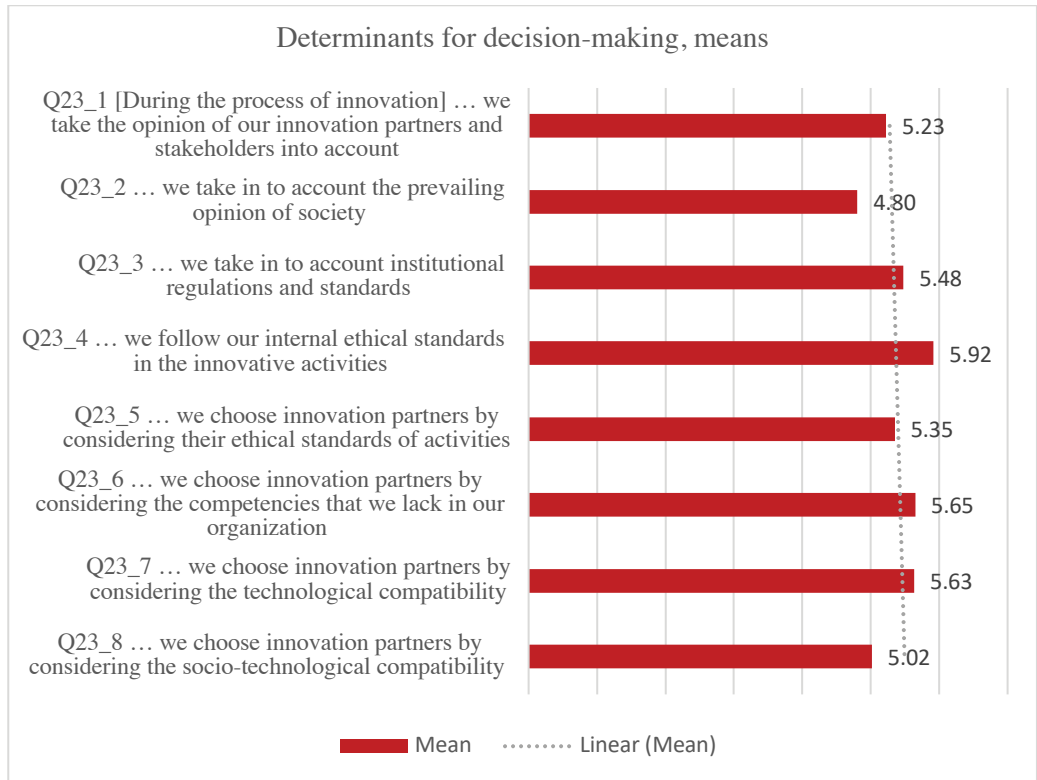


**Figure 7.** Determinants for Decision-making during RI implementation, means

The third descriptive finding concerns the application of RI activities during innovation implementation in the firm (Figure 8). The transparency and information sharing with the stakeholders and partners is the most expressed RI activity in firms. It is followed by such internal organizational processes as openness while evaluating potential limits and threats of an innovation. However, the integration of stakeholders into the innovation process is of less importance.
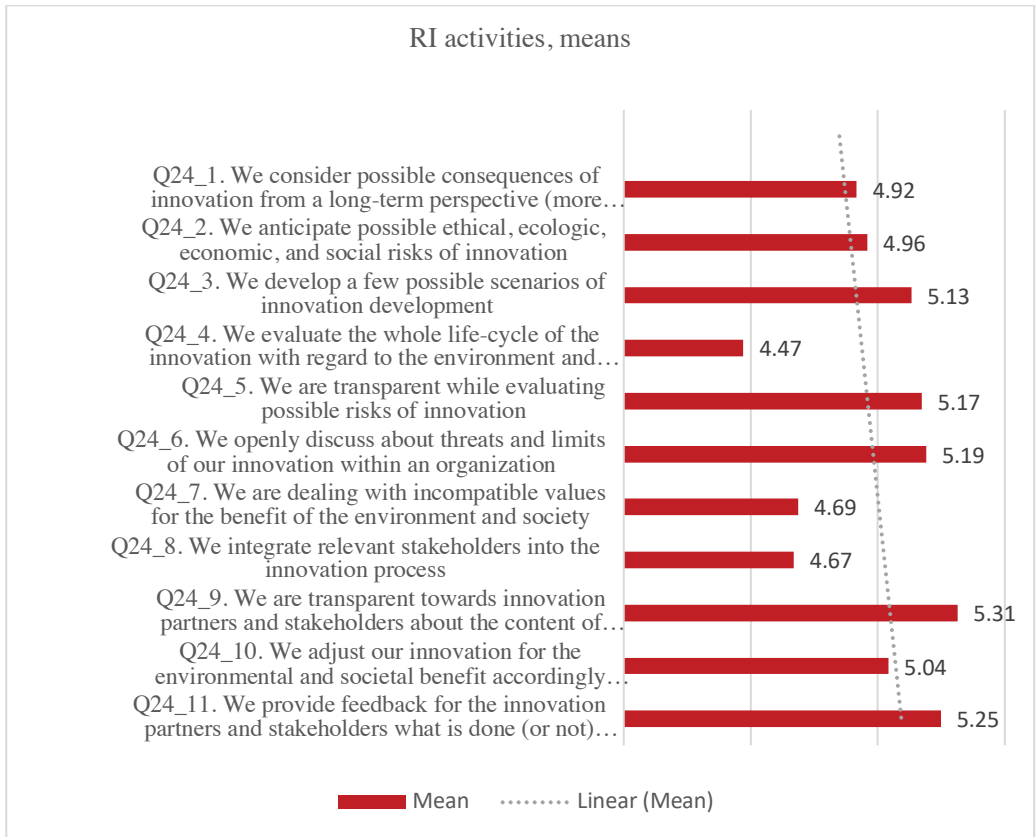
**Figure 8.** RI activities, means

**Reflective Measurement Model.** In order to evaluate whether items measured their assigned construct properly, the measurement (outer) model of all constructs had to be assessed (Hair et al., 2014a). However, there were discriminant validity issues with the existing constructs and in order to reach the threshold of Heterotrait-monotrait ratio (HTMT), the constructs had to be merged. Before merging the constructs, careful consideration regarding the existing theory was conducted. The new constructs are presented below (Table 19 and Table 20).

The initial constructs of decision-making were theoretically separated into Institutional, Ethical and Techno-economic. However, the final results showed that Institutional and Ethical decision-making should be considered as one construct (Table 19).

**Table 19**. Modified constructs of Decision-making

| Initial constructs | Modified constructs |
|---|---|
| ***Institutional decision-making***<br>1. [During innovation development] … we take the opinion of our innovation partners and stakeholders into account<br>2. … we take into account the prevailing opinion of society<br>3. … we take into account institutional regulations and standards<br>***Ethical decision-making***<br>4. … we follow our internal ethical standards in the innovative activities<br>5. … we choose innovation partners by considering their ethical standards of activities | ***Institutional and Ethical decision-making***<br>1. [During innovation development] … we take the opinion of our innovation partners and stakeholders into account<br>2. … we take into account the prevailing opinion of society<br>3. … we take into account institutional regulations and standards<br>4. … we follow our internal ethical standards in the innovative activities<br>5. … we choose innovation partners by considering their ethical standards of activities |
| ***Technological decision-making***<br>6. … we choose innovation partners by considering the competencies that we lack in our organization<br>7. … we choose innovation partners by considering the technological compatibility<br>8. ... we choose innovation partners by considering the socio-technological compatibility | ***Technological decision-making***<br>6. … we choose innovation partners by considering the competencies that we lack in our organization<br>7. … we choose innovation partners by considering the technological compatibility<br>8. ... we choose innovation partners by considering the socio-technological compatibility |

Regarding Responsible Innovation activities, there were three different constructs, i.e. Anticipation, Reflexivity and Responsiveness (Table 20). According to theory (Stilgoe et al., 2013) and operationalization in a business context (Lubberink et al., 2017), these activities were considered as distinct. However, results show that these initial constructs are interrelated and have to be measured as one general construct of Responsible Innovation activities.
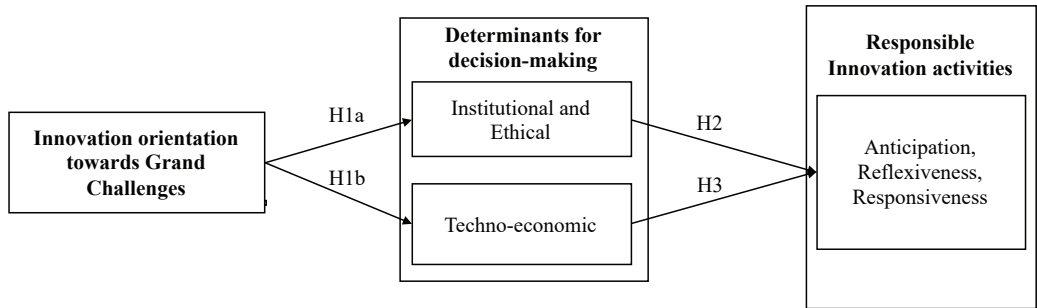
**Table 20.** Modified constructs of Responsible Innovation activities

| Initial constructs | Modified constructs |
|---|---|
| *Anticipation activities construct* | *Anticipation, Reflexivity and Responsiveness construct* |
| 1. We consider possible consequences of innovation from a long-term perspective (more than 3 years) for the benefit of the society and environment | 1. We consider possible consequences of innovation from a long-term perspective (more than 3 years) for the benefit of the society and environment |
| 2. We anticipate possible ethical, ecologic, economic, and social risks of innovation | 2. We anticipate possible ethical, ecologic, economic, and social risks of innovation |
| 3. We develop a few possible scenarios of innovation development | 3. We develop a few possible scenarios of innovation development |
| 4. We evaluate the whole life-cycle of the innovation with regard to the environment and society | 4. We evaluate the whole life-cycle of the innovation with regard to the environment and society |
| *Reflexivity activities construct* | 5. We are transparent while evaluating possible risks of innovation |
| 5. We are transparent while evaluating possible risks of innovation | 6. We openly discuss the threats and limits of our innovation within an organization |
| 6. We openly discuss the threats and limits of our innovation within an organization | 7. We deal with incompatible values for the benefit of the environment and society |
| 7. We deal with incompatible values for the benefit of the environment and society | 8. We integrate relevant stakeholders into the innovation process |
| *Responsiveness activities construct* | 9. We are transparent towards innovation partners and stakeholders about the content of the innovation |
| 8. We integrate relevant stakeholders into the innovation process | 10. We adjust our innovation for the environmental and societal benefit accordingly to the significant information given by the innovation partners and stakeholders |
| 9. We are transparent towards innovation partners and stakeholders about the content of the innovation | 11. We provide feedback for the innovation partners and stakeholders what is done (or not) with their input during the innovation process |
| 10. We adjust our innovation for the environmental and societal benefit accordingly to the significant information given by the innovation partners and stakeholders | |
| 11. We provide feedback for the innovation partners and stakeholders what is done (or not) with their input during the innovation process | |

Based on the modification of the constructs, hypotheses had to be aligned accordingly (Table 21). As a consequence, the research model was also modified based on the altered hypotheses (Figure 9).

