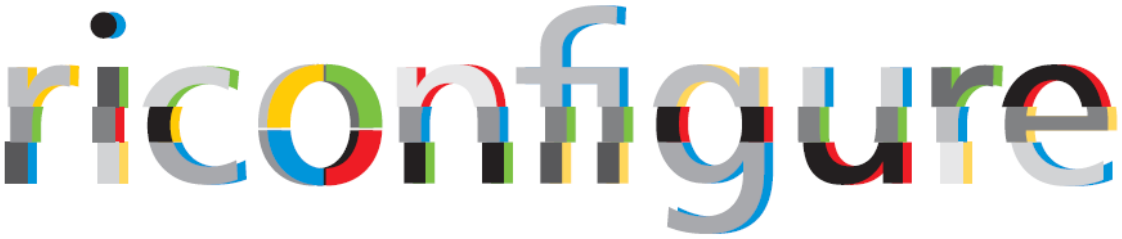

Quadruple Helix Collaborations in Practice

Stakeholder Interaction, Responsibility and Governance

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Abbreviations

CSO	Civil Society Organization
DBT	Danish Board of Technology
GW	Gigawatt, a hydrogen research project in The Netherlands
LOI	Letters of Intent
IHS	Institute for Advanced Studies Vienna, Austria
ISPT	Institute for Sustainable Process Technology
NDA	Non-disclosure agreement
OI	Open Innovation
QHC	Quadruple Helix Collaborations
RRI	Responsible Research and Innovation
R&D	Research and Development
SDG	Sustainable Development Goals
SL	Social Lab
WUR	Wageningen University and Research

Executive summary

The RiConfigure Project

This report presents the lessons we have learned during the three years of the RiConfigure Project[1]. The project was carried out between 2018 and 2021 and was coordinated by the Danish Board of Technology (DBT). The overall aim of the project was to obtain a better understanding of what happens when the four main sectors of society (industry, academia, policy and civil society) collaborate during research and development (R&D) projects. Following literature on the topic we conceptualized these phenomena as *quadruple helix collaborations* or 'QHCs' (Arnkil, Järvensivu, Koski, & Piirainen, 2010; Carayannis & Campbell, 2009, 2012). Quadruple helix collaborations can constitute a dynamic environment where early risks can be signaled and early value potential can be realized. Of particular interest in QHCs is the participation of civil society. Both theory and practice have suggested that civil society is, more so than other helixes, absent from R&D. Traditionally, society is not seen as a participant in innovation but rather the party that receives innovation in the form of technological artefacts made available on the market. The field of responsible research and innovation (RRI) seeks to change this and move societal involvement 'upstream', that is, at a moment when values and expectations from civil society can still influence the design of new technology (Pidgeon & Tee, 2007; Wilsdon & Willis, 2004). Although civil society is of special interest, the other three helixes - academia, policy and industry - are equally needed to shape new innovations 'upstream' and thus realize the RRI ideal. The RiConfigure project aimed to investigate quadruple helix collaborations and to understand its inner workings as well as its relationships with the outside world of governance structures at regional, national and European level.

Methodology

The project was methodologically anchored in two points. First, we took as a starting point the method of action research (Reason & Bradbury, 2001; Whitehead & McNiff, 2006). This meant that we sought to *intervene* in the reality under study (QHCs) as opposed to merely observing this reality from afar. This approach is opposed to classic qualitative and quantitative research where observers seek the position of neutrality from which they interact as little as possible with the reality under study. Second, we opted for *social labs* (SL) as instruments for studying and intervening in real-life innovation projects (Hassan, 2014; Timmermans, Blok, Braun, Wesselink, & Nielsen, 2020). In this project, a social lab is the platform through which RiConfigure researchers interact with the selected real-life cases of QHC. Five such social labs – we refer to them sometimes as 'cases' - were selected

[1] More details about the RiConfigure Project and its members can be found here: http://riconfigure.eu/

in the following countries: Austria, Colombia, Denmark, Germany and The Netherlands. Through organizing social labs we sought to obtain a better understanding of QHCs and specifically the presence of civil society in QHCs. Additionally, we sought to help the stakeholders involved in QHC to foster the interaction and inclusion of all helixes into the innovation process. The RiConfigure SLs are driven by the philosophy of *responsible research and innovation* (RRI) where stakeholder inclusion is associated with more robust innovation products and a better understanding of the risks and benefits associated with these products (Jeroen van den Hoven, 2014; Koops, Oosterlaken, Romijn, Swierstra, & van den Hoven, 2015).

Each of the five social labs was designed in order to answer the following three questions. The first one concerns the real-life practice of QHC; the second one concerns the relationship between QHCs and the principles put forward in RRI literature, and the third one concerning the relationship between QHCs and the governance (political) context in which these QHCs are active.

1. How do partners interact within a QHC and what contributes to the success of such interaction?

2. To what extent do the parties engage in practices, and develop competences, that are in line with the model of RRI?

3. What is the relationship between public governance frameworks on the creation and success of QHCs?

Results

Regarding practice the main lesson we have learned is that the theory of QHC is quite different from the practice of QHC. Once applied in practice, the theoretical idea of four helixes collaborating together in research and innovation stumbles upon a myriad of real-life barriers such as funding, role distribution, incentives, power structures and path dependency. These barriers, which are detailed in section 2, can sometimes be overcome. Yet in order to do so, the in-between step of *reflecting* upon these barriers and their origin is crucial. In this context, we have identified a series of opportunities and 'enhancers' that can be further exploited to get the best out of such a collaboration. Specifically when it comes to civil society, participation of citizens can help experts learn the language of the laymen or at least realize that they do not necessarily speak the same language. These and other results described in the present report seek to create a more developed picture of the barriers and opportunities for QHCs.

Regarding the RRI competences for QHC, it can be stated that in general stakeholders are much more flexible and adaptive than the theoretical four-fold categorization would suggest. In fact, when it comes to systemic innovations that are unavoidably impactful for society as a whole, it is almost a 'job requirement' that one be skilled in navigating the RRI competences distinguished in the RRI literature, e.g., systems thinking, moral competence, learning skills (Ploum, Blok, Lans, & Omta, 2018).

Regarding the relationship between governance frameworks and QHCs (see section 4) it can be noticed that this relationship is not yet a very strong one. Policy is not, at this moment, written with the specific aim of fostering quadruple helix collaborations nor is it in any clear way the driving force behind existing QHCs. When QHC are formed, they spring into existence not because of some compelling policy framework but rather because of a mutually recognized benefit of the presence of stakeholders from all sectors.

Steps forward

The QHC theory and models can benefit from a closer investigation of empirical reality. The promised benefits that would ensue form QHCs, from increased problem-solving capacity to moral robustness, can only be achieved if we first obtain a more realistic picture of how QHCs work in reality. In this report we have highlighted several preliminary results from our interaction with our social labs. These results can be further corroborated with research into (i) the power structures within the QHC collaboration and (ii) the actual co-innovation process and the norms that govern this process.

Chapter 1 Introduction

1.1 The Quadruple Helix Collaboration

A quadruple-helix collaboration ('QHC') is a form of collaboration in research and development between the four major sectors of society: industry, government, research institutes, and the public (Andrews & Entwistle, 2010; Brink & Madsen, 2016; Bryson, Crosby, & Stone, 2006; Carayannis & Campbell, 2009, 2012). QHCs have received increased attention in the past decades due to their doubly promise of increased efficiency and increased responsibility. In terms of efficiency, QHCs promise to provide extra problem-solving capacity, particularly when it comes to tackling complex societal problems, also known as wicked problems (Head & Alford, 2015). When systematic change is needed for tackling these complex problems and individual organizations alone cannot deliver, it is these quadruple collaborations that could do the job. By integrating expertise and value-driven behavior from all four helixes, quadruple-helix collaborations are expected to not only succeed more where individual sectors alone would fail but also to create a more responsible innovation environment. The inclusion of stakeholders in innovation – in our case, the inclusion of the four sectors – has always been a point of focus in literature on responsible research and innovation or 'RRI' (Owen, Macnaghten, & Stilgoe, 2012; Owen & Pansera, 2019). By triggering a collaborative innovations between the representatives of the four helixes, QHCs promise a more responsible integration of value and mitigation (or avoidance) of risk.

1.2 Theoretical background and research questions

The project was built on a theoretical framework in which the success of QHCs is hypothesized to depend on four factors: building structure, fostering interaction, creating value, and learning (Schroth et al., 2019). By building structure, we mean the formal and informal rules, procedures, and agreements that the participants set up as a structural background of their interaction. By fostering interaction we mean the process of engaging in actual exchanges that pertain to alternative designs and the organization of work around the R&D process. By creating value we mean the participants' focus on an increase in all four kinds of value that pertain to the four helix: academic value, business value, societal value and political value. The four values are described in more detail in Figure *. Finally by learning we mean adaptation of the four helixes to the specific interaction as it is taking place in the QHC and to the collaboration with other helixes more generally.

Figure 1 Values at stake in the QHC

Helix	Values	Definition	Prototypical Behavior	Prototypical outputs
Industry	Business Value	Direct or indirect monetary worth	Starting a business, investing in a business, mergers and acquisitions, managing a business.	return on investment, market share etc.
Policy	Political Value	The contribution of an act to the continuation and justice of a political system.	Campaigning for or against a policy, a program or an individual.	Votes (for party or for policy)
Academia	Research Value	The contribution of an act to the development of an academic field or science in general	Publishing and presenting academic work.	Publications, patents, books, academic and honorary titles, citations
Civil society	Societal Value	The contribution of an act to the protection of civil rights.	Protests, petitions, lobbying, starting and managing an NGO.	Rights and artefacts that answer societal needs.