**Table 21**. Modified hypotheses

| Initial hypotheses | | Modified hypotheses | |
|---|---|---|---|
| H1a: | *Innovation orientation towards Grand Challenges has a positive influence on Institutional decision-making* | H1a: | *Innovation orientation towards Grand Challenges has a positive influence on Institutional and Ethical decision-making* |
| H1b: | *Innovation orientation towards Grand Challenges has a positive influence on Ethical decision-making* | | |
| H1c: | *Innovation orientation towards Grand Challenges has a positive influence on Techno-economic decision-making* | H1b: | *Innovation orientation towards Grand Challenges has a positive influence on Techno-economic decision-making* |
| H2a: | *Institutional decision-making has a positive influence on Anticipation activities during the innovation process* | H2: | *Institutional and ethical decision-making have a positive influence on Responsible Innovation activities during the innovation process* |
| H2b: | *Institutional decision-making has a positive influence on Reflexivity activities during the innovation process* | | |
| H2c: | *Institutional decision-making has a positive influence on Responsiveness activities during the innovation process* | | |
| H3a: | *Ethical decision-making has a positive influence on Anticipation activities during the innovation process* | | |
| H3b: | *Ethical decision-making has a positive influence on Reflexivity activities during the innovation process* | | |
| H3c: | *Ethical decision-making has a positive influence on Responsiveness activities during the innovation process* | | |
| H4a: | *Techno-economic decision-making has a positive influence on Anticipation activities during the innovation process* | H3: | *Techno-economic decision-making has a positive influence on Responsible Innovation activities during the innovation process* |
| H4b: | *Techno-economic decision-making has a positive influence on Reflexivity activities during the innovation process* | | |
| H4c: | *Techno-economic decision-making has a positive influence on Responsiveness activities during the innovation process* | | |

**Figure 9**. Modified research model

*Indicator reliability* is measured at the construct level by outer loadings of all the indicators (Table 22). Associated indicators have much in common when the outer loadings on a construct are high. The majority of the indicators with outer loadings excess the minimum value of 0.7, except for Grand Challenges item GC6 (0.691) and Decision-making items INS1 (0.698), INS2 (0.679) and INS3 (0.688). According to Hair et al. (2014a), the elimination of an item has to be considered when the loading is below 0.4 or when the deletion increases measures of AVE and composite reliability. After conducting the analysis, the elimination of the item GC6 resulted in increased measures of AVE, composite reliability (in the later stage the measures of discriminant validity also increased and the threshold of Heterotrait-monotrait ratio was achieved), thus it was carefully decided to eliminate the item. Regarding items INS1, INS2 and INS3, it was considered that the items contribute to the content validity of the construct from a theoretical perspective (Hair et al., 2014a). Eventually, bootstrapping with 131 cases and 8000 samples to evaluate the significance of the item was conducted (Henseler, Ringle, and Sinkovics, 2009). Results showed that items INS1, INS2 and INS3 were significant, thus it was decided to keep them.

*Internal consistency reliability.* To measure the reliability of internal consistency, two measures were used, namely, Cronbach's alpha and Dillon-Goldstein's rho (MacKenzie, Podsakoff, and Podsakoff, 2011) (Table 22). However, Dillon-Goldstein's rho measure is more suitable for PLS-SEM, since this measure does not assume equal reliability for all items (Hair et al., 2014a). In terms of internal consistency, all the Latent variables present high internal consistency reliability as expressed by composite reliability (Dillon-Goldstein's rho) score (Table 22). The value can be regarded as satisfactory since the minimum value of 0.70 is acceptable, and even 0.60 is acceptable in exploratory research (Nunally, Bernstein, 1994; Hair et al., 2014a). Thus, all constructs are well above the minimum acceptable level.

**Convergent validity (AVE)** is the degree of association between the measures of a construct and is equivalent to the commonality of a construct (Hair et al., 2014a). The convergent validity of the construct indicates whether the manifest variables that reflect the latent variable have high loadings on it and exceed the value of 0.50. To check for convergent validity, indicator validity and average variance extracted (AVE) were analyzed. The indicator validity is evident as all the manifest variables

have loadings on latent variables of at least 0.7 and above, thus indicating that constructs explain more than half of the variance of its indicators (Hair et al., 2014a) (Table 22).

**Table 22**. Indicator reliability, Composite reliability and Convergent validity

| | | Indicator reliability | | Composite reliability | | Convergent validity |
|---|---|---|---|---|---|---|
| | | *Indicator loading* $\lambda \geq 0.7$ | *T-value* | *Cronbach's Alpha* $\alpha \geq 0.7$ | *Dillon-Goldstein's rho* $\rho \geq 0.7$ | *Commonality* $AVE \geq 0.5$ |
| **Construct** | Item | | | | | |
| *Grand Challenges* | **GC** | | | | | |
| | GC1 | 0.758 | 12.001 | | | |
| | GC2 | 0.774 | 13.165 | | | |
| | GC3 | 0.841 | 25.415 | 0.889 | 0.907 | 0.642 |
| | GC4 | 0.804 | 13.738 | | | |
| | GC5 | 0.808 | 17.456 | | | |
| | GC7 | 0.818 | 21.056 | | | |
| *Decision-making* | **DMN** | | | | | |
| | INS1 | 0.698 | 8.903 | | | |
| | INS2 | 0.679 | 7.784 | | | |
| | INS3 | 0.664 | 8.302 | 0.777 | 0.797 | 0.529 |
| | ET4 | 0.777 | 13.637 | | | |
| | ET5 | 0.807 | 21.340 | | | |
| | TE6 | 0.729 | 9.320 | | | |
| | TE7 | 0.864 | 20.898 | 0.733 | 0.756 | 0.649 |
| | TE8 | 0.818 | 20.918 | | | |
| *RI Activities* | **RI** | | | | | |
| | ANT1 | 0.774 | 19.440 | | | |
| | ANT2 | 0.792 | 18.010 | | | |
| | ANT3 | 0.719 | 11.091 | | | |
| | ANT4 | 0.727 | 11.527 | | | |
| | REF5 | 0.859 | 29.186 | | | |
| | REF7 | 0.660 | 8.855 | 9.333 | 0.935 | 0.600 |
| | REF6 | 0.827 | 24.686 | | | |
| | RES8 | 0.800 | 18.447 | | | |
| | RES9 | 0.739 | 10.587 | | | |
| | RES10 | 0.825 | 28.824 | | | |
| | RES11 | 0.779 | 16.390 | | | |

Bootstrapping conducted with 131 cases and 8000 samples.

**Discriminant validity.** The discriminant validity of the constructs indicates whether manifest variables relate mainly to one or to more than one construct (Table 23). The more conservative *Fornell-Larcker criterion* is used only for reflective constructs (Hair et al., 2014a) and indicates that the square rooted AVE should

exceed a correlation with any other construct (Fornell, Larcker, 1981, p. 46). Intercorrelations among most of the latent variables are lower compared to the square root of AVE (the bolded numbers), thus, the *Fornell-Larcker criterion* for discriminant validity is met. As results show, indicator loadings are higher on relevant constructs than on other constructs, thus a basic discriminant validity requirement is achieved.

**Table 23**. Correlations and Discriminant Validity (Note: Bold numbers illustrate the squared root of AVE)

|      | GC    | INS   | TE    | RI    |
| ---- | ----- | ----- | ----- | ----- |
| GC   | **0.801** |       |       |       |
| INS  | 0.353 | **0.727** |       |       |
| TE   | 0.284 | 0.613 | **0.806** |       |
| RI   | 0.495 | 0.500 | 0.574 | **0.775** |

In the case of cross-loadings of the constructs (Table 24), discriminant validity is established when each item loads highest on its assigned constructs (Chin, 1998). Results show that discriminant validity is established.

However, according to Henseler, Ringle and Sarstedt (2015), the analysis of cross-loadings has some shortcomings in PLS-SEM analysis:

> The paucity of research on the efficacy of cross-loadings in variance-based SEM is problematic because the methods tend to overestimate indicator loadings due to their reliance on composites. At the same time, the introduction of composites as substitutes for latent variables leaves cross-loadings largely unaffected. The majority of variance-based SEM methods are limited information approaches, estimating model equations separately so that the inflated loadings are only imperfectly introduced in the cross-loadings. <…> Another major drawback of the aforementioned approach is that it is a criterion, but not a statistical test. (p. 118).

Thus, for the final analysis a criterion of Heterotrait-monotrait ratio (HTMT) for discriminant validity assessment was tested (Henseler et al., 2015) (Table 25). HTMT is defined as "the average of the heterotrait-heteromethod correlations (i.e., the correlations of indicators across constructs measuring different phenomena), relative to the average of the monotrait-heteromethod correlations (i.e., the correlations of indicators within the same construct)" (Henseler et al., 2015, p. 121). To test HTMT, bootstrapping was conducted.

There were some discriminant validity issues related to the constructs of Institutional and Ethical Decision-making, and Anticipation, Reflexivity and Responsiveness activities. After carefully consulting scientific literature, it was decided to merge Institutional and Ethical Decision-making constructs, as they both represent formal and informal values. Also, these two constructs are formed on the basis of Responsible Innovation field studies. Following the same procedure, the constructs regarding RI activities, Anticipation, Reflexivity and Responsiveness

activities were also merged into one construct generally representing RI activities. After merging the problematic constructs, HTMT was reached that allowed to proceed with the Structural Model assessment. At the same time, the hypotheses were corrected based on the new constructs and their relationships.

**Table 24.** Cross-Loadings of the Constructs

|  | Grand Challenges | Institutional and ethical DMN | Techno-economic DMN | RI activities |
|---|---|---|---|---|
| GC1 | **0.758** | 0.213 | 0.147 | 0.306 |
| GC2 | **0.774** | 0.241 | 0.230 | 0.343 |
| GC3 | **0.841** | 0.327 | 0.317 | 0.517 |
| GC4 | **0.804** | 0.261 | 0.152 | 0.331 |
| GC5 | **0.808** | 0.273 | 0.202 | 0.368 |
| GC7 | **0.818** | 0.340 | 0.258 | 0.444 |
| INS1 | 0.185 | **0.698** | 0.457 | 0.427 |
| INS2 | 0.259 | **0.679** | 0.344 | 0.277 |
| INS3 | 0.327 | **0.664** | 0.335 | 0.327 |
| ET4 | 0.205 | **0.777** | 0.505 | 0.385 |
| ET5 | 0.301 | **0.807** | 0.548 | 0.544 |
| TE6 | 0.113 | 0.411 | **0.729** | 0.408 |
| TE7 | 0.226 | 0.416 | **0.864** | 0.423 |
| TE8 | 0.311 | 0.613 | **0.818** | 0.534 |
| ANT1 | 0.428 | 0.381 | 0.417 | **0.774** |
| ANT2 | 0.459 | 0.434 | 0.490 | **0.792** |
| ANT3 | 0.399 | 0.375 | 0.425 | **0.719** |
| ANT4 | 0.456 | 0.333 | 0.333 | **0.727** |
| REF5 | 0.431 | 0.459 | 0.512 | **0.859** |
| REF7 | 0.250 | 0.463 | 0.447 | **0.660** |
| REF6 | 0.477 | 0.456 | 0.401 | **0.827** |
| RES8 | 0.460 | 0.409 | 0.464 | **0.800** |
| RES9 | 0.216 | 0.520 | 0.442 | **0.739** |
| RES10 | 0.387 | 0.472 | 0.439 | **0.825** |
| RES11 | 0.292 | 0.388 | 0.483 | **0.779** |

After corrections, almost all of the values meet the threshold of 0.85 for distinct concepts (Kline, 2011). Only Techno-economic decision-making is higher than 0.85 but lower than 0.90 for similar concepts. Techno-economic decision-making and Institutional decision-making constructs are theoretically associated and derived from one item block. However, it does not exceed the minimum threshold of 0.9 for similar concepts, thus it could be concluded that discriminant validity is exhibited based on the HTMT method.

**Table 25.** Heterotrait-monotrait ratio

|  | Original Sample (O) | Sample Mean (M) | 5.0% | 95.0% |
|---|---|---|---|---|
| Grand Challenges -> RI activities | 0.533 | 0.532 | 0.420 | 0.636 |
| Institutional and Ethical DMN -> RI activities | 0.627 | 0.630 | 0.495 | 0.757 |
| Institutional and Ethical DMN -> Grand Challenges | 0.410 | 0.418 | 0.274 | 0.567 |
| Techno-economic DMN -> RI activities | 0.676 | 0.678 | 0.560 | 0.788 |
| Techno-economic DMN -> Grand Challenges | 0.321 | 0.340 | 0.205 | 0.483 |
| Techno-economic DMN -> Institutional and Ethical DMN | 0.773 | 0.778 | 0.653 | 0.897 |

Bootstrapping conducted with 131 cases and 8000 samples.

**Structural Model.** In order to evaluate the quality and hypothesized relationships, a structural model regarding 1) collinearity issues, 2) the significance and relevance of the structural model relationships, 3) the level of $R^2$, 4) the effect sizes of $f^2$, and 5) predictive relevance $Q^2$ and $q^2$ effect sizes were assessed (Hair et al., 2014a). Based on conceptual and empirical research, the goodness of fit is not applicable in a PLS-SEM context (Henseler, Sarstedt, 2013).

*Collinearity* was assessed by using inner VIF values. The tolerance levels of VIF values are higher than 0.20 and lower than 5 (Hair et al., 2014a). As seen in the results (Table 26), all VIF values are clearly below the threshold of 5. Thus, collinearity among endogenous and exogenous constructs is not an issue and thus there is no common method bias.

**Table 26.** Inner VIF values

| Corresponding exogenous constructs | Endogenous constructs | | | |
|---|---|---|---|---|
|  | RI activities | Grand Challenges | Institutional and Ethical DMN | Techno-economic DMN |
| RI activities |  |  |  |  |
| Grand Challenges |  |  | 1.000 | 1.000 |
| Institutional and Ethical DMN | 1.601 |  |  |  |
| Techno-economic DMN | 1.601 |  |  |  |

*Path coefficients* range from -1 to 1, where values closer to 0 denote non-significant values. Results show that all relationships in the structural model are significant exceeding the T-value of 1.96 (significance level 5%) (Hair et al., 2014a). According to the results of PLS analysis (Figure 10 and Table 27), Techno-economic decision-making has the strongest and most significant positive impact on Responsible Innovation activities (0.374).

*Coefficient of determination* ($R^2$ value) is a measure of the model's predictive accuracy (Hair et al., 2014a). $R^2$ values range from 0 to 1, where the value of 0.20 is

considered to have a weak, 0.50 – moderate, and 0.75 – strong predictive accuracy (Hair, Ringle, and Sarstedt, 2011). With regard to variance, the values of $R^2$ for Responsible innovation activities show that the model explains almost 40% of the variance in this construct (Table 27). The values of $R^2$ for Institutional and Ethical Decision-making explain 12% of the variance in this construct. Finally, the values of $R^2$ for Techno-economic Decision-making explain only 8% of the variance.

**Effect size $f^2$** explains how strongly a dependent latent variable is influenced by independent constructs (Table 27). Techno-economic Decision-making has an almost medium effect (0.145) on RI activities, while the rest of the constructs have only a small effect on endogenous variables.

**Predictive relevance $Q^2$** implies that exogenous constructs have a predictive relevance for the endogenous construct if it has a greater value than zero (Table 27). A relative measure of predictive relevance $q^2$ indicates a small, medium or large predictive relevance. Based on the results, Institutional and Ethical Decision-making has a small degree of predictive relevance (0.044) on RI activities, and Techno-economic Decision-making has a slightly larger degree of predictive relevance (0.059) on RI activities.

**Table 27.** Evaluation of the Structural Model

| Endogenous variable | Exogenous variable | Path Coefficient  > 0.20 | T-value* | $f^2$  > 0.02 – small effect  > 0.15 – medium effect  > 0.35 – large effect | $q^2$ |
|---|---|---|---|---|---|
| RI activities  $R^2 = 0.397$  $Q^2 = 0.215$ | Institutional and Ethical Decision-making | 0.327 | 3.473 | 0.110 | 0.044 |
|  | Techno-economic Decision-making | 0.374 | 4.330 | 0.145 | 0.059 |
| Institutional and Ethical Decision-making  $R^2 = 0.125$  $Q^2 = 0.055$ | Grand Challenges | 0.353 | 4.529 | 0.143 | - |
| Techno-economic Decision-making  $R^2 = 0.081$  $Q^2 = 0.043$ | Grand Challenges | 0.284 | 3.709 | 0.088 | - |

Bootstrapping conducted with 131 cases and 8000 samples.
*90% significance t-value = 1.64; 95% significance t-value = 1.96; 99% significance t-value = 2.58*
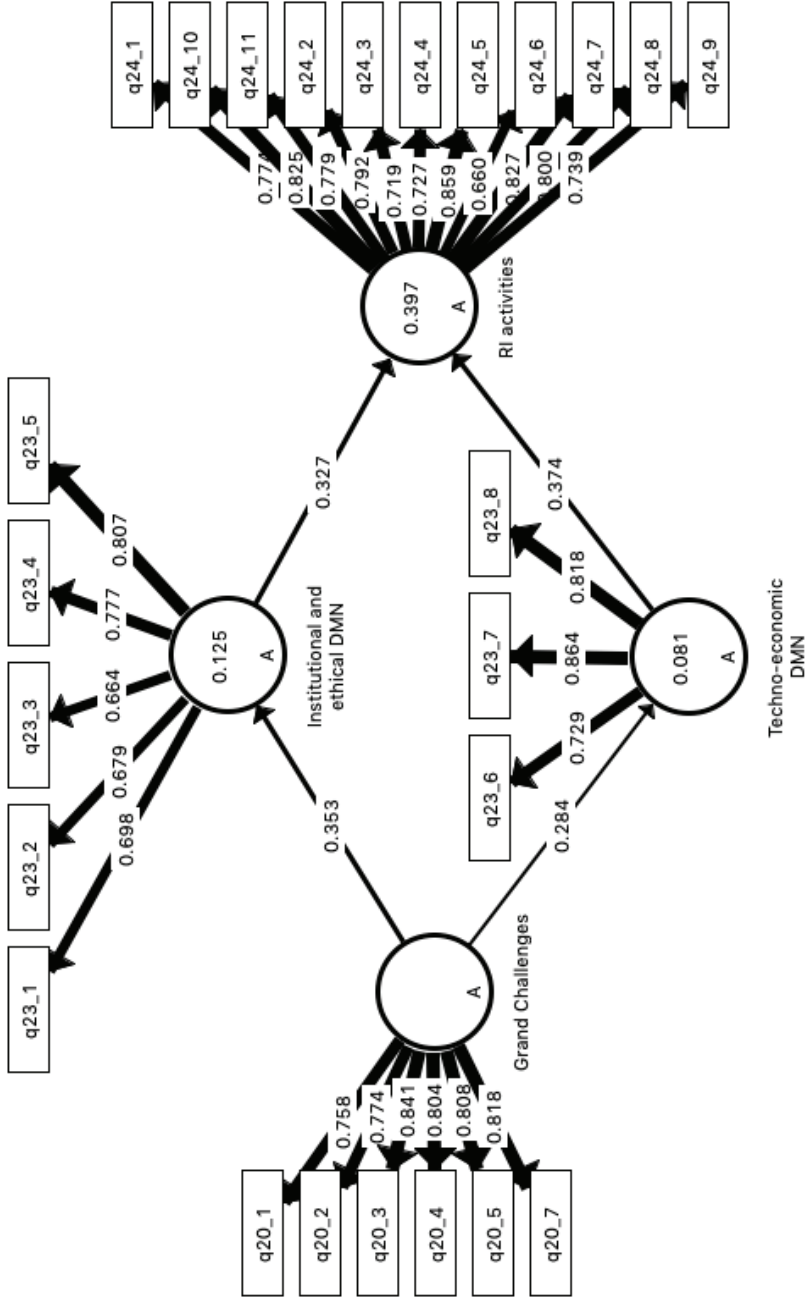
**Figure 10.** Results of the PLS analysis of RI implementation in innovative firms

In Table 28, the summary of the status of hypotheses is presented. The strength of innovation orientation towards Grand Challenges is positively related to institutional and ethical decision-making, lending support to Hypothesis H1a (b=0.353, p<0.001, t=4.529), and to techno-economic decision-making, thus supporting Hypothesis H1b (b=0.284, p<0.001, t=3.709). Institutional and ethical decision-making positively contributes to responsible innovation activities, thus Hypothesis H2 is supported (b=0.327, p<0.001, t=3.473). Finally, Techno-economic decision-making has a positive influence on responsible innovation activities, thus Hypothesis 3 is also confirmed (b=0.374, p<0.001, t=4.330).