Adapted from Popa, Blok, and Wesselink (2020)

In employing this analytical framework, our project combines insights from a wide variety of fields such as Responsible Research and Innovation (Blok & Lemmens, 2015; Owen et al., 2012; Owen & Pansera, 2019), Science and Technology Studies (STS) (Douglas, 2003; Felt & Fochler, 2010), as well as already existing research on QHCs (Campbell and Carayannis, 2018; Monteiro and Carayannis, 2017; Campbell et al., 2015) and co-innovation/co-creation (Galvagno & Dalli, 2014) (Saragih & Tan, 2018). With this as a basis, we have drawn the following three main areas of focus for our research.

- First, the actual *practice* of QHC has many unexplored aspects that are little understood in comparison to the more 'standard' intra-sectorial collaboration (e.g. between two or more business). Yet we know that QHCs are significantly different than, say pure business or pure research alliances (Bryson, Crosby, & Stone, 2015). We know that QHCs present specific interactional challenges due to their composition of stakeholders with different worldviews and backgrounds (Ahonen & Hämäläinen, 2012; Fernandez, Desroches, Marquis, Turcotte, & Provencher, 2017; Gutiérrez, Márquez, & Reficco, 2016). When the profit-oriented activities specific to businesses need to be reconciled with the publication-oriented activities of knowledge institutes, the policy-oriented activities of the government and the value-oriented activities of the public, parties experience "clashes in expectations and/or identities" which predispose the collaboration to "distrust, conflict, and premature failure" (Le Ber & Branzei, 2010, p. 163). From this first theme we extract the following research question.

Question 1. How do partners interact within a QHC and what contributes to the success of such interaction?

- Second, the contribution of QHCs to a more responsible R&D process, whether it is through a better inclusion of stakeholders or increased anticipatory capacity, has yet to be substantiated in practice. It is true that QHCs are expected to generate innovations that are more carefully attuned to the needs of different sectors of society – a more 'RRI' form of innovation (Owen, Bessant, & Heintz, 2013). Yet it is not clear whether, and how, QHCs are generating this RRI alignment. The outcome of a more inclusive QHC seems to be that R&D is 'checked' by more than just one sector and thus better attuned to each sector's specific needs (Ahonen & Hämäläinen, 2012). But is this really the case? And if so, what are the contributing factors, such as individual competences, to this QHC-RRI relationship?

Question 2. To what extent do the parties engage in RRI practices, and have or develop RRI competences?

- Although QHCs can be detached from their political and social context for analytical purposes, the relationship between QHCs and this context might determine the collaboration's success or failure. When individuals and institutions want to engage in QHC, various regional, national and European governance structures can encourage but also discourage such transitions. It is therefore important to know the extent to which the politico-institutional context impacts QHCs and to understand the nature of this impact. We are thereby interested in legislature, funding schemes, power structures and other governance activities that have an influence on QHCs and whether the parties engaged in QHCs are aware of these influences. Our third question is thus:

Question 3. What is the impact of public governance frameworks on the creation and success of QHCs?

1.3 Action Research through Social Labs

Action research is a family of related perspectives and tools "that integrate theory and action with the goal of addressing important organizational, community and social issues together with those who experience them" (Coghlan & Brydon-Miller, 2014). This closeness between the researcher and the phenomenon under investigation is the defining character of action research. The researcher gives up the objective ('neutral') position of the expert and collaborates with the research subjects in order to understand their world view and contribute to their problem-solving endeavor. Action research is particularly appropriate for the present purposes because the collaboration of the four helixes in R&D, and the inclusion of civil society in particular, appears as a 'wicked problem' (Brown, Harris, & Russell, 2010; Skaburskis, 2008). Wicked problems are characterized by uncertainty at all

levels in the problem-solving process, from problem recognition to the application of the solution, and by the lack of clear ownership such that no single individual or single organization is responsible for solving the problem. By contrast, consider a relatively simple problem: the building of a house. There is a clear point of dissatisfaction (lack of house) and a clear methodology to approach it (external construction, internal construction, finishing). There might be hurdles along the way, and these hurdles might even need to be solved in collaboration with other stakeholders (e.g., the municipality), but the problem is relatively straightforward. Now compare this with one of the best known complex problems of our time: climate change. Who needs to solve climate change? What is climate change? Is climate change even a problem? These are open questions and their openness makes climate change a complex, wicked problem.

It is important to note that in this project we are in fact dealing with two dimensions of complexity. First, QHC is typically engaged in solving a complex problem: improving the sustainability of an energy system, transforming an organization or community, labor enhancement without labor replacement etc. We can assume that the problem at hand in these QHCs is relatively complex for if it had been simple, straightforward, and relatively easy to solve, then the formation of a QHC would not have been necessary. Second, the inclusion of helixes during the QHC is itself a complex problem, particularly since inclusion of civil society actors ('the fourth helix') is not a problem owned by any particular helix but is rather a shared problem within the QHC. Thus, when trying to make R&D more inclusive, there is no agreed-upon formulation of the problem beyond a tautological statement that R&D is not inclusive enough; also, there are no definite known criteria for evaluating whether R&D is 'indeed' inclusive or inclusive enough. These matters will most likely need to be decided and negotiated together with those that are involved in the R&D process and experience the issue of R&D inclusivity. This makes stakeholder inclusion in QHCs a complex problem. Action research is therefore particularly suited as a methodology for the theme of stakeholder collaboration within QHCs. To conclude, not only is stakeholder involvement in QHCs a complex problem, but the QHCs themselves are also typically set up in order to solve a complex problem.

The general field of action research is populated by a wide variety of more specific tools. In our case, we have chosen to work with the 'social lab' methodology (Hassan, 2014; Timmermans et al., 2020). A social lab, itself a term with many denotations, is typically a long-term process in which individuals tackle a shared problem and draw lessons from their communal effort. The Social Lab process is ideally informed by a sustained process of learning – from each other and from the resistance shown by the recognized problems - and thus consists of recurring learning circles (Kolb, 1984). We employed the term 'social lab' in this theoretically-motivated way, but also in a more empirically-motivated way, as an umbrella term for the activities that we undertook in our partnership with the R&D cases. A unifying guideline that we maintained throughout this diversity of practices is the following statement of a social lab's three-fold aim:

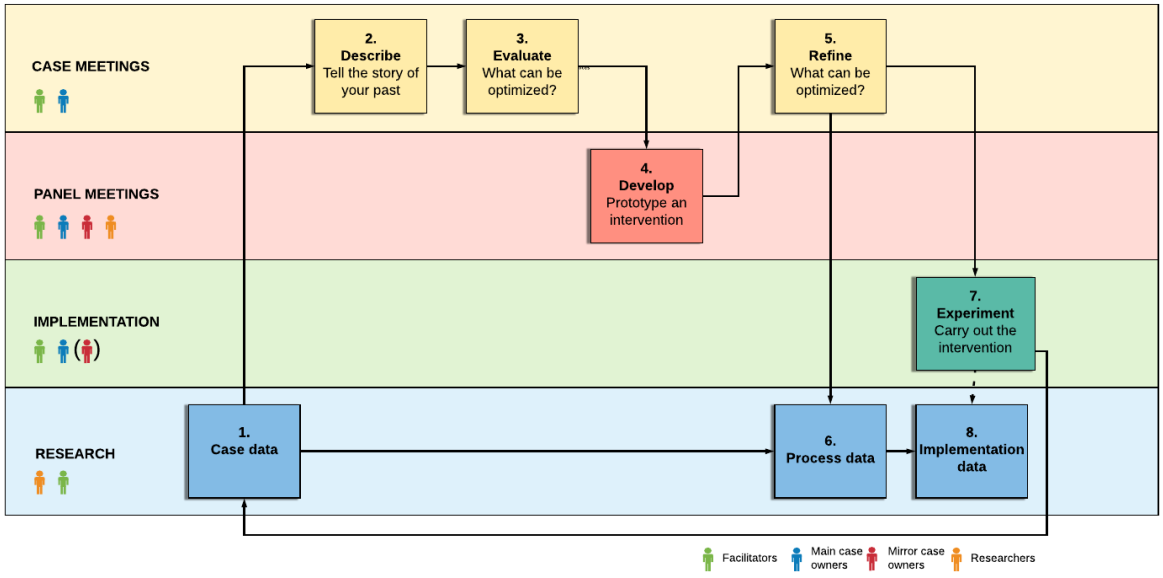
- Inclusion: Social labs bring together stakeholders with different worldviews who collaborate in order to understand and solve the problem
- Experimentation: Social lab is a safe environment for testing, trying, failing etc.

- Reflection: Social lab is designed to encourage reflection, learning, trust-building etc.

In practice, conducting a social lab consists of a series of meetings with the QHC partners. Depending on the nature of the intervention, these meetings can be the standard meeting where stakeholders sit around a table and discuss but a meeting can also be a field trip, one-to-one discussions, focus groups, group exercises etc. In these meetings stakeholders directly or indirectly address their project goals but also keep an eye for stakeholder inclusion and specifically the inclusion of civil society.

In order to set up the social lab we have made a distinction between different kinds of meetings and different kinds of roles within those meetings. An overview is presented in Figure 1 below and a more detailed description of these steps in deliverable D1.2 to be found on the RiConfigure website (www.riconfigure.eu). Steps 1-8 distinguished in Figure 2 below constitute one cycle of our social lab, each partnership with a case undertaking to develop the cycle 3 times during our collaboration.

Figure 2 The Social Lab Process



1.4 The Selected Cases

RiConfigure has partnered with five projects that are engaged in innovation activities within the selected countries. The partnership has been established at the beginning of the project, through consortium partners that were either affiliated with the case in question or were in contact with them. The partnership was free of charge and was understood as being mutually beneficial: cases absorbed the expertise from the RiConfigure project while SL managers absorbed the hands-on knowledge of the case's problem and a platform on which to perform action research. Each case is briefly described below.