**Table 28.** The status of hypotheses

| Hypothesis | Status |
|---|---|
| ***Innovation orientation towards Grand Challenges -> Decision-making*** | |
| *H1a: Innovation orientation towards Grand Challenges has a positive influence on Institutional and Ethical decision-making* | Supported (0.353) |
| *H1b: Innovation orientation towards Grand Challenges has a positive influence on Techno-economic decision-making* | Supported (0.284) |
| ***Institutional and ethical decision-making -> RI activities*** | |
| *H2: Institutional and ethical decision-making have a positive influence on Responsible Innovation activities during the innovation process* | Supported (0.327) |
| ***Techno-economic decision-making -> RI activities*** | |
| *H3: Techno-economic decision-making has a positive influence on Responsible Innovation activities during the innovation process* | Supported (0.374) |

To summarize, the analysis of the survey responses in relation to Grand Challenges showed that respondents from innovative firms mostly tend to contribute to solving social exclusion and discrimination problems, as well as to solving the problems with energy, water and food preservation, and solving the problems of sustainable economic growth during innovation implementation. Regarding decision-making during responsible innovation implementation, respondents indicated a greater likelihood to base their decision on a firm' internal ethical standards. Lastly, with regard to responsible innovation activities, firms gave the highest importance to being transparent towards innovation partners and stakeholders about the content of innovation.

The analysis of the structural model showed that innovation orientation towards Grand Challenges has a positive influence on both institutional and ethical, and techno-economic decision-making in innovative firms. Surprisingly, techno-economic decision-making showed the strongest influence on responsible innovation activities, followed by institutional and ethical decision-making.

# 4. DISCUSSION

## 4.1. Discussion of the Research Findings

In the context of Grand Challenges, Responsible Innovation has emerged as a new approach to govern innovation towards positive contributions to society and the environment (Burget et al., 2017). The business sector is seen as one of the key sectors in mitigating Grand Challenges (Lubberink et al., 2017). However, according to empirical research in RI (Blok et al., 2015), firms fail to implement RI. This research has been developed to investigate the understanding, implementation and its nature of RI in the business sector.

The aim of this dissertation was to validate the conceptual framework for Responsible Innovation implementation and its networked nature from the firm's perspective by applying the behavioral norms approach. The conceptual framework was validated based on qualitative and quantitative research results (Figure 11). Qualitative research results led to the determination of nature and decision-making factors influencing the implementation of RI in firms and, finally, to the confirmation of the propositions. The firm's internal and external environment was revealed as forming the networked nature making an impact for RI implementation in the firm, where external environment was represented by the firm's external stakeholders. Furthermore, the structure of institutional, ethical and techno-economic decision-making constructs in relation to RI were operationalized and integrated into the quantitative study's instrument. On the basis of a quantitative study, the relationships of the constructs influencing the implementation of RI activities were confirmed.

The findings of the case study allowed to confirm the suggested propositions (see section 1.3.4.). Qualitative results provide evidence that without external sources with innovative ideas, medical engineering firms would not be capable of developing and commercializing innovation due to the high costs in the exploration stage (Pittaway et al., 2004). As empirical results show, a firm's relationship with its external environment provides the possibility for firms to be aware of society's needs and what innovative ideas could solve the existing problems, so at the same time it gives value for society and has more potential to be commercially successful innovations. This corresponds with the egocentric approach of the firm which highlights the networked nature of the firm with the external stakeholders that interact to implement innovations (Oksanen, Hautamaki, 2014). This is also in line with current RI studies (Gurzawska et al., 2017) that due to the growing consumers' interest in more sustainable and responsible innovations, firms should consider a more active integration of consumers that help to enhance RI activities. Therefore, the firm acts as a focal actor within its network of external stakeholders maintaining access and benefit from network knowledge, reputation and other intangible and tangible resources leading to responsible innovation implementation. Thus, *Proposition 1* that *Innovative firms tend to operate in a networked nature consisting of internal and external environments while implementing RI* is supported.
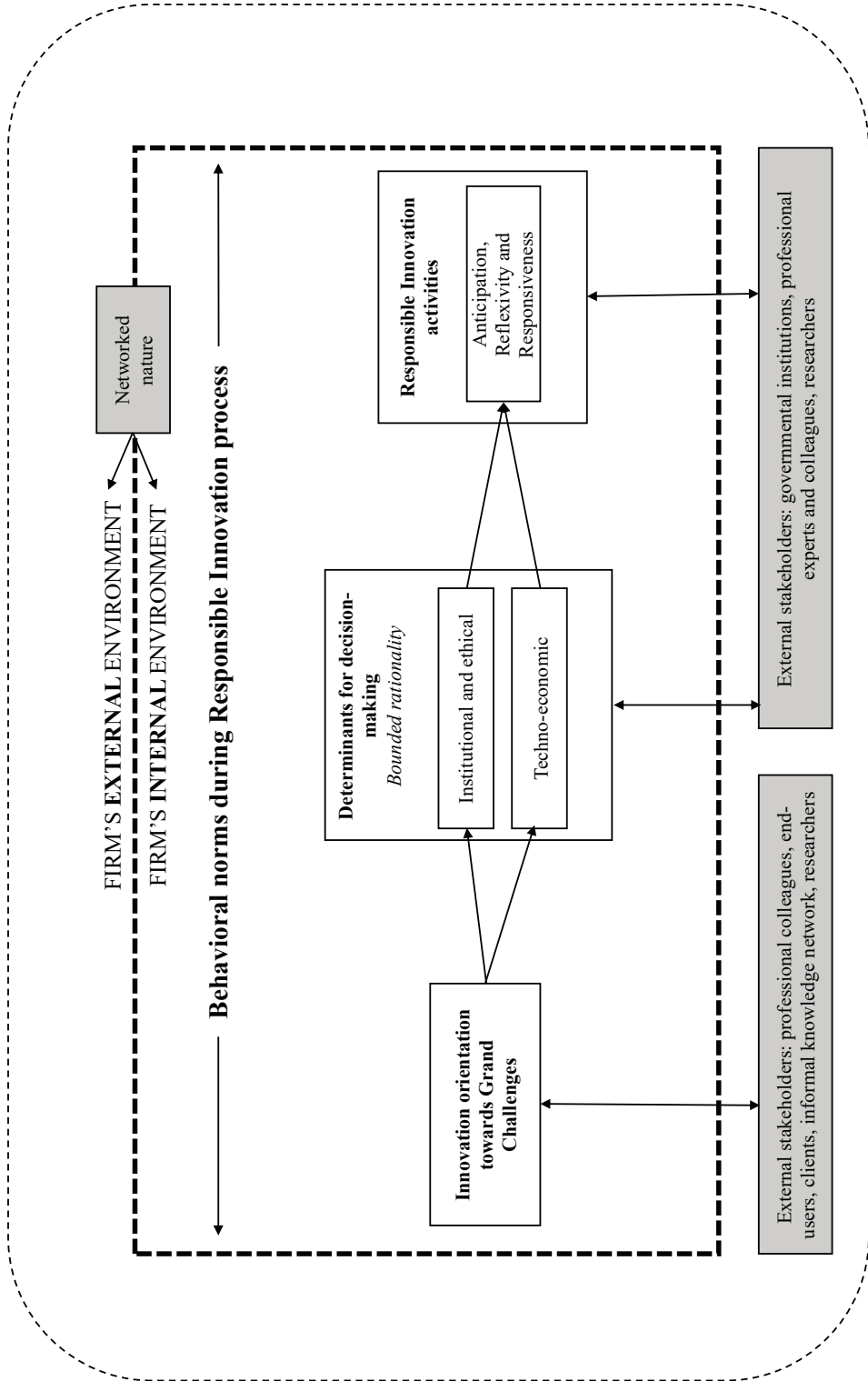
**Figure 11.** The validated conceptual framework for RI at the firm level

The study also reveals the dominant role of Institutional norms in RI implementation. As indicated by the interviews, formal and informal institutional norms are at the foundation of responsible innovation. In industries constrained by formal institutional norms like standards, laws and regulations this is a first step into the development of responsible innovation. Interviews also indicated the importance of informal institutional norms like the opinion of the firm's stakeholders and the prevailing general opinion of the society as an important antecedent for developing socially desirable innovation. The results of the case studies also suggest that institutional standards and regulations in some cases form the basis for RI and could be interpreted as the first level of responsibility in innovation development. This partially confirms the conceptual model of Pavie et al. (2014) and previous research in RI in the industry (Petraite et al., 2017), where the first stage of compliance with the standards and law is only a precondition to enter the network. However, in some cases, standards and regulations are also necessary in order to mitigate some of the social, ethical or ecological issues. When the company goes beyond the existing standards and regulations, this could be understood as the 2nd level responsibility in innovation implementation.

In line with RI scholars emphasizing the importance of Ethical aspects in RI development (Grunwald, 2011, 2014; Stilgoe et al., 2013), internal ethical standards were crucial in implementing responsible innovation. Not only was the innovation responsible, but it was also a radical innovation in the medical engineering field due to the high ethical standards of a firm. In this case, this is in line with von Schomberg (2013) that ethical aspects should be seen as a positive rather than a constraining factor for innovation development. Based on these findings, *Proposition 2* that *Firm's external stakeholders play an important role in a firm's internal RI implementation* is supported.

Furthermore, the qualitative results confirmed that the implementation of RI activities such as anticipation, reflexivity, and responsiveness during firm's innovation development enhance the quality and societal acceptance of innovation, as in line with some empirical findings of RI studies (Hin et al., 2015; Garst et al., 2017).

According to the *quantitative results*, Grand Challenges as an innovation orientation is significant in fostering institutional and ethical decision-making (path coefficient 0.353). This is in accordance with the responsible innovation literature (Sutcliffe, 2013), where the major existing problems are first reflected by institutions and firm's ethical values. It was determined that Grand Challenges also contribute to the Techno-economic decision-making. Although the value of path coefficient is the least (0.284), this result shows that in the practice of RI implementation, Grand Challenges still contribute to pragmatic techno-economic decisions made in firms.

Another finding sheds light on the major role of Techno-economic Decision-making in implementing RI practices (path coefficient 0.374). This is an important theoretical contribution of this study, as the majority of RI scholars, in general, underestimated the importance of techno-economic aspects in RI (Von Schomberg, 2013; Guston, 2013; Grunwald, 2014). The major importance of techno-economic

decision-making in RI in firms is in line with the findings of Garst et al. (2017). In their study, it was found that firm's instrumental (economic) motives "of fulfilling consumer demand, staying competitive, and managing reputation do not only serve the firm's self-interest but also support the dissemination of their responsible products." (p. 18). As a consequence, techno-economic decision-making significantly contributes to the realization of responsible innovation implementation at the firm level. This clearly shows that firms established a holistic set of decision-making in their innovation implementation in order to foster RI related activities. Thus, techno-economic aspects play the main role and they are necessary to integrate into the whole RI analysis at the firm level in order to come out with more responsible outcomes of innovation development.

Results also show that institutional and ethical decision-making significantly contribute to RI implementation (path coefficient 0.327). This is in correspondence with responsible innovation literature (Sutcliffe, 2013; Stilgoe et al., 2013; Grunwald, 2014).

Ultimately, the quantitative results in relation to the validated framework for responsible innovation implementation showed a change of the constructs' structure. In the proposed conceptual model, institutional and ethical decision-making were suggested as separate constructs, however, PLS-SEM results showed that it is rather one construct where institutional and ethical decision-making are interrelated. A possible explanation could be that both institutional and ethical decision-making are understood as a whole set of informal norms that together play a role in developing responsible innovation, while the other set of techno-economic decision-making reflects the pragmatic norms. In fact, such derived concepts as technology assessment (TA) and ethical technology assessment (eTA) that are related to RI can suggest insights of institutional and ethical aspects being closely related, since there was a demand from established institutions promoting TA and eTA to include societal and ethical aspects into technology development (Ribeiro et al., 2016). Since formal and informal institutions promote certain values, it consequently affects the internal values of the innovators via education, institutional regulations, etc. (Pelle, Reber, 2013)

The changes of the structure of the responsible innovation activities construct were also modified after the measurement model analysis. As based on RI literature (Stilgoe et al., 2013), anticipation, reflexivity, and responsiveness were conceptualized as separate constructs. However, in the validated framework, it was shown that responsible innovation activities should be understood as one construct representing interrelated activities of anticipation, reflexivity and responsiveness. Overall, these changes regarding constructs of institutional and ethical decision-making and responsible innovation activities indicate that the relationships of the constructs are more important than the structure of the constructs in this early stage of exploring responsible innovation implementation in a firm.

Regarding *descriptive results* of firms evaluating the importance of Grand Challenges during their innovative activities, a possible explanation of the results of the interviews with medical engineering firms could be that social exclusion and discrimination problems are seen as twofold – first, an opportunity for innovative

solutions, and second, the manifestation of ethical values in contributing to developing the Welfare society. During interviews, the majority of the firms expressed creative and economic possibilities in the existing problems. Thus, developing new innovative solutions that fulfil the expectations of those who are socially excluded and discriminated is also considered as finding a new niche. Simultaneously, firms are driven by their ethical motives to contribute to the welfare of society. Firms expressed their will to solve an existing societal problem and increase the level of life quality for those, who are not that wealthy or even indigent. Regarding sustainability aspects, firms confirmed that for them sustainability is mostly related to economic benefit. Firms care about the environment, but they also looking for win-win solutions, when they can both implement sustainable solutions in their innovative processes and benefit economically. The last aspect of sustainability was mentioned as a partner's demand. Since the majority of firms have international partners, firms in Lithuania are motivated to increase the overall quality of their innovation development to meet the criteria of their partners. In some cases, high quality of innovation development is a prerequisite for firms to get involved with professional networks. When analyzing decision-making, the most important determinant was ethical – firms make decisions usually based on their internal ethical standards. This corresponds to the results of the qualitative study when it was mentioned that firms tend to rely on their ethical values. This result is important in showing a shift of a firm's culture in a way that firms choose to act according to what they think is the right way. The last descriptive finding regarding the application of RI activities during innovation implementation in a firm revealed that the transparency and information sharing with the stakeholders and partners is the most expressed RI practices, which partially contradicts the existing literature (Blok et al., 2015) due to information asymmetry. This finding again shows the importance of ethical values in the firm's innovative activities. The second most important determinant was providing feedback for the innovation partners and stakeholders on what was done according to their feedback. These two activities theoretically are associated with responsiveness activities, thus showing that innovative firms mostly care about good and trust-based relationships with their innovation partners and stakeholders.

### 4.2. Contribution to Theory

This thesis mostly contributes to the current understanding of *Responsible Innovation research.* Scientific literature analysis revealed that the definition of Responsible Innovation and its implementation is the object of on-going scientific discussions. Furthermore, scientific literature analysis revealed essential differences across sectors in relation to defining and implementing Responsible Innovation. This study's theoretical contribution is based on Responsible Innovation conceptualization in the firm.

To the author's knowledge, this thesis is one of the *first quantitative studies* which examines RI implementation at the firm level. So far, the public sector and academia gained most of RI scholars' attention, while the business sector was least examined. Moreover, previous studies have focused on the macro level of RI by

examining the governance of RI from the public governance perspective. This study thus challenges the dominant research tradition and extends the research focus to *the micro level of RI* (organizations) in the business sector.

This study *converges two main – normative and processual – perspectives on RI*. Previous studies have emphasized the prescriptive normative approach towards Responsible Innovation, mostly investigating what norms should be incorporated into RI concept. Another dominant perspective to RI was processual, i.e. mainly focusing on the practices and tools that could be applied in the innovation process to enhance RI, thus causing a lack for the important role of norms in RI (Blok, 2019). Hence, a holistic approach was required in order to define crucial elements constituting RI. In addition, this study applies a *behavioral norm approach* for RI implementation at the firm level that both combines normative and processual aspects of RI, thus overcoming the existing gap in RI literature. The application of behavioral perspective for RI is in correspondence with studies on RI (Gurzawska et al., 2017; Timmermans et al., 2017) that bridge the traditional dichotomy between purely normative and pragmatic approach and is capable of explaining and fostering the behavioral change towards better implementation of responsible innovation.

This study also reveals the important *decision-making aspects* from the firm's inner and external environment fostering the implementation of Responsible Innovation practices. So far, the decision-making aspect of RI implementation is an underresearched area in the field, requiring further investigations on the basis of empirical findings in this study.

Additionally, this study also contributes to the operationalization of RI activities at the firm level. The traditional RI activities (i.e. anticipation, inclusion, reflexivity, and responsiveness) established by Stilgoe et al. (2013) were challenged and after careful deliberation, only anticipation, reflexivity and responsiveness were adopted in the business sector. The inclusion activity was not eliminated but rather understood as an integrative part of anticipation, reflexivity, and responsiveness. However, in quantitative study anticipation, reflexivity and responsiveness activities were merged into one construct of responsible innovation activities due to high intercorrelations.

In addition, in order to achieve RI, different types of responsibility are required, like contractual, legal and moral responsibility (Dreyer et al., 2017). Although there is a tendency to exclude legal and contractual responsibilities from the RI concept and studies, they are nevertheless important dimensions in implementing RI. A systemic view is needed to understand how companies are embedded in different dimensions of responsibility. The importance of legal and contractual responsibilities is highly related to networked responsibility, which is also empirically confirmed (Timmermans et al., 2017) as fostering a firm to adapt new norms in their innovative activities.

This study also makes a theoretical contribution to the *Innovation Management* field. The issues of responsibility and sustainability are acknowledged in the field, where the development of more responsible and sustainable innovation is regarded as an opportunity for the firm to gain first-mover advantage and thus achieve a competitive advantage in the field (Bessant, 2013). By implementing innovations in

a more responsible manner, it can act as a driver for new products to emerge that would require new ways of organizing business and looking for new sources (suppliers) that would eventually serve new markets. Since the research on uncertainty (regarding innovation project, market) is constantly emerging (Nelson, Winter, 1982; Nonaka, Takeuchi, 1995), responsible innovation is a key for firms to sustain legitimacy in society.

### 4.3. Managerial Implications

Besides theoretical contribution, this study has several important implications for managers. *Qualitative* findings revealed that innovative firms operate in the networked nature from egocentric perspective towards their external stakeholders. Firms investing more in relationships and their integration into innovation development will result not only with additional knowledge and competencies (Gurzawska et al., 2017), but also with possibly a more responsible innovation idea that will have more chances to be valuable for customers.

Additionally, a successful aspect of medical engineering firms was their investment in developing a responsible innovation idea that will solve societal issues. A close collaboration with external stakeholders putting emphasis on responsibility criteria of an innovation idea results in more meaningful and engaging innovation process where both internal and external stakeholders are more motivated to implement it. Although the implementation of innovation can take a longer due to a search of a responsible innovative idea, qualitative findings show that it is a better strategy for the firm in a long-term perspective. Thus, it is crucial that firms are aware of the existing socio-ethical and environmental issues so they can allocate adequate time for a purposeful innovation idea. Hence, a responsible innovative idea can result in creative and unique decisions after long elaborations and joint work with external stakeholders, as it was in the case of some medical engineering firms. Those creative innovative solutions with deliberate care for solving existing issues can result in first-mover advantages. Therefore, managers devoting their efforts to elaborating the responsible innovation idea will strengthen a social license to operate within society but will also benefit economically.

*Quantitative* findings demonstrate the importance for firms to reflect on the awareness of the Grand Challenges and look for ways to mitigate Grand Challenges with firm's innovative solutions. Due to different perceptions of responsibility across industries, the first step for managers towards setting up and integrating the Grand Challenges into firms' innovation implementation could be a consultation on Sustainable Development Goals by United Nations that are considered as closest to the business (Dreyer et al., 2017). Furthermore, in the context of the rise of societal awareness and quest for more responsible innovation, the implementation of responsible innovation is seen as an inevitable trend that will be adopted by the industry sooner or later. As it was mentioned in the interviews and RI literature (Gurzawska et al., 2017), the implementation of responsible innovation has to be understood as an investment rather than an additional cost. With this mental change in firms, it is possible to implement responsible innovation in firms more successfully.

In firms, innovation orientation towards Grand Challenges contributes both to institutional and ethical, as well as techno-economic decision-making. This confirms the holistic approach combining both institutional and ethical, as well as techno-economic decision-making during responsible innovation implementation. By strengthening the holistic approach both to institutional and ethical, as well as techno-economic decision-making during responsible innovation implementation, organizations can systematically achieve an advantage in more responsible innovations that better serve the society and environment. This could be achieved by applying a multi-disciplinary approach to innovation by integrating philosophers and sociologists into the innovation practice in order to reflect on possible socio-ethical issues, as it is suggested in RI literature (Stilgoe et al., 2013). Or at least different departments to work together in the evaluation of socio-ethical risks that also contribute to meta-responsibility, as it was indicated in the responsible innovation research in the ICT sector (Chatfield et al., 2017). According to their empirical results, an open discussion about possible ethical and societal risks, personnel can provide concrete solutions to these risks.