Figure 3 The selected cases for the five social labs

Smart Factory OWL (Germany)

SmartFactoryOWL is a LivingLab for Industry 4.0 technologies in East Westphalia-Lippe that offers companies and research institutions comprehensive services for the development and testing of new products and technologies. It also functions as an open research and demonstration platform for the digital transformation. Together with companies from industrial production, industry chambers, research organizations and universities, regional political actors, trade unions and works councils, the aim of SmartFactoryOWL is to jointly develop new solutions and strategies for the future of work in industry 4.0.

GIGAWATT (The Netherlands)

The Netherlands has made a commitment towards developing its hydrogen economy before 2030. GIGAWATT (GW) is one of the many projects in which the four helixes discuss various aspects of the upscaling of hydrogen production. In the case of GW, the topic of R&D is the design of an industrial-scale electrolysis plant that would produce 'green hydrogen' (i.e., hydrogen produced with green energy) on the scale of one gigawatt. The partners in the GW project will together explore what is needed to build such an electrolysis installation in the Netherlands in the upcoming years. The project is being coordinated by the Institute for Sustainable Process Technology (ISPT), with support from industry partners such as Nouryon, Shell, Yara, and OCI Nitrogen, as well as local governments from five different potential hydrogen regions in The Netherlands.

Open Innovation within Austrian Railways (Austria)

Austrian Railways, a publicly owned major railways corporation, Open Innovation team is experimenting with modes of open innovation to complement its technology focused innovation processes. The core of the project is observing and participating in extending open innovation practices to create a new physical and virtual mobility innovation space, in the form of an innovation campus, that involves and engages actors from all four areas of the quadruple helix. The social lab aims at observing and assisting change of innovation focus and modes in order to disrupt traditional forms of technology-driven innovation, involve and engage new innovation players from across different sectors of the innovation landscape, create a less top-down and more cooperative innovation environment while also maintaining and developing operation excellence and bettering user experience through-out the company and its services.

Climatorium (Denmark)

The Climatorium is an innovative climate center and a meeting point that brings together civil society, authorities, businesses and educational institutions to discuss lifestyle, prevention and adaptation to the climate challenges we face. Climatorium aims, through collaboration between private and public companies, knowledge institutions and civil society, to develop new solutions to current and future challenges in the areas: Coastal Climate Challenges, Green Energy, Circular Economy, Water and the Environment. Solutions that can be used and disseminated locally, regionally, nationally and internationally. The Climatorium opened new premises in 2020 on the west coast of Denmark. One of the objectives is to increase innovation through day-to-day interaction and planned in-house seminars for stakeholders and project partners.

Ideas for Change (Colombia)

This case implements a scientific-technological solution that allows, through the social appropriation of science, technology, and innovation, the development of a collective strategy that provides energy and social welfare to the Kanalitojo community. The project aims to transform of the living conditions of the participating communities through the collaborative construction of a science, technology and innovation solution.

In addition to these main cases, RiConfigure Social Labs interacted with other cases similar to the five main ones. We call these 'mirror cases' (if they also participated in some social lab meetings) or 'reference cases' (if they are merely studied from afar without participation in social lab meetings). All these contact points with the cases – whether main, mirror or reference cases - produced valuable data on quadruple helix collaborations and its relation to RRI. The variety of instruments that were used to collect this data is shown in Figure 3 below. In the figure it can be seen that all cases delivered certain type of data on governance, quadruple helix interaction process and responsible research and innovation, whereas only the *main* case also delivered data on the intervention – since the intervention was not carried out in other cases.

1.5 Overview of the report

The present report is organized as follows. In Chapter 2, we provide an answer to the first research question by providing an analysis of QHC practices in the five selected cases. To this end, we highlight the elements that foster the interaction and help the collaboration as well as those that hamper the collaboration or complicate it. In Chapter 3, we answer the second research question by tackling the relationship between RRI principles and the QHC process. For this we look at some of the RRI competences of the participants involved, the effectiveness of leaders in creating boundary-crossing interactions and the learning process created by the SL interventions. In Chapter 4 we provide the results of our analysis concerning the relationship between the governance context (political and socio-economical) and the QHCs we have interacted with. In this section we take a look both at the regulations that actually impact the collaborations in questions as well as the participants' perception of this impact. In Chapter 5, we formulate the main lessons we learned as well as several proposals for further research on the topic of quadruple helix collaborations.

Chapter 2. The practice of Quadruple Helix Collaborations

One of the remits of the RiConfigure project is to take a closer look into how actual QHCs are developing and functioning in actual practice. Typically, research on this topic focuses on the macroeconomic level and regional development and innovation systems (Monteiro & Carayannis, 2017). Macro level analysis may function as a starting point for taking a closer look at the actual processes and interactions between representatives from each helix or the interactions between the QHC participants and their respective organizations and socio-political contexts. Furthermore, the inherent normative claim (Carayannis & Campbell, 2009, 2012) that civil society must be engaged does not reveal the actual role that civil society plays in such constellations. The present section seeks to provide precisely such a closer look at the details of the QHC process. We use data collected via the application of a qualitative and quantitative questionnaire addressed to social lab partners that was based on the theoretical framework prepared for this project (Schroth et al. 2019) as well as a series of progress reports prepared by social lab managers, complemented by 54 brief QH case reports prepared by the five partners responsible for the social labs respectively.

The observed cases are diverse as they have been initiated by stakeholders from different helixes, have different modes of financing and providing funds for the innovation process, and work towards different types of output, ranging from commercial products to social innovation. Our preliminary findings point toward the conclusion that many of the observed cases struggle with actively involving a wide number of stakeholders from all four helixes – especially those from civil society – securing funding for all partners, and aligning the (implicit) interests or goals for the innovation process. QHC is thus challenging and success is dependent on a variety of factors, some of which are case specific and others that may be brought about by more general (socio-cultural) factors. Furthermore, we see that the involvement of the fourth helix (civil society) happens more effectively in cases where public funds and public missions are involved, and also in cases that aim for social innovation. We have organized our findings along four major dimensions that are identified in the theoretical framework of our project: building structure, fostering interaction, learning and adapting. We have added one subsection that reflects on an important finding: namely the influence of factors that are outside of the QH collaboration. In some cases, actors from outside of the QHC but may have a powerful influence over it. This is relevant as some of these impacts may be managed by the instruments and factors described in our theoretical framework.

2.1 Building institutional structure

The importance of building institutional structure for the QHC has been highlighted in the literature on QHCs (Selsky and Parker 2005; Bryson *et al.* 2006; Seitanidi and Crane 2009; Bryson *et al.* 2016; Arnkil *et al.* 2010) and reaffirmed in our theoretical framework: "In order to effectively build a structure for QH-collaboration, formal procedures for partner selection, reporting, and communication have to be developed, (…) [additionally] a common goal has to be identified and agreed upon" (Schroth et al. 2019, p. 8). Given the recognized impact of the initial phases for creating, managing and maintaining QHCs, building structure can be seen as a key element for their success. Building structure is a complex process and involves a number of interrelated aspects: co-creating a shared vision and a common goal for the innovation, ensuring institutional and personal trust between collaboration partners, creating an open and positive cooperation arena and internal legitimacy that is based on confidence between the partners (Selsky and Parker 2005, 855, 864; Bryson *et al.* 2006, pp. 47–48; Bryson *et al.* 2015, pp. 6–7; Kriz *et al.* 2018, p. 29; Arnkil *et al.* 2010, p. 79 as referred to in Schroth et al. 2019).

An important element of the building structure process is that it is not a one-time exercise but needs regular efforts and adaption throughout the collaboration. In the Austrian SL (IHS), for example, we experienced that the initial plan to build an Open Innovation Campus was not feasible as this included a long-term commitment and higher financial risks for the initiators. The Open Innovation Team of the Austrian Railways therefore decided to shift the focus towards building a community first before there will be commitment to an infrastructure project. By this adaption the initiators put focus on the collaboration process before the innovation platform and could include different actors, like start-ups and academia to a higher level who were eager to support shaping the collaboration.

Securing funding and establishing a financial framework that is both output-oriented and benefits all partners is one of the key perquisites for QHCs, and, in many cases, decisive for its maintenance. Many of the QH cases observed in RiConfigure were at least partially funded by public means, which constitutes a temporarily stable funding framework that provided resources for all four helixes to actively participate in the innovation processes. Particularly, the fourth Helix often lacks sufficient financing and depends on the other partners or on non-paid engagement. While there are a number of policy documents that herald the necessity for QH type of innovation (BMWFW & BMVIT, 2016; ERAC, 2019) however, actual funding instruments are often readily available for a QH mode of collaboration and follow traditional innovation models or Triple Helix approaches (i.e. policy-research-industry collaborations). In some observed QH cases, lack of financial resources was compensated by efforts of individuals who performed work "on top" of their daily business. In other cases, support was offered beyond the collaboration by external partners who provided knowledge or infrastructure to the QHC. Financial contribution of partners is closely related to the (often tacit) power structures that emerge in QH constellations; the funding partner sometimes assumes the responsibility of 'running the show', thus often dominating discussions or agenda setting processes.

The selection of partners is also dependent on financial resources, as these can determine which stakeholders can enter a collaboration. Stakeholders with no financial or time resources often are excluded from the selection process due to such financial reasons. Furthermore, those partners who initiate a collaboration also hold decisional power about the inclusion of new stakeholders. Civil society is often the last one to enter this selection process, dominantly on the push of either a public funding body/project, or for social legitimation purposes. In both cases this provides the civil society partner little room to negotiate conditions of entry into the collaboration.