The challenge for managers is to balance between institutional, ethical and techno-economic decision-making, and a successful combination leads to the application of RI activities. Thus, managers that are aware of the Grand Challenges will make better decisions during innovation implementation. Consequently, the synergy of ambidextrous combination of institutional and ethical with techno-economic decision-making will lead to enhanced responsible innovation activities, possibly resulting in increased quality and success of innovation as well as increased trust and corporate image regarding stakeholders.

## 4.4. Policy implications

The results of this dissertation also bring several repercussions for policy makers, since systematic thinking is promoted as an amplifying way to better understand and foster responsible innovation.

As can be seen in the validated model for responsible innovation implementation in firms, Grand Challenges play a significant role both in fostering institutional and ethical, and techno-economic decision-making. Thus, policy makers can learn that in order to mitigate Grand Challenges at the national level, there is a need to distinguish between urgent and less threatening issues. The urgent issue could be an example regarding the banned research on babies' stem cells during interviews, which, in fact, was regarded as a push for creativity to look for new ways to proceed with the research. However, in the case of less threatening issues, firms need to be educated and supported rather than constrained by rigid regulations as it can affect creativity (Dreyer et al., 2017) and demotivate regarding the required resources for new alternatives. A possible option is to organize scientific workshops together with firms in certain industries to provide relevant solutions and improvements. Furthermore, the development of RI certification incentives is suggested as one of the most effective way to balance between rigid requirements and building a community with higher moral norms (Gurzawska et al., 2017).

Responsible innovation and its successful implementation in firms is inseparable from society that is active, conscious, engaged and demanding a positive change from firms. The ability to change in accordance to new emerging values is the basis for societal survival (Dreyer et al., 2017), and in this case, according to interviews and RI literature (Schlaile et al., 2018), a special role is given to consumers. Thus, policy makers should invest in consumer education and solutions that could provide possibilities for society to learn about Grand Challenges and potential socio-ethical issues from a global and national perspective, thus fostering ecosystem thinking (Gurzawska et al., 2017). This could enhance the societal potential to understand their own role in influencing responsible innovation implementation in firms.

Additionally, on the basis of interviews, some firms clearly expressed that the initial innovative idea was already directed towards socio-ethical issues. Thus, governments shall clearly try to influence better conditions for SMEs oriented towards responsible innovation from the very beginning. SMEs can be motivated to implement responsible innovation by establishing responsibility awards or setting responsibility as the main criterion for public funding (Gurzawska et al., 2017).

According to quantitative results, both institutional and ethical, and techno-economic decision-making have strong influence on responsible innovation activities in firms, thus policy makers shall try to influence a higher understanding of socio-ethical issues of firms. For example, by providing opportunities to foster a closer collaboration between firms, professionals and/or researchers in management, philosophy and sociology areas can enhance the meta-responsibility and better engagement in responsible innovation (Chatfield et al., 2017). In their research, it was even found that a majority of firms in ICT voted that ethics committees (79.4%) outside organizations should be involved in the identification and evaluation of socio-ethical problems.

However, what is problematic in Lithuanian firms is the lack of a wider civil society integration into the implementation of responsible innovation. Both qualitative and quantitative results showed that firms are not yet explicitly taking into account the general opinion of the society and firms are not that willing to integrate relevant stakeholders into the innovation process during responsible innovation implementation. RI as a concept requires extending the firm's external stakeholder network beyond the value chain actors and embrace a wider stakeholder network representing various societal groups and public interest. Furthermore, empirical research (Lehoux et al., 2017) shows that civil society understands the risks of new technologies, thus public engagement methods like workshops or online forums could be promoted as meaningful ways to enhance the general understanding of responsible innovation. Accordingly, organizational structures should be established that could allow different stakeholders to meet (for example, virtual forums and platforms), deal with the socio-ethical issues and desirable future agendas.

### 4.5. Limitations and Prospects for Future Research

Regarding qualitative research, a possible limitation could be the medical engineering sector, which may reduce the generalizability of the findings. At the same time, RI studies suggest to specifically focus on different industries in order to apply the most appropriate incentives for RI implementation (Gurzawska et al., 2017). Thus, RI research, focusing on certain industries like the food industry (Blok et al., 2015), information and communication technologies (Stahl et al., 2013), robotics (Stahl et al., 2014), are necessary in order to consider the industrial differences and come up with specific industrial solutions regarding RI implementation towards the positive social change.

Regarding quantitative research, the measures used relied on individuals' self-assessed statements about their own organizational activities. Self-assessments are considered to be not objective, however, an objectively measurable criterion does not exist (Criscuolo et al., 2013). In addition, quantitative research was conducted in cross-sectional nature of innovative firms in Lithuania, thus future research could be conducted in specific sectors.

This study offered a conceptual framework and empirical operationalization of the interrelated elements of RI implementation at the firm level, therefore, it could be elaborated and improved upon in future research. In this study, the structures of the constructs (institutional and ethical decision-making and responsible innovation activities) were changed after the calculations of the measurement model, thus future research could be focused on developing more detailed items of the constructs.

This research integrated decision-making aspects during RI implementation in firms. In fact, from decision-making literature, organizational structure is regarded as a critical issue due to the prevailing tendency that the majority of the decisions are made by top-level management, such as the board of directors, CEOs. However, they usually do not possess the highest level of knowledge that is possessed by the discipline specialists, i.e. managers at all levels within all operations and staff groups with further subdivisions into specialties and subspecialties (Gaynor, 2015, p. 45). Hence future research could relate RI to other organizational behavior elements, such as culture and organizational structure.

**CONCLUSIONS**

The theoretical and empirical results of this study on Responsible Innovation implementation at the firm level led to the following findings:

*1. Responsible Innovation is understood as a democratic, inclusive and transparent innovation process during which firms address issues related to Grand Challenges, engage with their stakeholders and collectively seek to come up with innovations that have a positive added value for the society and environment.*

*2. RI is understood as a construct formulated by two conceptual dimensions, i.e. normative and processual.*

The normative dimension is understood as efforts to develop meta-responsibility during the responsible innovation implementation in order to mitigate the Grand Challenges and put efforts in solving ethical, social, ecological and economic issues of innovation. Processual dimension is understood as an inclusive and reflexive innovation process, where relevant stakeholders should be democratically integrated from innovation idea generation to commercialization phases.

*3. Decision-making is argued as a missing link in the holistic understanding of responsible innovation implementation.*

The conceptual element of decision-making combines the insights of responsible innovation studies, resource-based view approach and technology-related thinking and hence it is deemed to be coherent with the business sector context in this way enhancing understanding and logic behind the firm's behavior regarding responsible innovation implementation.

*4. Behavioral norms perspective is suitable for analyzing responsible innovation implementation at the firm level.*

RI as a concept calls for a transformation of values and actual behavior of societal members and innovators towards mitigating the Grand Challenges, therefore, the focus is shifted on how firms behave during innovation process. From a behavioral perspective, it is understood that the whole RI implementation consists of small everyday economic decisions. The application of the behavioral perspective is beneficial in disclosing behavioral norms, as a behavior in a specific situation based on a set of informal norms that are regarded as valid in the organization.

*5. Conceptual framework of the Responsible Innovation implementation at the firm level allows explaining the networked nature and processes of RI implementation that take place in the firm.*

Responsible innovation implementation occurs in a firm's networked environment. Firm's internal and external environments represent the networked nature of the firm and its stakeholders. From organizational behavior understanding, the external environment represents a permeable boundary of the firm that is induced by the existing norms or values that are either institutionalized or impacted upon existing/emerging as social norms. Because firms scan the external environment consisting of a wide range of different stakeholders, they notice the changing norms and values that have to also be reflected in the firm's inner environment due to its need to have a social license to operate and be accepted by society. Within this complex setting, a central coordination role is assigned to behavioral norms during

responsible innovation implementation that induces the behavior towards 1) innovation orientation towards the Grand Challenges, 2) institutional and ethical or techno-economic decision-making, and 3) anticipation, reflexivity and responsiveness activities. At the firm level, these behavioral norms are the basis for a potential behavioral change in a firm's responsible innovation implementation.

*6. Mixed-method research strategy integrating qualitative and quantitative research methods was adopted in order to reveal a complex phenomenon of responsible innovation implementation at the firm level.*

The adopted mixed methods research strategy allowed to uncover the research object which otherwise may have been limited with a single method application. The rationale behind choosing mixed methods was the purpose of complementarity in order to measure some overlapping but also different aspects of responsible innovation implementation at the firm level.

*7. Responsible innovation implementation is facilitated by the networked nature of the firm.*

An integration of external stakeholders into the firm's responsible innovation implementation contributes to a potentially more responsible innovative idea generation and its implementation in the firm. Case firms are dependent on their external stakeholders for external ideas for medical innovation that can better solve societal issues. The firms seek out new ideas, but it is essential that these ideas come out of real need, i.e. would solve an existing health problem.

*8. Institutional and ethical decision-making aspects are interrelated and should be understood as one unit that positively influences responsible innovation activities.*

Quantitative results in relation to the validated framework for responsible innovation implementation showed a change of the structure of the constructs. In the proposed conceptual model, institutional and ethical decision-making were suggested as separate constructs, however, PLS-SEM results showed that it is rather one construct where institutional and ethical decision-making are interrelated. Both institutional and ethical decision-making are understood as complete sets that together play a role in developing responsible innovation.

*9. Responsible innovation activities should be understood as one construct representing interrelated activities of anticipation, reflexivity and responsiveness at the firm level.*

As based on RI literature (Stilgoe et al., 2013), anticipation, reflexivity, and responsiveness were first conceptualized as separate constructs. However, in the validated framework, it was shown that responsible innovation activities should be understood as one construct simultaneously representing applied activities of anticipation, reflexivity and responsiveness in firms.

*10. Innovation orientation towards Grand Challenges positively influences not only institutional and ethical decision-making, but also techno-economic decision-making.*

*11. Techno-economic decision-making plays a major role in fostering responsible innovation activities in firms.*

Techno-economic aspects do play the main role and they are necessary to integrate into the whole responsible innovation implementation analysis at the firm level in order to come out with more responsible outcomes of innovation development.

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## APPENDICES

Appendix 1. Interview guideline

| Criterions | Questions | Result |
|---|---|---|
| *Introduction* | *The goal and the topic are presented for the informant. Responsible innovation concept is presented and explained.* | |
| *A profile of the firm* | ▪ What was the reason and how was the firm established?<br>▪ What kind of innovative products are you developing? | A general knowledge about the innovative firm. |
| *Input phase – idea generation* | ▪ What was the main motive or stimulus for your innovative product?<br>▪ Could you describe how the most successful innovation in your firm was developed?<br>▪ How do you decide which innovative idea should be implemented? | To reveal what are the determinants for the selection of (potentially) successful responsible innovation idea. |
| *Responsible innovation implementation* | ▪ What are the internal or/and external requirements for the innovative products you create?<br>▪ Could you describe how responsible innovation is implemented in your firm until it is commercialized?<br>▪ How do you ensure the highest quality of responsible innovation implementation in the firm?<br>▪ What environmental aspects/issues related to innovation and its implementation do you consider?<br>▪ What social aspects/issues related to innovation and its implementation do you consider?<br>▪ What ethical aspects/issues related to innovation and its implementation do you consider? | To reveal how responsible innovation is implemented in a firm and how the aspects of responsibility regarding ethical, social and environmental issues of the innovation are integrated/managed. |
| *Decision-making aspects during Responsible innovation implementation* | ▪ What are the determinants influencing decision-making during responsible innovation implementation?<br>▪ How do you choose the most important decision-making aspects during responsible innovation implementation?<br>▪ How do you balance between pragmatic and responsibility aspects during innovation implementation? | To reveal what determinants are important for decision-making during responsible innovation implementation. |
| *Relationship with external stakeholders* | ▪ What kind of external stakeholders are participating or are integrated into the responsible innovation implementation? | To reveal the integration level and the nature of collaboration with external stakeholders. |

| | | |
|---|---|---|
| | ▪ How do you choose external stakeholders for collaborative responsible innovation implementation?<br>▪ What are the determinants for the selection of external stakeholders you collaborate?<br>▪ How do you collaborate with your external stakeholders? | |
| *Closure* | *A gratitude for an interview is expressed. Also, the possibility for a follow-up is inquired.* | |

## Apklausa "Atvirųjų inovacijų valdymo ir kompetencijų poreikių identifikavimas Lietuvoje" 2016

*Mokslo projektas "Atvirųjų ionvacijų ekosistemos: technologinių, institucinių ir socialinių veiksnių sąveikų įgalinimas" (AISTIS)*

Mielas apklausos dalyvi,

Dėkojame Jums už pagalbą prisidedant prie Kauno technologijos universiteto vykdomo mokslo projekto „Atvirųjų inovacijų ekosistemos: technologinių, institucinių ir socialinių veiksnių įgalinimas" (AISTIS). Mes siekiame išsiaiškinti svarbius akcentus, susijusius su atvirųjų inovacijų taikymu, identifikuoti atvirųjų inovacijų valdymui reikalingas kompetencijas bei išsiaiškinti kitus tyrimui aktualius klausimus.

**Tyrimo anketoje vartojame kelias sudėtingesnes sąvokas**, todėl norime jas paaiškinti:

- **Inovacija** – naujų technologijų, idėjų ir metodų komercinis pritaikymas pateikiant rinkai naujus arba patobulintus produktus (prekes ar paslaugas), įdiegiant naujus (patobulintus) gamybos (paslaugų teikimo) ar veiklos organizavimo, rinkodaros procesus.

- **Atviroji inovacija** – inovacijos būna vidinės, kurias plėtoja pačios organizacijos, ir atvirosios, į kurių plėtojimą organizacijos įtraukia išorinius partnerius, t.y. inovacija kuriama bendradarbiaujant su išore.

- **Inovacinis projektas** – tai projektas, kurio metu generuojama, vertinama arba diegiama inovacija.

- Moksliniai tyrimai ir eksperimentinė (socialinė, kultūrinė) plėtra (**MTEP**) – mokslo, technologinė ir eksperimentinė plėtra.

Apklausa yra anoniminė. Klausimyne daugiausiai naudojama ranginė Likerto skalė, skirta sužinoti respondento sutikimą arba nesutikimą su pateiktais teiginiais. Apklausoje 32 klausimai.

Ačiū Jums už Jūsų laiką ir įžvalgas!

Nuoširdžiai,
AISTIS tyrėjų komanda

# 1. Organizacijos profilis

[Q1] Organizacijos pavadinimas.

[Q2] Savivaldybė, kurioje yra Jūsų organizacijos pagrindinis biuras.

[Q3] Organizacijos įkūrimo metai.

*[Techninė pastaba: klausimas persikoduoja į „1 – veikia iki 1 m.“, „2 – veikia nuo 1 m. iki 3 m.“, „3 – veikia nuo 3 metų iki 10 m.“, „4 – veikia virš 10 m. (įkurti po 1991 m. kovo 11 d.), „5 – veikia virš 25 metų“]*

[Q4] Ar Jūsų organizacija yra užsienio kapitalo įmonė?

☐ Taip, yra

☐ Ne, nėra

[Q5] Darbuotojų skaičius.

Pasirinkite vieną iš atsakymų:

☐ 1-9 darbuotojai

☐ 10-49 darbuotojai

☐ 50-249 darbuotojai

☐ virš 250 darbuotojų

[Q6] Darbuotojų, turinčių aukštąjį išsilavinimą, procentas nuo bendro darbuotojų skaičiaus

[Q7] Organizacijos vadovo lytis.

Pasirinkite vieną iš atsakymų:

☐ Vyras

☐ Moteris

[Q8] Kam yra skirti Jūsų organizacijos produktai ir/ar paslaugos?

Pažymėkite visus, kurie tinka:

☐ B2B (juridiniams asmenims)

☐ B2C (fiziniams asmenims)

[Q9] Pasirinkite savo organizacijos pagrindinės veiklos sritį.

Pasirinkite vieną iš atsakymų:

☐ A Žemės ūkis, miškininkystė ir žuvininkystė

☐ B Kasyba ir karjerų eksploatavimas

☐ C Apdirbamoji gamyba

☐ D Elektros, dujų, garo tiekimas ir oro kondicionavimas

☐ E Vandens tiekimas, nuotekų valymas, atliekų tvarkymas ir regeneravimas

☐ F Statyba

☐ G Didmeninė ir mažmeninė prekyba; variklinių transporto priemonių ir motociklų remontas

☐ H Transportas ir saugojimas

☐ I Apgyvendinimo ir maitinimo paslaugų veikla

☐ J Informacija ir ryšiai

☐ K Finansinė ir draudimo veikla

☐ L Nekilnojamojo turto operacijos

☐ M Profesinė, mokslinė ir techninė veikla

☐ N Administracinė ir aptarnavimo veikla

☐ O Viešasis valdymas ir gynyba; privalomasis socialinis draudimas

☐ P Švietimas

☐ Q Žmonių sveikatos priežiūra ir socialinis darbas

☐ R Meninė, pramoginė ir poilsio organizavimo veikla

☐ S Kita aptarnavimo veikla

*[Techninė pastaba. Atsakymai atrenkami, kad atitiktų kvotą pagal veiklos rūšį visoms Lietuvoje registruotoms įmonėms ir organizacijoms. Paruošiama atskira matrica]*

[Q10a] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**C**" atsakymo variantą.

Pasirinkite vieną iš atsakymų:

☐ C20 Chemikalų ir chemijos produktų gamyba

- [ ] C21 Pagrindinių vaistų pramonės gaminių ir farmacinių preparatų gamyba
- [ ] C25.4 Ginklų ir šaudmenų gamyba
- [ ] C26 Kompiuterinių, elektroninių ir optinių gaminių gamyba

- [ ] C27 Elektros įrangos gamyba
- [ ] C28 Niekur kitur nepriskirtų mašinų ir įrangos gamyba
- [ ] C29 Variklinių transporto priemonių, priekabų ir puspriekabių gamyba
- [ ] C30 Kitų transporto priemonių ir įrangos gamyba *(išskyrus C30.1 Įvairių tipų laivų statyba ir C30.3 Orlaivių ir erdvėlaivių bei susijusios įrangos gamyba)*
- [ ] C30.3 Orlaivių ir erdvėlaivių bei susijusios įrangos gamyba
- [ ] C32.5 Medicinos ir odontologijos prietaisų, instrumentų ir reikmenų gamyba
- [ ] Kita

[Q10b] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**H**" atsakymo variantą.

Pasirinkite vieną iš atsakymų:

- [ ] H50 Vandens transportas
- [ ] H51 Oro transportas
- [ ] Kita

[Q10c] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**J**" atsakymo variantą.

Pasirinkite vieną iš atsakymų:

- [ ] J58 Leidybinė veikla
- [ ] J59 Kino filmų, vaizdo filmų ir televizijos programų gamyba, garso įrašymo ir muzikos įrašų leidybos veikla
- [ ] J60 Programų rengimas ir transliavimas
- [ ] J61 Telekomunikacijos
- [ ] J62 Kompiuterių programavimo, konsultacinė ir susijusi veikla
- [ ] J63 Informacinių paslaugų veikla
- [ ] Kita

[Q10d] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**K**" atsakymo variantą.

Pasirinkite vieną iš atsakymų:

☐ K64 Finansinių paslaugų veikla, išskyrus draudimą ir pensijų lėšų kaupimą

☐ K65 Draudimo, perdraudimo ir pensijų lėšų kaupimo, išskyrus privalomąjį socialinį draudimą, veikla

☐ K66 Pagalbinė finansinių paslaugų ir draudimo veikla

☐ Kita


[Q10e] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**M**" atsakymo variantą.

Pasirinkite vieną iš atsakymų:

☐ M69 Teisinė ir apskaitos veikla

☐ M70 Pagrindinių buveinių veikla; konsultacinė valdymo veikla

☐ M71 Architektūrinė ir inžinerijos veikla; techninis tikrinimas ir analizė

☐ M72 Moksliniai tyrimai ir taikomoji veikla

☐ M73 Reklama ir rinkos tyrimas

☐ M74 Kita profesinė, mokslinė ir techninė veikla

☐ M75 Veterinarinė veikla

☐ Kita


[Q10f] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**N**" atsakymo variantą.

Pasirinkite vieną iš atsakymų:

☐ N78 Įdarbinimo veikla

☐ N80 Apsaugos ir tyrimo veikla

☐ N82 Administracinė veikla, įstaigų ir kitų verslo įmonių aptarnavimo veikla

☐ Kita

[Q10g] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**O**" atsakymo variantą.

Pasirinkite vieną iš atsakymų:

☐ O84 Viešasis valdymas ir gynyba; privalomasis socialinis draudimas

☐ Kita


[Q10h] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**P**" atsakymo variantą.