Regional aspects of collaboration potential and selection driver was observed in a number of cases. As trust is important for a successful collaboration, previous cooperation or regional proximity drive partner selection in many cases, as a certain trust base is given. Face-to-face meetings on a regular basis are a key element for *building trust* and for aligning expectations – however this, again drive selection towards a regional or local scope. Face-to-face meetings help stakeholders to "speak a common language", to commit beyond duties (of single partners), and to include voices of all helixes. However, the situation might turn out to be more complex and we do not see reasons to advance face-to-face interaction as a solution in itself. In one of our cases, the academic partner was barely visible to the farmers and when they did meet face-to-face, the partner provided a training full of jargon and buzz words, which created a lot of tension between the two and frustration on the side of the farmers. Similar situation raised our awareness to the fact that face-to-face interaction does not necessarily mean that the partners speak truly to each other, if this personal meeting is just used to "speak down" on one party. Openness in communication and knowledge-sharing is beneficial for strengthening ties between the partners, but it does not seem to come automatically during face-to-face interaction.

In order to plan and organize the collaboration process, various legal instruments were named as useful by a number of cases, as it allows to foster trust, to define responsibilities and (shared) goals. While a number of cases worked on the basis of rather loose legal and governance frameworks, these also emphasized that clearer guidelines helped the collaboration process. Examples for such instruments include non-disclosure agreements (NDAs), letters of intent (LOIs), and written workplans. However, in some cases, civil society partners were not used to these kinds of contracts and this caused irritation. Yet, these contracts are not necessarily restricted to the partners of a collaboration, but may be established with external bodies, such as funding agencies or external governance boards, in order to secure their support. Having clear rules-of-the-game is particularly relevant when collaboration is dependent on a single actor that provides specific kind of resources, or when certain players are limited in their ability to be fully engaged due to lack of resources or physical distance. Legal and governance frameworks are also important if unforeseen events may threaten the collaboration, such as individuals or partners leaving the collaboration, withdrawal of support by external forces, changes in governance boards (e.g., of holding companies) or other external influences and local security issues. A solid framework may give guidance and secure financial and political support past such events.

Finally, a common vision and shared goals are named as one of the most relevant elements for QHCs to work and to overcome barriers. As the QHCs involve more than just technological breakthroughs they engage a number of different value and interest-sets, such goals must include working towards a specific kind of value output that may be embodied in a tangible product or a social innovation that is aimed at new social practices that better meet social needs than already existing solutions, institutions or policies. As one of our case members put it: "if objectives are clear, barriers will be workable". While sometimes there are conflicting goals among partners, it is repeatedly acknowledged that the involvement of all helixes in a collaboration process increases the potential for creating meaningful value. Common vision and shared goals are not restricted to those of the particular QHC but are often complemented and guided by wider goals such as national R&I strategies or the UN SDGs. Envisioning even idealist perspectives may help motivate partners to overcome barriers by aligning goals and potential values. Particularly, goals of organizations and holding companies beyond the direct goal of the QHC are relevant for securing their financial and political support. In one SL case, for example, the overarching goal for the open innovation process and engagement of the four helixes was fostering cultural change within the whole organization and the OI process and awareness was planned to be utilized as driver for the whole corporation beyond the specific QH collaboration endeavor. Feedback loops, dissemination of shared goals beyond the QH may prove to be useful for securing the support and value alignment of actors related to, but outside of the actual QH collaboration, visible to the outside world. Sharing progress and output may add to creating favorable outside conditions for the collaboration to thrive. Many QHCs had an explicit or implicit economic drive with aims for creating commercial products or fostering regional growth. This emphasizes the importance of legal frameworks for managing profit.

2.2 Fostering interaction

During our interactions with the cases, we have observed a number of methods to foster interaction within QHCs. Regular personal meetings and face-to-face interaction events, workshops, co-creation spaces, bi- and trilateral meetings of different kinds are identified as key resource for QHC, as they help aligning goals, fostering trust, and making processes transparent. Furthermore, such personal meetings help overcoming communication barriers (e.g., understanding scientists) and power gaps (e.g., industry partners holding financial and infrastructural power). Such meetings also need to ensure the involvement of all helixes, and raise awareness for needs of partners. Furthermore, knowledge gaps among partners may be addressed, including space for mutual feedback. While these meetings are often organized as internal events, the activity of neutral moderators can be beneficial for overcoming communication barriers and for ensuring involvement of all helixes. This role was, in several of our cases, taken up by the academic partner offering a reflexive and critical perspective, but can in principle be fulfilled by any actor with the necessary skills for crossing helix borders. In one of the main cases, it was agreed to have monthly face-to-face meetings to get informed and to work on specific tasks together. It has shown that the timing of these meetings is especially relevant for civil society partners, who could only participate in meetings after the usual working hours. Also, it was agreed to always provide written protocols of such meetings to guarantee transparency and

give less engaged partners (mostly from the fourth helix) the chance to rejoin the group (during times of lockdowns these meetings were held online though).

Aside from the interaction methods discussed above, the role of management needs to be highlighted. Different forms of management help aligning and fostering interaction across the collaboration. These may consist of formal steering committees or a more loosely organized group that undertakes decision making. In one SL, this steering committee was a group of 'orchestrators' selected among all four helixes. Decision rights are to be formalized and/or included in policy or governance framework applied, thus distribution of tasks and responsibilities are more transparent and often better allocated across the four helixes. Such clear authority relations and decision/responsibility allocation is closely linked to a case's financial resources. If one of the partners is dominant in providing resources, this partner may easily control leadership roles and create frustration and potential drop out. After all, other partners may feel that their voices are not heard or their influence is not felt when decisions are made.

The active involvement of the civil society in innovation is, in many cases, a challenge. Of the 54 cases considered in this practice analysis, only 24 actively included the civil society across the collaboration process and included these in relevant decision-making processes (see Figure *). As the fourth Helix is often the last to join a new QHC, we observe a power relation where citizens/CSOs enter collaborations on conditions already established by other partners and/or are merely consulted along the innovation process. While many cases expressed openness towards civil society, we also experienced reluctance to extend the involvement of civil society, paired with the fear that these may slow down the innovation process. Similar concerns were expressed for partners of the public sector. The biggest challenge for extensively including actors from civil society is a lack of knowledge on how to best achieve this and which methods to apply. Additionally, the fourth helix is often understood as the selective and privileged types of publics such as civil society organizations (CSOs) or users of a specific product or service. We thus see very different understandings of what civil society really is. As a result, marginalized groups of civil society are often less visible. Citizens who enter QHCs need to have the resources and motivation to engage in such activities besides their work and other public and private responsibilities.

Figure 4 Number of cases that actively include civil society across the collaboration

Case owners/SL managers	**FH**	**WUR**	**IHS**	**DBT**	**ACAC**	**SUM**
Cases included in the analysis	6	25	12	7	4	54
Cases that actively include civil society	3	1	10	6	4	24

2.3 Learning and adaptation

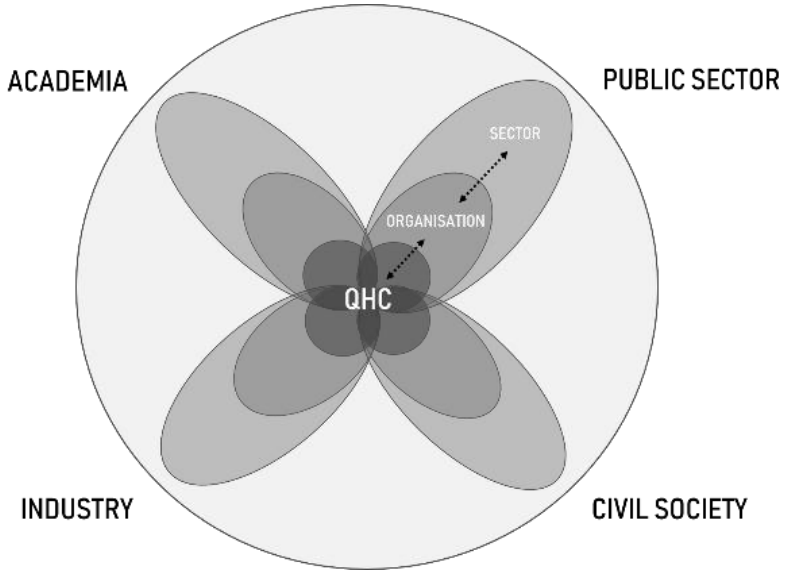
The studied QHCs showed eagerness to learn about how to collaborate and to integrate helixes in the collaboration process. For this reason, many cases have exchanged experiences with other QHC instances, particularly in earlier phases of the respective innovation projects. Dialogue events for exchanging experiences, such as the annual Austrian Open Innovation Stakeholder Meetings in Austria or the ISPT Day in the Netherlands as well as publicly available collections of (good practice) cases, are thus meaningful policy instruments to support exchange of knowledge. Some cases have reached out to existing networks in order to learn about how others collaborate. Respective training programs have also been initiated to overcome knowledge and culture gaps within the collaboration.

Regular reflection and shared learning processes concerning the collaboration has been described as useful in order to align goals and to ensure the involvement of all helix partners. The RiConfigure Social Labs and their experimental interventions and reflection are one example of creating spaces to critically discuss and respond to collaboration challenges and, respectively, to adapt its working modes. Such reflection is not limited to internal questions that arise from specific projects but also relevant for aligning with goals and expectations of the environment (e.g., of governance boards beyond the collaboration, R&I policy actors, etc.), to gain new ideas and to enrich perspectives of the QHC.

2.4 Alignment with external goals and expectations

QHC cases have revealed the importance of considering expectations and goals of external actors (i.e., actors that are not directly involved in the project activities of the QHC). External actors may have great impact on the QH practice and therefore need to be considered in order to maintain the collaboration. The strategic alignment, financing, structural support, as well as the general support of entering and proceeding with a QHC often depends on forces beyond the collaboration. This might include parts of companies or organizations beyond the units that are engaged in a QHC (respectively their governance boards), as well as forces stemming from the wider Helix such as other companies or (local) governments. The following figure visualizes these layers based on the example of the public sector.

Figure 5 Quadruple Helix flower model (Johannes Starkbaum)



In this example, the dark inner circle of the public sector helix could be a unit of a larger publicly owned company that is part of a QHC with a specific aim for value-creation. The larger lighter-gray ellipse then represents the whole company including governance board and its wider corporate strategy. The larger ellipse represents the public R&I sector including relevant parts of the government, ministries and other public bodies. These define goals for R&I and issue respective funding, which impacts governance strategies of publicly owned companies. Goals and funding opportunities are – at both, organizational and sector level – subject to change, which then might demand adaption by the QHC in order to secure political and financial support from this Helix. We can observe similar layers in other helixes such as industry including, e.g., questions of intellectual property (IP), technical and financial support.

Relevant decision-making power can be situated outside the QH constellations, in governance boards of the involved entities or even beyond (e.g. governments, holdings, associations). External impacts typically intensify once QHCs grow in size and/or in importance, as these then begin to impact the finances, branding and governance of their environment. While some of the contingencies and changes may be mitigated through appropriate QH internal procedures (see 2.1.), QHCs also need to maintain support of their environment(s) by illustrating their value, and, in the same move, by minimizing possible risks (e.g. costs, branding issues, etc.) which would hinder participation and building appropriate structures, stemming from risk avoidance of these outside players, in the first place. Beyond that, aligning and interacting with external actors also helps including further perspectives and finding new ideas in order to stimulate internal collaboration processes.

Finally, we have witnessed that external actors such as consultants, advisers and smaller start-up entities in search of funding partners, may take key roles in QHCs (facilitators, experts, co-creation meeting participants) and push their business agenda and thus hijack or bend the process. On the other side of the spectrum, key outside actors may providing support once they are informed and their goals are aligned with the goals of the collaboration. Examples for this second type of external actors are corporate holding CEOs of participating partners or regional politicians that support a QHC and its endeavor in corporate/political arenas beyond the collaboration.

In a few observed cases the lack of such processes proved to be detrimental to the collaboration. Change of management or strategy resulted in the withdrawal of one of the (industry) partners in one of the reference cases; a lack of showing short term financial benefit made one of the funders in another reference case withdraw support from the collaboration. In our main case change of personnel and other management changes resulted in goals and benefit expectation being moving targets that other partners found it hard to align their interests and ambitions with. QHCs are versatile and fluid forms of constellations, therefore contingency planning and openness towards change within and outside the QH arrangement may prove beneficial for the longevity and effectiveness of the collaboration.

Chapter 3. Responsibility in Quadruple Helix Collaborations

The inclusion of stakeholders in QHCs promises to result in innovations that are more attuned to the different needs of the four helixes and society in general. QHCs are, in short, proposed as instances of *responsible research and innovation* or *RRI* (Koops et al., 2015; Owen et al., 2012; van den Hoven, Doorn, Swierstra, Koops, & Romijn, 2014). Yet the relationship between this ideal of responsible innovation and QHC remains fairly unexamined in current research, even though proponents of the QHC model have mentioned that the collaboration between the four helixes will result in a more democratized R&D process and democratization is part of the RRI ideal (Carayannis & Campbell, 2014; Meissner & Carayannis, 2017). In order to obtain a better understanding of the relationship between RRI and QHC, we needed to focus on some aspects of RRI that are the most relevant for the QHC setting. We therefore focused on the following two aspects of RRI:

- RRI competences are skills or knowledge that allows participants to engage in, or create, responsible research and innovation (Blok, Gremmen, & Wesselink, 2015). Borrowing insights from the study of competences for sustainable development we define RRI competences as individual competences (or 'skills') that are known to be linked to products or processes that are in line with the concept of responsible innovation. We thus assume that the skills necessary for fostering of RRI are at least partly different that the actors' 'business-as-usual' skills, namely, the professional skills that they use in their daily work. The competences we focus on are thus: systems thinking, transdisciplinary thinking and moral competence. These will be further defined below in discussing results.

- RRI leadership has been noted as an alternative to classical notions of leadership that were developed from the perspective of the individual organization (Crosby & Bryson, 2010b).The change in team composition when moving from organizational leadership to cross-organizational leadership, gives rise to a change in context: it is now a "shared-power, no-one-wholly-in-charge world" (Crosby & Bryson, 2010a). RRI leadership is leadership that can adapt itself to the needs of a multi-stakeholder project. By leadership we mean the activity of the organization (or organizations) leading the QHC. The aforementioned idea of a 'round table' presents us with a paradox for there seems to be little or no managerial roles in such an ideal egalitarian model. How does the leading organization escape or resolve this paradox?

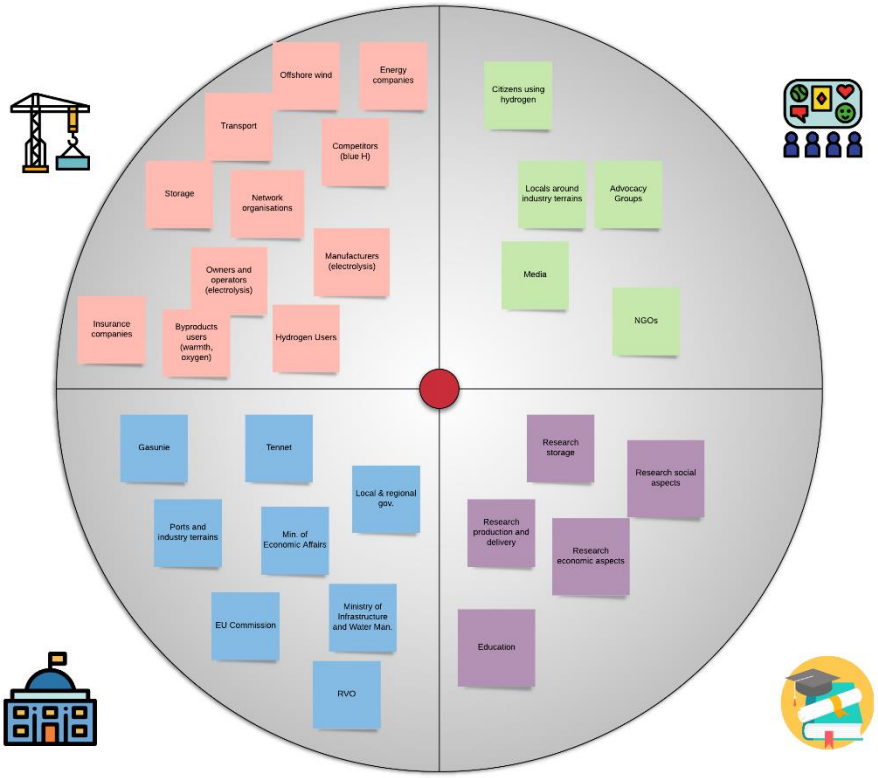
3.1 RRI competences in the Social Labs

Systems thinking competences

The systems thinking competence refers to the "ability to collectively analyze complex systems across different domains (society, environment, economy, etc.) and across different scales (local to global), thereby considering cascading effects, inertia, feedback loops and other systemic features related to sustainability issues and sustainability problem-solving frameworks" (Wiek, Withycombe, & Redman, 2011). Generally speaking, our case partners proved to be skilled in understanding the entire system in which the innovation took place as well as in engaging in discussions around this system. A good example of this skill is the identification and analysis of the stakeholders that have an interest in, or influence over, a certain project. In one form or another, all SL interventions involved some form of stakeholder analysis, usually in the initial phases of the intervention. Participants turned to be capable, with some individual variation and under the coordination of a social lab facilitator, to put their organization/project into context by identifying relevant stakeholders. Moreover, participants experienced such exercises as a useful exercise. Furthermore, as it will be seen in section 4 on governance, participants turned out to be skilled in identifying the influence of the political 'landscape' on their everyday work within the QHC. This awareness regarding the relevant governmental structures can also be seen as a systems thinking competence

The topics brought up for discussion concerning the socio-technical system of the QHC were varied. Sometimes, the institutional movements within a single organization were important enough to deserve attention from all QHC partners. Other times, the larger landscape movements at a national and international level were brought to the fore. In both cases, the explicitization and discussion of such issues turns out to be within reach for participants of various educational backgrounds. In Figure * below we show the results of such an analysis taken from one of our panel meetings. The figure contains all the actors identified by the case participants as actually or potentially (in the future) having an impact on the hydrogen economy. As it can be seen, individuals that are not necessarily trained to undertake system analyses of their project can deliver a fairly rich image of what QHC actors influence their everyday jobs. Furthermore, although this is not captured in Figure 3, each of the mentioned actors was in fact discussed briefly in terms of their power, their interests and their predicted behavior. This particular discussion only lasted around 45 minutes, but it could have been prolonged, especially since the power relationships between the actors is a difficult subject that brings everyone into the discussion.

Figure 6 Example of Stakeholder Analysis



Another example of system-analytical competences is the participants' ability to modify their strategies based on higher-level movements in the landscape. In the IHS social lab (Austria) initiated by the public sector, the activity of the QHC was influenced by unexpected movements in the organizational hierarchy and a change of political context due to elections. These were perceived as major systemic events that affected the organization's ability to take any radical decision or to invest major resources. The QHC participants reflected on this new organizational and political context, and concluded that the QHC process can best be realized by aiming for less impactful, more stabilizing activities. This means that they analyzed the system in its unprecedent configuration and concluded that it is more practical to go for the 'low-hanging' fruits instead of trying to trigger a more large-scale change. This turn in strategy, from performing in organization's eyes to performing in broader societal eyes, is a good example of how taking a systems perspective can in fact help a QHC legitimize its activities. By focusing on building a QHC community outside the organization and in this way

having an impact outside the organization – both of which are principal RRI competences – the QHC in question seeks stability within its own organization.

Diversity and Transdisciplinarity

Transdisciplinarity competence refers to the ability to "structure relations, spot issues and recognize the legitimacy of other viewpoints in business decision-making processes regarding environmental, social and economic issues, to involve all stakeholders and to maximize the exchange of ideas and learning across different groups (inside and outside the organization) and different disciplines (inter-disciplinarity)" (Lans, Blok, & Wesselink, 2014). Our QHC partners showed a good ability to think in terms of other approaches and disciplines. At the same time, in most SLs, and particularly in the WUR and IHS cases, parties acknowledged the linguistic difficulties involved in 'translating' technical aspects of the innovation process for other non-technical helixes. The QHC partners experienced this as a challenge because the 'general public', while not fully in control of the technical jargon, remained the source of useful criteria on moral matters, personal experiences and societal perspectives.

An illustrative example of the function of transdisciplinarity in the QHC is provided by the social lab initiated by industry where both case meetings and panel meetings brought together individuals from many different disciplines. Participants in these meetings were representatives of the many industries that are (and presumably will be) involved in the hydrogen economy in the future in that area: energy grid operators, gas infrastructure, energy providers, industries, ports and industry terrains. Stakeholders were encouraged to participate and to voice their own concerns from the perspective they are representing (or other perspectives). The discussion often is segmented into topics (e.g., 'water', 'transport', 'storage') on which the stakeholders then react and try to bring their insights. These topics are briefly presented by one stakeholder (typically a consultant) after which the parties begin the discussion. The QHC managers were particularly skilled at bringing all these views together and often 'translating' between them for the ones present.

Transdisciplinarity can also occur in the form questioning standard concepts coming from management science and even concepts stemming from our own project (RiConfigure). In two of our social labs, participants noted a difficulty in drawing a concrete line between the case and its context. As one manager noted, when the innovation process is in a constant dialogue with the landscape and is heavily influenced by that landscape, both the participants and the social lab managers might in fact experience difficulties in delineating insiders and outsiders. The term 'collaboration' is not helpful in this case because, under one interpretation, the partners are constantly collaborating with their environment, often beyond contractual agreements. A similar note was placed by other social lab managers who in fact had to undertake a more radical switch. Being constantly confronted with the impossibility of saying specifically where the innovation lies and who is the group in charge of the innovation, the SL managers switched from investigating a concrete innovation *project* to investigating an innovation *process.* In other words, the viewpoint was broadened from one explicit agreement, with a start date and an end date (i.e., the Gigawatt *project*), to the more general societal agreement on the need and value of innovation (i.e., the hydrogen innovation *process*). As we will

explain in the next section, this ambiguity regarding the innovation process itself 'spills over' to create ambiguity in leadership.

Moral competences and discussions

Sometimes referred to as 'ethical competence', moral competence is "the sensitivity of managers and professionals to moral issues in their organizational structures followed by moral judgment and actions" (Pohling, Bzdok, Eigenstetter, Stumpf, & Strobel, 2016). We encountered significant difficulty in evaluating the moral competence of the participants according to the established methodology. It is true that all our partners were aware of the importance of taking societal values into consideration in research and innovation – indeed, otherwise they would not have accepted the partnership in the first place. Yet it turned out difficult to assess whether the answers that were given regarding the social and ethical impact of their project were influenced by our presence during the interventions. Since responsibility and ethics are such compelling subjects and powerful themes, it is expectable that they influence those asked to speak about them and compels them (indirectly) to go for the 'standard treatment'. Nevertheless, some notable highlights can be mentioned.

For example, some stakeholders experienced the power relationship between the stakeholders involved in a project as relatively unfair. On the one hand, the government puts forward expectations on other stakeholders to create change and stimulate social innovation; on the other hand, the government is too rigid to move clearly by incentivizing the field in question. Law is then slower than practice. In discussing this, one partner also mentioned that not only the government but also civil society exhibits such unfair 'not-practice-what-you-preach' behavior. Thus, society is pressuring other stakeholders to change and to improve (e.g., when it comes to sustainability and CO_2 reduction) yet when it comes to changing their own behavior, civil society turns out to be quite rigid, often needing systematic guidance and examples before they budge in a specific direction. This rigidity of the civil society is also shown in their unwillingness to accommodate the fact that responsibility (or sustainability) is not the only value on the plate and that other values must play a part if a fair decision-making process is to take place. These are thus some examples where stakeholders were exhibiting the competence of assessing a situation based on shared principles (in this case, the principle of fairness and practicing what is being preached). Reflection on new ideas and approaches was initiated in one of the main cases mostly at discussion and networking events, where speakers would present their learnings from new implementing innovative solutions. At these events, including speakers from civil society and actively approaching speakers from non-traditional areas was a way to engage in ethical and moral discussions and to bring in new perspectives on the problems at hand.

3.2 RRI leadership

RRI leadership is the leadership that can adapt itself to, but also encourage, the production of RRI outcomes. By leadership we mean the behavior of the organization (or organizations) that have a leading role within the studied. Recent scholarship has proposed the concept of integrative leadership

as a solution for creating responsible innovation in cross-sectoral collaborations (Silvia & McGuire, 2010). The main idea of integrative leadership is that the leader functions as a catalyst more than as a manager: "So the question becomes why in some cases does a reaction occur (integration; partnerships that create public value), whereas in other cases it does not? The answer lies in the presence of a catalyst or catalysts. Catalysts are those parts of the system that enable a reaction, or in other words, bring together the different pieces at the right time' (Morse, 2010). The 'RRI leader' is seen as someone who functions more as a catalyst than a manager with administrative tasks: catalysts are those parts of the system that enable a reaction, or in other words, bring together the different pieces at the right time' (Morse, 2010).

In practice, the application of these ideas from leadership literature was hampered by significant complexity in answering the 'who-is-in-charge-question'. In an ideal QHC, with a clear identifiable leader and a series of managerial tasks that belong to that leader, leadership can be isolated as a variable in the big QHC picture. However, most of our cases exhibited a much more complex picture of leadership than the organizational terminology might suggest. Before explaining this further it is important to relate this ambiguity to the previously mentioned ambiguity regarding the QHC process itself. Indeed, when innovation is diffuse either because it is grands-scale and systemic or because it is shared by a variety of actors, the question of leadership needs to be reformulated. The traditional (mainly organizational) concept of a leader becomes too rigid.

In all social labs, the leaders were observed organizing boundary events and taking initiative in establishing or maintaining contact between the collaborating partners of the QHC and other actors. In some cases, this activity was part of the QHC itself, in others it was the result of the result of the QHC's interactions with the RiConfigure partners during the social lab. These events consisted in a variety of episodes in which participants from a variety of sectors get to share their worldview with the partners in the QHC. The creation and maintenance of these episodes is particularly restrained in the context of innovation that is primarily industry-oriented (business-to-business). In such a context, the relationship between the partnering businesses seems more isolated from civil society involvement. However, through sustained intervention it became clear that the views of civil society can do 'trickle down' into B2B context. More indirectly, the discourse about risks in various media can also influence the business-to-business context. For example, the employees of one of the organisations industry engaged in the business-to-business relationship become something like a 'sample' of civil society which the leaders of the QHC can easily access. In most cases, the strong presence of one or two helixes creates a powerful gravity point which leaves little space for other helixes to commit resources to the project. The strong presence of the initiating helix can in this sense be a deterrent for other helixes to commit resources to the project. As with the RRI competences, a leadership's effectiveness in crossing boundaries and bringing helixes together is very much dependent on the institutional context and the 'landscape' variables at any particular moment.

When enough resources *are* present and the nature of the QHC is such that it is meaningful for other helixes to participate, the leaders were shown to take advantage of the situation and create trans-disciplinary episodes. In one of the social labs, the participants organized day-length meetings in which all helixes were present. The organizations selected for participation were either industrial partners related to the QHC or regional government or an agency related to the theme. In general,

the stakeholders that end up participating are representatives of the many helixes that are (and presumably will be) affected by the innovation process lead in question. These meetings are not only useful for sharing visions and discussing questions stemming from each helix, but they constitute good networking opportunities for those involved. The value of these meetings needs to be stressed in advanced. These meetings could not be organized without the other helixes being ready to commit some of their resources (time, energy, finances) to these boundary-crossing events.

Finally, we want to note that using a moderator (or 'mediator') in QHC processes can be a way of transferring leadership structure consciously away from initiators/funding organizations to "outsiders." These outsiders operate indeed on behalf of the leading organization, but they are in a better position to stand on the proverbial center point between all the four helixes that pull the innovation process towards the specific four values (academic value, business value, societal value and political value). The work of such a mediator, for example, in the industry social lab (WUR) has enables a more equal footing between the partners and a communication approach that is less *directed* by a certain community leader and more *moderated* by someone with neutral (or in any case, less unidirectional) presence. Through such a move, the steering board can create a dialogue platform on which the RRI leadership competences can be put into practice and enhanced.

Chapter 4. Quadruple Helix Collaboration and Governance Structures

As explained in the introduction, the third aim of the RiConfigure project is to compare findings about the observable impacts of public governance frameworks (at Local, Regional, National, European and International level) on QH-collaborations. This is carried out in order to ascertain the institutional conditions under which QHCs are fostered and encouraged or instead hampered and discouraged.

What do we mean by governance? Governance is a mode of government that variously emphasizes co-regulation, co-steering, co-production, cooperative management and co-creation on the borderline between government and society (Archon, 2006; Guston, 2013; Kooiman, 1993; Van Asselt & Van Bree, 2011). Governance approaches are especially attractive to organizations with limited capacity for direct management of the societal phenomena they seek to steer. Such is the case for instance of public authorities who seek to shape the course of research and innovation (R&I) in their territories. We take as a point of departure a standpoint accepted in transition management, namely, that some governance structures are more appropriate than others for enabling sustainable development. In other words, there are aspects of the policy making that function as input of the QHC and influence QHCs irrespective of the topic of the collaboration or other processual factors (e.g., the partners' skills).

The question of the effective governance structures that stimulate a more inclusive, sustainable and ultimately just socio-economic environment has been discussed intensively in the past two decades. A variety of contexts have been studied from waste management, agriculture, energy supply and healthcare. Overarching claims that cover all these specific sectors are of course difficult to establish and subject to interpretation. However, past research has shown a series of trends and several proposals have been advanced for how the governance context is to relate to practice (broadly construed) in order to enable a more responsible R&D environment and inhibit traditional dynamics that typically push away from responsibility . We distinguish between four types of interactions between the governance structure and, in our case, the QHC: the strategic, tactical, operational and reflexive levels (Loorbach, 2007).

Governance efforts often overlap at various levels within one and the same territory – for example, in the EU local-, regional-, national-, and European-level efforts to govern research and innovation can come to clash with one another. To enhance collaborative research and innovation, rather than counteract it, governance frameworks must therefore seek an alignment between R&D agendas (including agendas of individual organizations) and more general innovation policy agendas at these various levels. This means at least that smart specialization strategies in the regions, national research and innovation strategies coordinated within the ERA cooperation, and European strategies for stimulating the emergence of science-with-and-for-society approaches (such as RRI and Open Science) must *work in conjunction and enable each other*. If such synergy between

different R&I-governance levels is achieved, each level will be better able to gain from and contribute to the emergence of new constellations, institutions, and actors.

Focusing on the topic of QHCs, we sought to understand the policy conditions that enable, maintain, but also hamper the successful development of QHCs.

Figure 7 Three different levels of governance that can influence QHCs

Strategic governance level – This is the level of vision development, strategy forming and long-term goal formulation. At this level we investigated whether there are governance structures that facilitate or hamper such activities.

Tactical governance level – This is the level of more concrete QHCs, alliances and networks. At this level we investigated whether governance structures encourage the formation of such alliances or work as barriers against it.

Operational governance level – This is the level of most concrete form of impact of governance structures on QHC: funding, incentives (positive and negative) and rewards for engaging in QHC. At this level we investigated whether there are such elements in the selected countries.

In order to understand this relationship between the governance framework and the QHC, two types of data have been used, making a distinction between the *objective presence* of factors of influence at the three levels – i.e., the extent to which relevant institutional factors can be found through desk research – and the *subjective presence* of factors of influence at the same levels – i.e., the extent to which participants in the Social Labs make use, or are at least are informed about the relevant institutional factors. This distinction was considered necessary in order to obtain some indications about how much the major existing frameworks were synchronized with the needs and expectations of real-life QHCs. At the same time, we wanted to test the degree of awareness of the same QHCs about their institutional environment.

The following observations represent the major insights on the observable interactions and impacts of Governance frameworks on actual QHCs. They were obtained by crossing the description of the existing governance measures around each SL and the recorded attitudes and points of view of the SL participants about their impacts on the collaborations in which they are actually involved.

4.1 Governance frameworks for QHCs: a varied landscape

The notion of a fourth helix besides Industry, Academia and Public sector in collaborations for innovation has been gaining saliency in the last years, and the term Quadruple Helix itself is currently having some traction, albeit it is not yet fully established. At European level, in the RRI model, which advocates for civil society engagement, the notion of QH per se was not originally contemplated. However, in Horizon 2020 the funding schemes related to RRI, explicitly request that a QH approach be considered. In the EU Open Innovation 2.0 strategy, the transition from a Triple Helix model to a Quadruple Helix model is clearly heralded. National innovation strategies in EU member states may

range from a mere "public understanding of science" approach to a fully-fledged conceptualization of the quadruple helix phenomenon.

At a national level, a good example is the 2016 Austrian Open Innovation strategy, which actively addresses the inclusion of civil society and openly advocates the need to broaden the TH model to a QH model and provides some resources to implement them (Open Innovation Strategy for Austria. Goals, Measures and Methods. Report by the Austrian Federal Ministry of Science, Research and Economy - BMWFW and the Austrian Federal Ministry of Transport, Innovation and Technology – BMVIT, 2016).

In other instances of national governance, similar strategies exist although the term "quadruple helix" is not explicitly used. Such governance strategies and policies indicate the need for collaboration among the actors included in the four components of the "helix", or simply to the need to involve civil society in innovation processes.[2] In the case of German STI policies ("science, technology and innovation"), there is often a reference to the involvement of civil society at the strategic level, a well-known example being the Artificial Intelligence STI strategy. The mentioned rationale is that the strategy is supposed to address societal challenges and that civil society should be integrated in the process, starting from the formulation of the strategy itself. However, when it comes to the actual funding programs in that thematic field, they are mainly meant to support science-industry collaborations. This partial inconsistency between strategies and instruments is a recurring feature reported also in other countries (for instance in the Austrian country profile). We can thus observe that even when there is a general strategy that directly or indirectly promotes QHCs, the actual funding schemes for the most part seem to be designed in prevalently Triple Helix or Open Innovation 1.0 mind-sets and subsequently broadened to reach for inclusion of civil society "downstream".

Finally, it must be noted that recommendations for intersectoral cooperation and civil society involvement can be found in diverse regional policies, whose primary objective is not the promotion of collaborative innovation, but to address challenges such as climate change, sustainable transportation, etc. Such is the case, for instance, of the climate change mitigation strategy in Denmark, in which the involvement of civil society is mandated in many instances, but the term "quadruple helix" is not used. Another example is the regional SDE policies in The Netherlands. It should be noted however, that in such policies the very definition of civil society involvement – and *civil society itself* - varies significantly. Equally importantly, in these regional policies, the inclusion of civil society is formulated sometimes as a requirement, sometimes as a mere recommendation. There is therefore, at least at a regional level, very difficult to evaluate the extent to which regional policies have any success (or impact) on actual innovation practices. Even in cases where funding

[2] Of course, it is not necessary for a program to actually contain references to quadruple- (or triple-) helix innovation in order for the program to result in QHCs. Rather, it is more fundamental that they highlight the need for co-operation and co-innovation relative to the problem(s) they wish to solve or more generally relative to their domain of reference. Nevertheless, the uptake of terminology from literature on QHC, co-innovation, responsible innovation and the like can be an indication of the degree to which movements towards a more collaborative innovation process are being undertaken and to what extent these movements are supported by current research conceptually and theoretically.

instruments explicitly require condition for funding or subsidy, the actual practices that result from that funding are difficult to see and evaluate.

4.2 QHC initiation and regulations

When we compare the existing governance frameworks with the experience of the Social Labs and the mirror and reference cases, we see that QHCs are not primarily triggered by ad hoc policies that are specifically designed for them. Rather, the QHCs appear in a governance environment offering a variety of more or less relevant incentives, of which they are not always fully aware, and of which they make use according with their core interests. This interaction between existing frameworks and the actors from the various helixes occur at different levels and in various configurations.

The interaction between governance frameworks and actual (or potential) QHCs is not always smooth. For example, in three of our four SLs the actors noticed that funding landscape for QHCs was somehow confusing and inconsistent with the more general, national or European strategies. This had a demotivating effect. Bureaucratic impediments and conflicts of competence among different governance actors were also reported. In some cases the governance framework prevents a smooth QHC because changes in the political environment at local or national level can cause major shifts in the focus of interest and in the allocation of resources while the collaboration was still ongoing. With these experiences, our collaborators noticed that the socio-technical system is not always designed to foster QHCs. Quite the contrary, a QHC is more often than not an exceptional event and needs additional financial and structural efforts to keep in place.

An interesting case is that of the political or 'symbolic' support of high-level policy regulations. This seems to be the case for climate-related QHCs where the many 'climate agreements' in place at this moment do not provide any direct (financial or practical) support but rather an encouraging framework in which to operate with existing resources or lower-level policies. This is the case for example in the Dutch Social Lab where high-level policy statements such as the National Climate Agreement and, higher still, the Paris Climate Agreement, have provided a backdrop for helixes such as industry and research to invest in QHCs. The inclusion of civil society might vary across projects, but the civil society is nevertheless included because of the main sustainability goal pursued.[3] A similar situation, albeit with a stronger role for civil society, was documented in another SL with regard to a Collaborative Regional Innovation Facility, aimed at engaging citizens to propose new ideas for regional development on topics such as tourism, mobility, economy, culture. The setting up of such a collaborative facility received an important guidance by the National Open Innovation strategy, which directly advocates and supports the QH model. However, once the facility started operating, the alignment with the strategy was not necessarily a priority and the activities ended up being supported by a plurality of funds, coming from a Ministry, a University and other local sponsors.

The conditions under which QHCs arise and persist cannot be fixed into pre-existing patterns. For example, in another social lab, a different kind of interaction between strategical policy and

[3] In that case, the participants themselves might regard the collaboration as a Triple Helix Collaboration that nevertheless includes the values of civil society.

tactical arrangements was identified. This social lab as well concerned climate change, specifically, a response to worsening sea-level conditions. The initiator was the city's Municipality, prompted by a National Action Plan that makes it mandatory for Municipalities to prepare local action plans and to partner with industry, the civil society and other actors to implement it. Yet in this specific case, the funds were provided by both the State and by European Union funds, even though the requirement for citizen-level collaboration was specifically formulated in the National Action Plan.

It needs to be highlighted that making institutional arrangements such as QHC mandatory is not necessarily a recipe for success. The production of societal value requires a prolonged thrust that must go beyond the immediate goals of specific projects. One of our cases exemplifies how institutional arrangements that make mandatory the inclusion of all the four helixes, can be short lived. In the case, a collaboration was established for the rehabilitation of aquatic ecosystems and traditional lifestyle, for the well-being of the local communities. The project was initiated by civil society organisations in the framework of the National Policy of Climate Change, in tune with the Ramsar International Agreement, which provided the funds for all helixes to operate together, but there seems to be a difficulty to maintain the involvement of the actors other than CS in a long term effort, once the actual project which originated the collaboration is over.

Based on the experience of the SLs, we can note that real-life QHCs appear as the result of a complex contextual interaction among specific actors (each bearing their own "good reasons"). Existing governance frameworks impacts these QHCs at various points and in various ways, resulting in a sort of "patchwork" of measures and legal arrangements from which to get resources and support.

4.3 QHCs and governance structure: a dynamic building process

Investigating the relationship between QHCs and the governance can best be seen as a constant building process directed towards establishing and constantly re-establishing the collective actor of the QHC. This instability is both a blessing and a curse, for in the efforts to constantly find the right balance, partners have a chance to bring in their organizational and cultural experiences, their motivation and their identity. All these aspects determine the capacity of the various actors to interact profitably with the relevant governance frameworks.

In this process of constant building, the initiator of the QHC plays a significant role in navigating the relationship between the QHC and the political, legal and organizational contexts. This was also pointed out in Chapter 2 above. The kind of policy measures that are actually used for activating the collaboration depend on the nature of the actor (industry, CSO, research organization, local authority, etc.), the sector in which it acts, its interests, and the objectives it is pursuing. In the case of strong research-industry partnership, the main players can be primarily motivated by their R&I interests and look for validation and recognition from an overarching national strategy. We have also seen that public sector actors can be motivated by national legal instruments that make it mandatory for them to build QH - like coalitions to pursue specific policies such as climate change mitigation. The QHC initiator together with the governance framework in which the QHC takes place can be seen as together taking the responsibility of the *Enabler* - the body that funds, fosters and

provides the infrastructure for the QHC. As enablers, it seems expedient for these institutions to realize that the QHC is constantly in the making, constantly building itself as projects go along.

Chapter 5. Lessons Learned and Steps forward

The QHC, with its promises of increased effectiveness and reasonableness, is in the making. With these preliminary results from our Social Labs, we seek to highlight what it means to be engaged in a QHC and, more generally, what it means to be engaged in a shift of perspective in innovation. To this end, we have focused on challenges and prospects of betterment regarding the QHC practice (Chapter 2), on the relationship between RRI and QHC (Chapter 3) and on the governance context in which these QHC collaborations are active (Chapter 4). In this chapter we want to draw out several avenues for further research on QHCs and the Social Lab methodology.

5.1 Lessons learned

The interaction between partners is difficult, but constant building and maintenance of the organizational structure around the QHC can help. For example, establishing a financial framework in which all four parties are included and in which their role is clearly determined is almost a *sine qua non* condition, given that in most of the analyzed project, the civil society does not have access to sufficient finances and thus depends on the other partners in this regards. Under such conditions, a conscious selection of partners, in which the initiator *begins* with the stakeholders-to-be-included can create the necessary platform for creating a QHC. That said, such processes can also take time and slow down the innovation process which can in fact generate tensions even before the kick-off. Finally, making sure that the partners share a common vision and shared goals, beyond the official narrative everyone is adhering to 'by default', is essential in maintaining QHCs and ensuring their effectiveness. Once these structural elements are taken care of, facilitators and managers can then work on the small-scale variables such as frequent interactive events that can ensure goal-and-expectation alignment and reflective learning. In addition, management styles that allow an allocation of responsibilities across the four helixes (as opposed to letting one helix take ownership/responsibility of the entire setting) can help maintain a high interest and avoid fundamental disruptions in the QHC.

On the topic of RRI competences, we have noticed that navigating the four helixes through systems thinking is not particularly challenging. Stakeholders whose daily work consist of this necessary 'placement in context' have acquired these skills before themes such as public engagement and citizen science became popular. That said, it is doubtful whether navigating public-private partnerships or even triple-helix partnerships (research, industry, policy) is on a par with navigating quadruple helix partnerships. Often bracketed in the former but essential in the latter, the capacity to discuss transdisciplinarily (i.e., between experts of various kinds, including the lay public) seems to still present some difficulties. Not all stakeholders are convinced of the benefits of integrating

society 'upstream' in the innovation process and as such do not see the need to develop skills and methods for engaging in this practice.

As emerged from the analysis of real-life QHCs cases, they often appear more like a spectrum of interaction among the four components, than a clear-cut coalition of equal partners. Sometimes one or more "helixes" are scarcely present or altogether missing. This is particularly true for the civil society component that can be substantiated in a very diverse way and about whose role there are diverging positions among the representatives of the other "helixes". In fact, as observed in the Danish SL, the participation of civil society often seems to play a marginal role or intervene at a later stage of the collaboration. In this regard, governance frameworks can play an important role both at the strategic level and at the tactical and operational ones, since they may envision civil society as major strategic actor or can make the participation of CSOs a requirement for the provision of funds to the collaboration (as for instance in the Columbian SL). Even when such requirements are in place, however, resistances or difficulties to properly include civil society by other actors of the collaboration have been observed (this seems a common issue expressed, in different forms, in all the SLs). Moreover, motivations towards the establishment of the collaboration and the use of the available governance instruments may largely vary among the involved actors according to their different interests and attitudes.

5.2 Steps forward

The research agenda for QHCs should focus in our view on obtaining a deeper understanding of the existing power relations between stakeholders in the QHC and of the process of co-innovation.

Understanding Power Relations in QHCs

Although we have been successful in penetrating the environment of five different QHCs, we must acknowledge that the resulting understanding is fragmentary and quite case-specific. To some extent, this is unavoidable. The knowledge we gather about an incipient phenomenon cannot but be anecdotal and 'tied down' to the details of the cases under investigation. Nevertheless, there are several features that seem to be of general import for the creation and management of successful QHCs regardless of case details. One of them is the relationships of power that are formed within a QHC.

The problem of power within QHCs could be formulated as a dilemma: helixes cannot be engaged in a game of strict equality because the added value of the QHC lies precisely in exploiting the asymmetry between the helixes and equality strictly understood (e.g., everyone has equal decision-making power) would be not only practically impossible but also detrimental to the innovation process. Additionally, it is not clear that the helixes *want* to be engaged in a game of strict equality because that would mean distributing responsibility across the field equally and representatives that currently have this responsibility might not want to give it up while those that do not currently have responsibility might not want it at all. For example, environmental organizations are more interested in maintaining a role as a critic of those in power (politics, industry etc.) rather than starting to systematically engage with these other helixes and start taking part in the resulting decisions. This is then one horn of the dilemma: strict equality does not seem to work

because it is both impractical and undesirable. On the other hand, *not* tackling the existing power structures does not seem to be a good option either. As many of our analyses in the previous chapters have shown, much of the hardship involved in setting up and maintaining QHCs stem one way or another from *existing* power relationships that prevent some helixes (particularly CSOs) from truly influencing the design process. The motto that 'Those who pay, get to say' applies to QHCs and this situation constitutes a barrier for a truly inter- and trans-disciplinary approach of the innovation process. This is then the second horn of the dilemma: existing structures of power are detrimental to a full utilization of the QHC potential.

Future research can engage in a closer study of these power relations with the tools of anthropology and political sciences. An insiders' view provided by anthropological studies can unearth the motivations behind the systems' maintenance of existing power relations and the concerns that come with the transition towards new power relations. A normative view provided by political studies can provide ways of organizing work in QHC that is motivated by other views of equality aside from the strict interpretation in which everyone has the same rights. For example, the concept of 'complex equality' (Arler, 2001; Miller & Walzer, 1995) and similar ideas in the study of pluralism (Kaul & Salvatore, 2020) can provide a starting point for a more sophisticated conceptualization of the relationship between the helixes.

A Closer look at The Co-Innovation Process

Although it is plainly clear that the partners involved in QHCs must co-innovate, the process of co-innovation has been mainly known through case-based empirical data. The concept of *co-innovation* refers to a collaborative endeavor through which an innovation output is shaped by multiple stakeholders. The process of co-innovation, also referred to as 'value co-creation' and 'open innovation' (Bhalla, 2011; Chesbrough, 2003; Grönroos, 2012; Saragih & Tan, 2018), is generally associated with QHCs but the word functions more like a buzzword than a determinant of clear methodologies or principles of collaboration.

Our case studies have provided an empirically rich picture of how stakeholders see co-innovation, this picture might need to be supplemented by a more theory-driven modelling of the process. The risk is otherwise that practitioners are forced to 'reinvent the wheel' every time they engage in co-innovation or that principles that can improve practice are never discovered and applied. The literature on co-innovation is of course already tackling these issues to some extent. From this study we have learned the relationship between helixes in practice (Chapter 2), their implementation of RRI principles (Chapter 3) and their relationship with governance structures (Chapter 4). Similarly, from past studies we have learned a lot about the context in which co-innovation occurs, e.g., methods for engaging stakeholders in co-innovation processes (Cuppen, 2012; Dahlander, Gann, & Wallin, 2021; Ramaswamy & Ozcan, 2014; Redlich, Moritz, & Wulfsberg, 2018), institutional and legal arrangements in which co-innovation occurs (Bossink, 2002), the management of such complex partnerships (Autio & Thomas, 2014; Bryson et al., 2015), the evolution of co-innovation from traditional models (Lee, Trimi, & Olson, 2012) etc. These studies provide valuable insights into co-innovation praxis, but the distinction between innovation and co-innovation - or between 'value creation' and 'value co-creation', 'closed innovation' and 'open

innovation' etc. – remains by and large a matter of intuition rather than theoretical determination. We have many descriptions and case studies of the process of co-innovation (and its semantic relatives) but the emerging picture is fragmentary and its philosophical assumptions remain mostly implicit.

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