☐ P85 Švietimas: Aukštasis mokslas (85.4)

☐ P85 Švietimas: Ikimokyklinis ugdymas (85.1)

☐ P85 Švietimas: Kitas mokymas (85.5)

☐ P85 Švietimas: Pradinis ugdymas (85.2)

☐ P85 Švietimas: Švietimui būdingų paslaugų veikla (85.6)

☐ P85 Švietimas: Vidurinis ugdymas (85.3)

☐ Kita


[Q10i] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**Q**" atsakymo variantą.

☐ Q86 Žmonių sveikatos priežiūros veikla

☐ Q87 Kita stacionarinė globos veikla

☐ Q88 Nesusijusio su apgyvendinimu socialinio darbo veikla

☐ Kita


[Q10j] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**R**" atsakymo variantą.

☐ R90 Kūrybinė, meninė ir pramogų organizavimo veikla

☐ R91 Bibliotekų, archyvų, muziejų ir kita kultūrinė veikla

☐ R92 Azartinių žaidimų ir lažybų organizavimo veikla

☐ R93 Sportinė veikla, pramogų ir poilsio organizavimo veikla

☐ Kita

[Q10k] Kuri **iš žemiau nurodytų** veiklų yra Jūsų organizacijos pagrindinė veikla?

**PASTABA**. Į šį klausimą atsakinėkite, tik tokiu atveju, jeigu [Q9] klausime pažymėjote „**S**" atsakymo variantą.

☐ S94 Narystės organizacijų veikla

☐ Kita

## 7. Atvirosios inovacinės veiklos tikslai

[Q20] Inovacinėje veikloje mes siekiame prisidėti prie ...

| | Visiškai nesutinku | Nesutinku | Iš dalies nesutinku | Nei sutinku, nei nesutinku | Iš dalies sutinku | Sutinku | Visiškai sutinku | Nežinau |
|---|---|---|---|---|---|---|---|---|
| [Q20_1] globalinio atšilimo problemų sprendimo | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_2] energijos, vandens ir maisto tausojimo problemų sprendimo | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_3] sveikatos problemų sprendimo | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_4] visuomenės socialinės atskirties ir diskriminacijos problemų sprendimo | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_5] visuomenės senėjimo problemų sprendimo | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_6] darnaus ekonominio augimo problemų sprendimo | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_7] visuomenės saugumo problemų sprendimo | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

*[Techninė pastaba. Atliekant faktorinę analizę „Nežinau" perkoduojamas į vidurinę reikšmę]*

# 8. Atvirųjų inovacijų veiklos atsakomybė ir etika

[Q23] Ar sutinkate su žemiau pateiktais teiginiais?

Inovacinio proceso metu …

| | Visiškai nesutinku | Nesutinku | Iš dalies nesutinku | Nei sutinku, nei nesutinku | Iš dalies sutinku | Sutinku | Visiškai sutinku | Nežinau |
|---|---|---|---|---|---|---|---|---|
| [Q23_1] vadovaujamės partnerių ir susijusių su mūsų kuriamomis inovacijomis asmenų (angl. stakeholders) nuomone | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_2] vadovaujamės bendra vyraujančia visuomenės nuomone | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_3] vadovaujamės instituciniais reglamentais ir standartais | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_4] vadovaujamės savo vidiniais etikos standartais | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_5] pasirenkame veiklos partnerius atsižvelgdami į jų taikomus etinius veiklos standartus | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_6] pasirenkame veiklos partnerius atsižvelgdami į trūkstamas kompetencijas mūsų organizacijoje | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_7] pasirenkame veiklos partnerius atsižvelgdami į mūsų technologinį suderinamumą | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_8] pasirenkame veiklos partnerius atsižvelgdami į mūsų socio-technologinį suderinamumą | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

*[Techninė pastaba. Atliekant faktorinę analizę „Nežinau" perkoduojamas į vidurinę reikšmę]*

[Q24] Ar sutinkate su žemiau pateiktais teiginiais? Mes, kurdami inovacijas ...

| | Visiškai nesutinku | Nesutinku | Iš dalies nesutinku | Nei sutinku, nei nesutinku | Iš dalies sutinku | Sutinku | Visiškai sutinku | Nežinau |
|---|---|---|---|---|---|---|---|---|
| [Q24_1] analizuojame galimas inovacijos pasekmes ilgalaikėje perspektyvoje (daugiau kaip 3 metai) žmonijos ir aplinkos naudai | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_2] numatome galimas inovacijos etines, ekologines, ekonomines ir socialines rizikas | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_3] plėtojame kelis galimus inovacijos įgyvendinimo scenarijus | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_4] vertiname visą inovacijos būvio ciklą žmonijos ir aplinkos labui | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_5] sąžiningai įvertiname galimas inovacijos grėsmes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_6] organizacijoje atvirai kalbame apie galimas inovacijos grėsmes/netobulumus/apribojimus | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_7] deriname tarpusavyje prieštaraujančias inovacijos vertybes žmonijos ir aplinkos labui | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_8] stengiamės įtraukti susijusius su mūsų kuriamomis inovacijomis asmenis (angl. stakeholders) žmonijos ir aplinkos labui | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_9] suteikiame partneriams ir susijusiems asmenimis (angl. stakeholders) skaidrią informaciją, susijusią su kuriamomis inovacijomis | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_10] koreguojame inovaciją priklausomai nuo partnerių ir susijusių asmenų (angl. stakeholders) suteiktos reikšmingos informacijos žmonijos ir aplinkos labui | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_11] informuojame partnerius ir susijusius asmenis (angl. stakeholders) apie jų idėjų integraciją į inovaciją | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

*[Techninė pastaba. Atliekant faktorinę analizę „Nežinau" perkoduojamas į vidurinę reikšmę]*

Appendix 3. Survey (in English)

**Survey "Identification of the Needs for Open Innovation Management and Competences in Lithuania" 2016**

*Based on a project "Open Innovation Ecosystems: Enabling Interactions of Technological, Institutional and Social Constituents" (AISTIS).*

Dear Survey Participant,

Thank you very much for helping us with the research on Industrial Needs for Open Innovation Management and Competences in Lithuania (abbreviated as AISTIS). We aim to interview companies in Lithuania in order to collect information regarding the real needs of companies for specialists working under the open innovation approach.

The concept of Open Innovation was introduced by Henry Chesbrough in 2003 and it "assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology. Open Innovation combines internal and external ideas into architectures and systems whose requirements are defined by a business model" (Chesbrough, 2003, p. 43).

In order to enable teaching open innovation on the basis of actual industry needs, we first study the level of open innovation adoption in companies in Europe, then, the level of open innovation knowledge and skills of employees in the companies. We try to develop open innovation manager profiles and specify the skills and knowledge that these specialists need in different industries. This research will help us to give recommendations to higher education on the development of open innovation curricula in Lithuania.

Thank you very much for your time and insights!

Yours sincerely,

AISTIS Team

# 1. Company profile

[Q1] Name of the company:

[Q2] Municipality in the country:

[Q3] Company was established in:

[Q4] Is your company foreign-capital based?

☐ Yes

☐ No

[Q5] Number of employees.

Please choose one answer:

☐ 1-9 employees

☐ 10-49 employees

☐ 50-249 employees

☐ more than 250 employees

[Q6] The percentage of employees with higher education:

[Q7] The head of organization is:

☐ Male

☐ Female

[Q8] The main market is:

☐ Industrial (B2B)

☐ Consumer (B2C)

[Q9] Please, select the Sector. Tick the one which provides the main source of revenue:

☐ A  Agriculture, forestry and fisheries

☐ B  Mining and quarrying

☐ C  Manufacturing

☐ D  Electricity, gas, steam and air conditioning supply

☐ E  Water supply, sewage treatment, waste management and regeneration

☐ F  Construction

☐ G  Wholesale and retail trade; repair of motor vehicles and motorcycles

☐ H  Transport and storage

☐ I  Accommodation and food service activities

☐ J  Information and communication

☐ K  Financial and insurance activities

☐ L  Real estate operations

☐ M  Professional, scientific and technical activities

☐ N  Administrative and support activities

☐ O  Public administration and defense; Compulsory social security

☐ P  Education

☐ Q  Human health and social work

☐ R  Artistic, entertainment and recreation activities

☐ S  Other service activities

[Q20] During innovation implementation, we seek to contribute to ...

| | Strongly disagree | Disagree | Partially disagree | Neither agree nor disagree | Partially agree | Agree | Strongly agree | I don't know |
|---|---|---|---|---|---|---|---|---|
| [Q20_1] solving the global warming | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_2] solving energy, water and food preservation problems | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_3] solving sustainable economic growth problems | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_4] solving social discrimination and exclusion problems | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_5] solving ageing society problems | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_6] solving sustainable economic growth problems | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q20_7] solving privacy issues of society | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

[Q23] Do you agree with the statements below?

During innovation implementation ...

| | Strongly disagree | Disagree | Partially disagree | Neither agree nor disagree | Partially agree | Agree | Strongly agree | I don't know |
|---|---|---|---|---|---|---|---|---|
| [Q23_1] we take the opinion of our innovation partners and stakeholders into account | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_2] we take in to account the prevailing opinion of society | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_3] we take in to account institutional regulations and standards | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_4] we follow our internal ethical standards in the innovative activities | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_5] we choose innovation partners by considering their ethical standards of activities | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_6] we choose innovation partners by considering the competencies that we lack in our organization | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_7] we choose innovation partners by considering the technological compatibility | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q23_8] we choose innovation partners by considering the socio-technological compatibility | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

[Q24] Do you agree with the statements below? During innovation implementation, we...

| | Strongly disagree | Disagree | Partially disagree | Neither agree nor disagree | Partially agree | Agree | Strongly agree | I don't know |
|---|---|---|---|---|---|---|---|---|
| [Q24_1] … consider possible consequences of innovation from a long-term perspective (more than 3 years) for the benefit of the society and environment | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_2] … anticipate possible ethical, ecologic, economic, and social risks of innovation | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_3] … develop a few possible scenarios of innovation development | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_4] … evaluate the whole life-cycle of the innovation with regard to the environment and society | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_5] … are transparent while evaluating possible risks of innovation | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_6] … openly discuss the threats and limits of our innovation within an organization | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_7] … are dealing with incompatible values for the benefit of the environment and society | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_8] … integrate relevant stakeholders into the innovation process for the societal and environmental benefit | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_9] … are transparent towards innovation partners and stakeholders about the content of the innovation | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_10] … adjust our innovation for the environmental and societal benefit accordingly to the significant information given by the innovation partners and stakeholders | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| [Q24_11] … provide feedback for the innovation partners and stakeholders what is done (or not) with their | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |