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Boundary Work to Enable Innovation in the Life Sciences: A Comparative Case Study

by

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Résumé

La collaboration précompétitive dans le secteur des sciences de la vie est l'une des stratégies employées conjointement par le secteur public et le secteur privé dans le but de réduire les obstacles liés à l'innovation dans la découverte de nouveaux médicaments. Cette étude se concentre sur les consortiums de recherche précompétitive agissant en tant qu'organisations frontière pour stimuler l'innovation grâce au « boundary work » dans l'espace précompétitif. Nous explorons ce phénomène du point de vue de la gestion en analysant et en comparant deux études de cas, ainsi qu'en ajoutant à la littérature existante des informations tirées de données empiriques sur deux études de cas de consortiums précompétitifs qui facilitent la collaboration dans ce contexte pluraliste. Avec une approche inductive, cette étude permet de mieux comprendre comment les organisations frontières sont organisées et comment elles arrivent à créer une collaboration efficace entre compétiteurs afin d'innover et atteindre des objectifs communs, avec quels résultats, bénéfices et défis, et ainsi en tirer des leçons pour la pratique et des recherches futures spécifiquement dans le domaine des sciences de la vie.

Mots-clés: *organisation frontière boundary work, boundary organization, partenariat public-privé, collaboration précompetitive, innovation ouverte*

Abstract

Pre-competitive collaboration in the life sciences sector is one of the strategies that the public and private sector jointly leverage in order to stimulate and lower the barriers to innovation in early-stage drug discovery. This research study focuses on pre-competitive research consortia acting as boundary organizations to enable innovation through boundary work in the pre-competitive space of early drug discovery and research. We explore this phenomenon from a strategic management perspective by analyzing and comparing two case studies and adding to existing literature insights from empirical data into the types of boundary work that prevail in this pluralistic context. Through an inductive approach, this research provides insights into how boundary organizations operate and how they are able to enable collaboration between competitors in the life sciences in order to innovate and achieve common goals, what results and benefits are generated and with what challenges, along with implications for practice and further research in the context of life sciences research.

Keywords: *boundary work, boundary organization, public-private partnership, pre-competitive collaboration, open innovation*

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"Alone we can do so little; together we can do so much." – these words by American author and educator Hellen Keller could not resonate more with me. Although this thesis oftentimes felt like solitary work, I am grateful for each person who has inspired me, supported me, and contributed to this research in any big or small way.

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Thank you!

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List of Abbreviations

C.1	Consortium 1
C.2	Consortium 2
FDA	U.S. Food and Drug Administration
PPP	Public-private partnership
R&D	Research & Development
USD	United States Dollar
WHO	World Health Organization

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Introduction

A global pandemic can bring into bright spotlight the need for innovation in the life sciences as key to discovering and developing new therapeutics and treatments to meet the most pressing needs such as bringing a pandemic to an end. A global pandemic can also highlight the importance of public-private partnerships and the increasing need for greater collaboration across companies, industries, sectors, and geographies to share knowledge, expertise, resources, and capabilities from both public and private stakeholders (Guimon & Narula, 2020) to move with speed in a joint effort to save lives and livelihoods. It is this type of complex challenge that pre-competitive research consortia aim to solve by bringing together academia where knowledge is created, the pharmaceutical industry where therapeutics are developed and brought to market, as well as public funding to ultimately benefit patients and society. It is this type of complex challenge that any one of these entities cannot solve alone.

The pharmaceutical industry has significantly contributed to public health and welfare over the past century by bringing to market treatments for diseases such as diabetes, infections such as AIDS, psychiatric treatments, and solutions for major health challenges such as cancer (Hunter, 2011). However, over the past decades, in spite of increased investment in research and development, breakthrough science and innovation has been slowing down compared to the past (Hunter, 2011). We still do not have treatments for neurodegenerative diseases like Alzheimer's and we have not yet cured cancer.

Compelled to continue to deliver solutions to help solve the most pressing unmet medical needs and seize emerging opportunities to improve healthcare, the pharmaceutical industry has been adopting and experimenting with new collaboration models with the mission to accelerate innovation (Munos, 2014). What was once a closed and siloed industry is increasingly embracing open innovation through public-private partnerships which enable collaboration, knowledge creation, and diffusion of knowledge beyond boundaries in the

form of public domain data to support research and development (Munos, 2014). Open innovation is a pre-requisite for public-private partnerships which satisfy the need for external collaboration across the process of discovery, development, manufacturing, and commercialization of new medicines (Martinez-Grau & Alvim-Gastom, 2019). Now, more than ever, scientists and researchers need to work together to share knowledge and resources across geographical, industry, and organizational boundaries to solve the most urgent and complex challenges.

Public-private partnerships take the form of pre-competitive research consortia operating as boundary organizations that facilitate collaboration between unlikely allies such as industry and academia. The concept of "boundary organization" is defined by Guston (2001) as a means to stabilize the boundary between science and policy. In the life sciences, boundary organizations bring together academia where knowledge is created, members of pharmaceutical and biotechnology industry where medicines and therapeutics are developed and brought to market, as well as public funding to ultimately benefit society at large.

Pre-competitive can be "defined as competitors sharing early stages of research that benefit all" (Hunter, 2011, p. 56), which happens before potential drug candidates are identified. The purpose of this research is to increase our understanding of how pre-competitive research consortia operating as boundary organizations enable collaborative innovation by facilitating collaboration between different actors in the private and the public sectors to improve the research and development process and generate value for society. Although pre-competitive collaboration is not a new phenomenon and it is a highly strategic topic for stakeholders involved, it has not yet been sufficiently studied from a strategic management perspective in the life sciences. I am curious to explore this phenomenon to further our understanding of boundary organizations in this pluralistic setting where competitors in the pharmaceutical industry, academia and public sectors come together not only to develop the next breakthrough innovation, but also to share it with the broader scientific community.

The core focus of this research is to shed light on the following research question: ***how do pre-competitive research consortia enable innovation in the life sciences?*** To do so, we collected empirical data from two (2) pre-competitive research consortia whose mission is to enable innovation in the life sciences. We used semi-structured interviews as data collection tool to explore and gain insights towards the research question from consortia members as well as industry members working in partnership towards common goals.

Following an inductive approach to data analysis, we identified and analyzed the emerging themes and sub-themes into a holistic framework to explain the key elements of how pre-competitive research consortia operate along with the results and benefits they generate. Our findings suggest that pre-competitive research consortia play an important role in establishing governance and mechanisms to facilitate boundary work in order to enable innovation between unlikely allies in the life sciences.

After exploring and reviewing the literature, we will present the methodology used to collect empirical data, the research design and the conceptual framework, and then present our findings and discussion, along with limitations of the present research study and avenues for future research.

Chapter 1: Literature Review

Innovation in research and development (R&D) is a major challenge in the biotechnology and pharmaceutical sector as the industry is striving to increase research productivity in order to bring to market novel medicines and therapeutics. This chapter will present a brief historical perspective of the industry, the concept of open innovation and pre-competitive collaboration as the industry's response to decrease in R&D productivity as a way to solve its innovation dilemma, and boundary work leading to the conceptual framework that informs the present research to shed further light into enabling innovation in the life sciences.

Pharmaceutical Industry: A History of Innovation

The beginning of the pharmaceutical industry can be traced back to the 1800s in Europe (Munos, 2014). Speciality chemistry firms emerged from the dye industry with the establishment of firms like Sandoz in Switzerland and Bayer in Germany and their evolution into becoming the first pharmaceutical companies (Waller et al., 2011). Developing a new drug is a complex process which can take from 12 to 15 years and could cost over $1 billion USD (Hughes et al., 2011). Despite all the progress thus far and the increasing investment in R&D, the pharmaceutical industry has been facing decreasing productivity over the last decades and has been facing an innovation dilemma. As a result, the industry has turned increasingly, yet still reluctantly, to partnerships and collaborations to expand opportunities to access knowledge, resources and capabilities to supplement R&D efforts and successfully bring new medicines to patients faster and at a lower cost (Martinez-Grau & Alvim-Gastom, 2019).

According to Bianchi et al. (2011), the traditional method of drug development may become unviable since the cost of drug development is increasing with time, and the subsequent profits will not be sufficient to cover the need for reinvestment in other research projects. Therefore, the pharmaceutical industry is moving from an integrated drug development

model to strategic alliances and outsourcing of scientific services (Bianchi et al., 2011). In these current models, resources are gathered through partnerships such as funds from industry or government agencies, contribution of knowledge from academia and scientific communities (De Vrueh & Crommelin, 2017).

In 2018, the global pharmaceutical industry was estimated to be worth $1.11 trillion USD and it was anticipated to rise to $1.41 trillion USD in 2020 (Mikulic, 2019). There is increasing global demand for medicines and increasing pressure to innovate and continue to bring new drugs to market (Waller et al., 2011). Regulatory authorities have also been doing their part in bringing safer and better-quality pharmaceutical products to market through rapid approval of new products (Waller et al., 2011).

This brings us to the concept of open innovation and public-private partnerships (PPP) to help solve the innovation dilemma in research and development. According to Munos (2014), while there may be a research productivity crisis in the pharma industry, the barriers to information sharing have never been lower. Increasing innovation and research productivity demands shared solutions (Munos, 2014). To better situate the context of the present research at the pre-competitive stage of early research and drug discovery, Figure 1 from Lee et al. (2019) illustrates the end-to-end high-level research and development process and timeline for a new drug from discovery of potential drug targets to early research and drug development and finally, regulatory approval – in this case, the U.S. Food and Drug Administration (FDA). The pre-competitive stage represents the "Drug Research & Discovery" phase on the far-left hand-side, before a potential drug target has been identified and can become a breakthrough medicine once moved to "Lead Optimization", hence kick-starting preclinical trials.

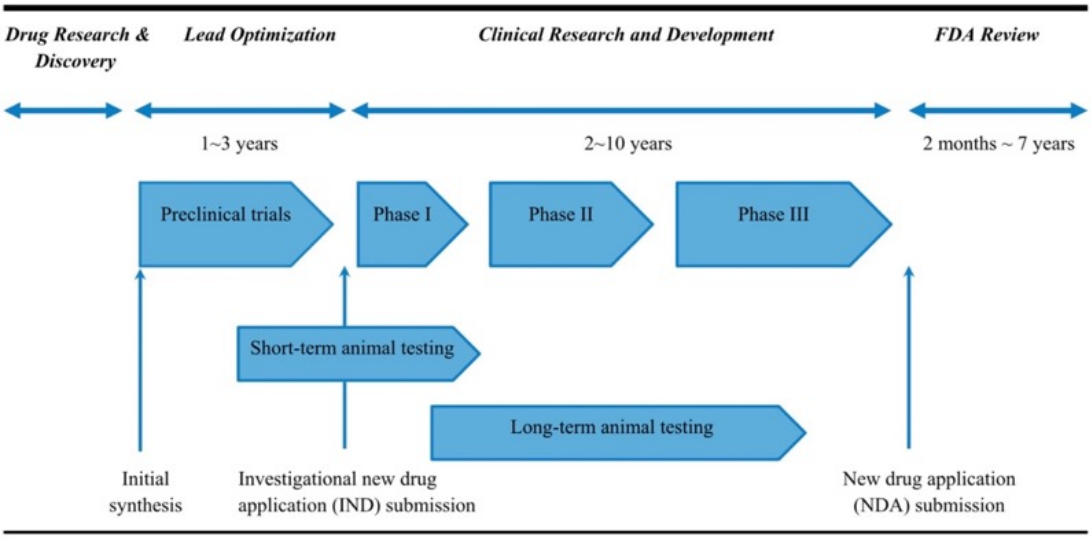

Figure 1: Pharmaceutical new product development process by Lee et al. (2019)

Public-Private Partnerships and Open Innovation

New collaboration models have emerged with the common mission to accelerate innovation. "Open innovation" – a term that was first coined by Henry Chesborough in 2003 – is defined as the "use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesborough, 2011). Open innovation is fairly well established in the pharmaceutical industry, despite initial resistance due to culture and mindset barriers (Martinez-Grau & Alvim-Gastom, 2019). Open innovation is, in fact, a pre-requisite for public-private partnerships which satisfy the need for external collaboration across the process of discovery, development, manufacturing and commercialization of new medicines (Martinez-Grau & Alvim-Gastom, 2019).

One means by which the pharmaceutical industry is developing open innovation is through the use of common industry-academia platforms that enable collaboration, knowledge creation and the diffusion of knowledge beyond boundaries in the form of public domain data. Pre-competitive research consortia aim to solve the most pressing needs that one entity

cannot solve alone by bringing together public and private partners to join forces, resources and expertise towards common goals.

According to De Vrueh & Crommelin (2017), public-private partnerships are "multiple stakeholder partnerships designed to improve research efficacy" (De Vrueh & Crommelin, 2017, p. 1). Over the past decades, over 100 public-private partnerships have been formed, impacting and benefiting the lives of millions of people across the world (Henjewele & Fewings, 2014). Every year almost $70 billion USD are invested in health research targeting disease areas (Ziemba, 2003). These partnerships mainly happen between the pharmaceutical industry and academia and appear to have enormous potential in the life sciences sector (Chaguturu, 2014). However, despite an acceleration of PPP creation, it is still unclear how effective they are in delivering innovation and improving R&D in the life sciences.

The skyrocketing cost of R&D has caused many smaller pharma companies to cease their research operations related to new drug discovery and drug development. The process of screening and selection of molecules that could potentially become new medicines require significant investment and a time period of 12 to 20 years to reach the market, with a high failure rate of 95% (Chaguturu, 2014). Another cause of unrest among many industries is patent expiry (Chaguturu, 2014). Patent expiration allows other pharma companies to legally manufacture the same drug with lower prices, causing a shift in pricing from an original brand to a generic one (Henjewele & Fewings, 2014). Funding from the pharmaceutical industry to academia was previously focused on disease biology processes and the work was mostly based on theories and hypothesis (Henjewele & Fewings, 2014). However, there has been a shift towards more practical approaches to innovation. More collaborative approaches have been taking shape, leveraging different funding models such as royalty payments, grants, and intellectual property rights. PPPs have proved to improve research efficiency and change the imperative towards sharing problems to find shared solutions (Palmer & Chaguturu, 2017).

An example of a successful public-private partnership is the Human Genome Project. This project represents progress in unfolding genomic science for all without any restriction and with timely access to all partners involved (Murray-Rust, 2008). The Human Genome Project was funded by various public and private entities. Owing to its immense potential, a vast spectrum of industries participated in order to generate the maximum output from this unprecedented research project (Murray-Rust, 2008). Both the pharma industry and the scientific community benefited from it. Not only did the pharmaceutical industry benefited by investigating the role of drugs on disease and on the human body, scientists were able to investigate artificial intelligence, and different institutions focusing on further identifying neural functioning as well as the link with human behaviour equally had access to this unprecedented research and resulting insights (Murray-Rust, 2008).

The need for public-private partnership encompasses a wide range of goals. The Innovative Medicine Initiative is an example of a public-private partnership which benefits from a significant long-term commitment made in 2008 between the European Federation of Pharmaceutical Industries and Associations and the European Commission (Goldman, 2011). The main goal of this collaboration is to analyze the changing landscape of health and public health to address challenges in bringing new medicines to market (Goldman, 2011). Through this platform, all stakeholders such as large pharmaceutical companies, regulatory agencies, small and medium sized enterprises, patient organizations, and public research institutions share the same rights and responsibilities to work together, to share data, and to collaborate towards common goals in driving innovation forward (Goldman, 2011).

The organization of shared industry-university platforms such as the Human Genome Project and other similar platforms is not simple because it requires competitors to collaborate at the pre-competitive stage – meaning, in the early research and development stage – as explained earlier in this paper, before any outcome becomes a competitive element with market potential (Wellcome Trust, 2003). Pre-competitive research has benefitted competitors in which early results of researches have been disclosed to the broader scientific community at the same time as they were disclosed with consortia members (Wellcome Trust, 2003). This

way of working and embracing open innovation requires open mindedness, building trust, diversity of thought and expertise, will to experiment and contribute, as well as transparency.

Pre-competitive consortia themselves need to be set up and become involved to manage and ensure that collaboration takes place while at the same time enabling this to happen in a context where participants may be competitors. In the literature, the term "boundary organization" by Guston (1999) has been coined to describe the kind of organizational form required to manage this collaborative process and will be discussed in the next section.

Pre-Competitive Research Consortia as Boundary Organizations

This section builds on the previous section to present the industry's response to decreasing research productivity through the concept of pre-competitive collaboration as boundary organizations embracing open innovation. According to Hunter (2011), "pre-competitive research consists of basic or applied research and can include part of the development phase. At the precompetitive stage, research results are not immediately marketable even though they are the basic tools for creating new products and processes" (Hunter, 2011, p. 57). In the biomedical enterprise, competitors share early stages of research that benefit all. The definition of "competitors" for the biomedical enterprise must encompass industry, academia, government, and regulatory scientists as well as many other relevant stakeholders, including patient advocates. Key players in the industry include the government, academia, big pharma and biotech companies, many small biotech and small pharma companies involved in research and development, research centers, venture capitalists, patient groups, and everyone at large (Munos, 2014). Currently, most collaborations happen between industry and academia, between industry members, industry and suppliers, industry and patient groups, industry and venture capitalists, and industry and anyone (Munos, 2014).

"Boundary organization" is a concept coined by (Guston, 1999) to describe a way to organize and stabilize boundaries at the intersection between science and policy. For the

purpose of this research, "boundary organization" refers to pre-competitive research consortia operating as entities with permanent staff members who work at the interface of science and policy to enable collaboration with the purpose of enabling innovation. As an example, boundary organizations such as the Innovative Medicines Initiative mentioned earlier are intended to improve performance of the overall collaboration processes while improving R&D and stabilize interactions inter- and intra-organization. Crona and Parker (2009) note that boundary organizations emphasize that science policy interaction is a dynamic and continuous process (Humphreys, 2009).

A relevant research study by O'Mahony & Bechky (2008) looked into how community projects worked in open-source software development worked with private firms with divergent and convergent interests. They highlighted the role of boundary organization as one of setting the boundaries of the collaborative space, establishing a governance structure, managing membership and ownership, as well as controlling production. This research study by O'Mahony & Bechky (2008) contributes to organizational theory by explaining the mechanisms that enable unlikely allies with convergent and divergent interests to collaborate and provide analytic levers to understand when boundary organizations work in the software development sector. This concept could also apply to the pharmaceutical industry since it represents what the industry has been doing in recent years to work together, in spite of competitive forces, toward the common mission of accelerating innovation.

Adding to O'Mahony & Bechky (2008) regarding the role of boundary organizations in enabling collaboration, a more recent study by Perkmann & Schildt (2015) specifically looking into a pre-competitive research consortia in the life sciences, identified two key mechanisms through which boundary organizations enable collaboration between unlikely allies such as it is the case within pre-competitive research consortia in the life sciences, namely "mediated revealing" and "enabling multiple goals". On one hand, mediated revealing requires first and foremost – trust. Trust between interacting parties and the boundary organization. This refers to the "confidence [that] the involved parties have that an actor will adhere to mutually agreed lines of action" (Perkmann & Schildt, 2015). The

boundary organization acts as a trusted intermediary to facilitate collaboration between parties (Perkmann & Schildt, 2015). On the other hand, enabling multiple goals consists of "allowing multiple goals to co-exist instead of optimizing activities and costs around either purely industrial or purely academic goals" (Perkmann & Schildt, 2015). Therefore, this is another mechanism through which boundary organizations facilitate collaboration and working towards multiple goals that co-exist between industry and academia. Figure 2 on the next page represents and excerpt from Perkmann & Schildt (2015), illustrating these two mechanisms.

This study by Perkmann & Schildt (2015) also provides a framework for the role of universities in research consortia with members of the industry. This empirical research is unique in that it focuses on a case study of an international pre-competitive collaboration in the life sciences, thus providing a track record of past activities to discuss challenges encountered in bringing together unlikely allies. Although the study has its methodological and practical limitations since it does not explain how the two mechanisms identified lead to efficiency and innovation, it is a good foundation for further research such as the present study to further shed light on the pre-competitive phenomenon and help managers and industry leaders better understand its dynamics to hopefully bring the industry into a new era of innovation and research and development productivity.

While the research study by Perkmann & Schildt (2015) is highly relevant starting point for the present research study, it does not shed light into how effective pre-competitive collaboration between universities and industry is, nor does it extensively address challenges that occur in the process. This is also what further motivates our research.

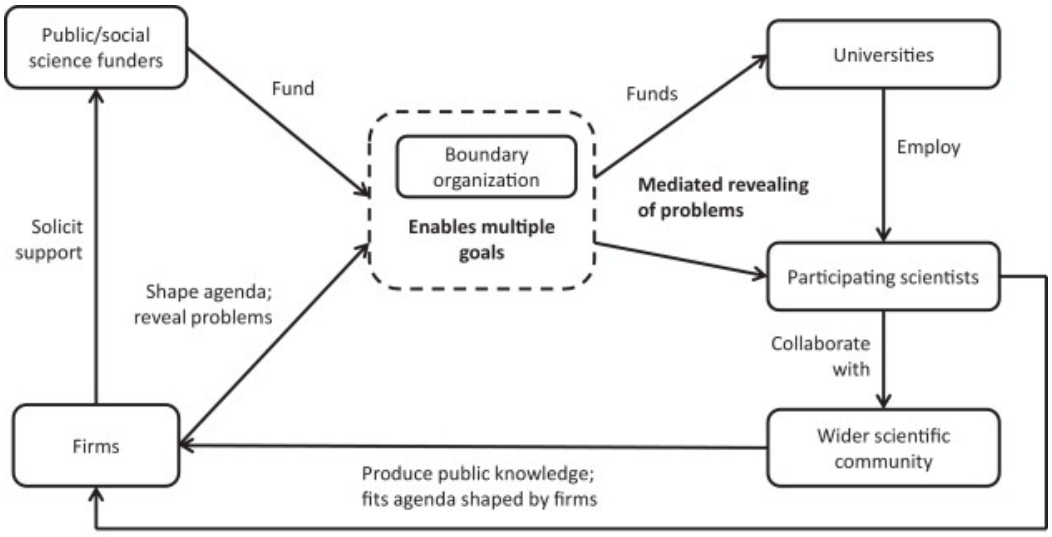

Figure 2: Key mechanisms to enable pre-competitive collaboration by Perkmann & Schildt (2015)

Boundary Organizations as Innovation Accelerators

Pre-competitive collaboration is important not only for the pharmaceutical industry or for academia. Maximizing R&D output and leveraging the best knowledge and expertise to drive the best outcomes is what the pharmaceutical industry is aiming for to improve health and healthcare (Buse & Walt, 2000). Whereas getting funds for to conduct research and clinical trials and subsequently setting up a research centre for innovation and patency, funding is required, which can be provided by industries and government bodies. Pre-competitive collaboration also helps to identify disease burden, regional methods to combat an epidemic and to learn from one another, so the experience of one region educates others all around the globe. This initiates a dynamic process of knowledge society (Buse & Walt, 2000). Innovation generated via internal and external elements promotes an environment in a company where ideas flow in a dynamic way. Companies working in collaboration gain significant competitive advantages by working together and are able to deliver what each individually cannot deliver otherwise (Buse & Walt, 2000).

While the pharmaceutical and biotechnology industry are becoming increasingly acquainted with the dynamics of pre-competitive collaboration, uncertainty prevails about this approach in the industry and little research has focused on the dynamics collaborating pre-competitive in a highly competitive industry, possibly because of the level of secrecy within the industry and skepticism to open up after all despite opening up to collaboration in early-stage research. A consulting report by Gastfriend & Lee (2015) highlights a set of challenges associated with collaborating pre-competitively between boundary organizations and their members. These challenges could be mostly classified as people and process challenges, such as: establishing trust, decision-making, culture clash between different members as well as between industry and academia, balancing different interests, risk-aversion and the perception of risk amongst parties involved. One of the most heated debates highlighted is around Intellectual Property (IP) and defining "pre-competitive collaboration" – which does not appear to have a clear definition across industry and academia and seems left to interpretation. Given this set of challenges that boundary organizations must compose with, the present study is particularly relevant for management and governance practices in the pharmaceutical industry today, again, with the aim to enable collaborative innovation.

Boundary Work to Enable Innovation

Now that we have briefly explored some of the challenges that the pharmaceutical industry is facing, public-private partnerships and pre-competitive research consortia as boundary organizations to enable collaborative innovation, we explore "boundary work" as a key focus of this research to understand how pre-competitive consortia enable innovation by working at boundaries to enable innovation between competitors in the life sciences.

Originally coined by Gieryn (1983), the term "boundary work" was initially used "to describe discursive strategies used by scientists to demarcate science from nonscience" (Langley et al., 2019, p. 704). Recent research by Langley et al. (2019) conducted an integrated synthesis of the literature on boundary work and identified "three […] interrelated forms of boundary

work – conceptually distinct in theory, yet intricately intertwined in practice" (Langley et al., 2019).

Several forms of boundary work identified by Langely et al. (2019) are relevant for the present study in the context of pre-competitive consortia in the life sciences. The first one is *collaborative boundary work* (or "working *at* boundaries") which "focuses on practices through which groups […] and organizations work at boundaries to develop and sustain patterns of collaboration and coordination in settings where groups cannot achieve collective goals alone" (Langley et al., 2019). This form of boundary work could be relevant in the context of pre-competitive consortia since the goal is to achieve collaborative innovation while working *at* boundaries with different pharmaceutical companies in a competitive environment.

The second form of boundary work identified by Langley et al. (2019) is *configurational boundary work* (or "working *through* boundaries") refers to "managers, institutional entrepreneurs, or leaders [reshaping] the boundary landscape of others to orient emerging patterns of competition and collaboration, often combining elements of both" (Langley et al., 2019). This form of boundary work could be relevant in the context of pre-competitive consortia since the work happens through boundaries in a context where elements of collaboration and competition co-exist.

Lastly, *competitive boundary work* (or "working *for* boundaries") "focuses on how people defend, contest, and create boundaries to distinguish themselves from others to achieve some kind of advantage" (Langley et al., 2019). This includes, for instance, "how groups or organizations do boundary work to define legitimate membership and exclude others" (Langley et al., 2019). This could equally be relevant to pre-competitive research consortia in the life sciences given that they work *at* boundaries, by bringing together competitors towards a common goal, being very selective of its members.

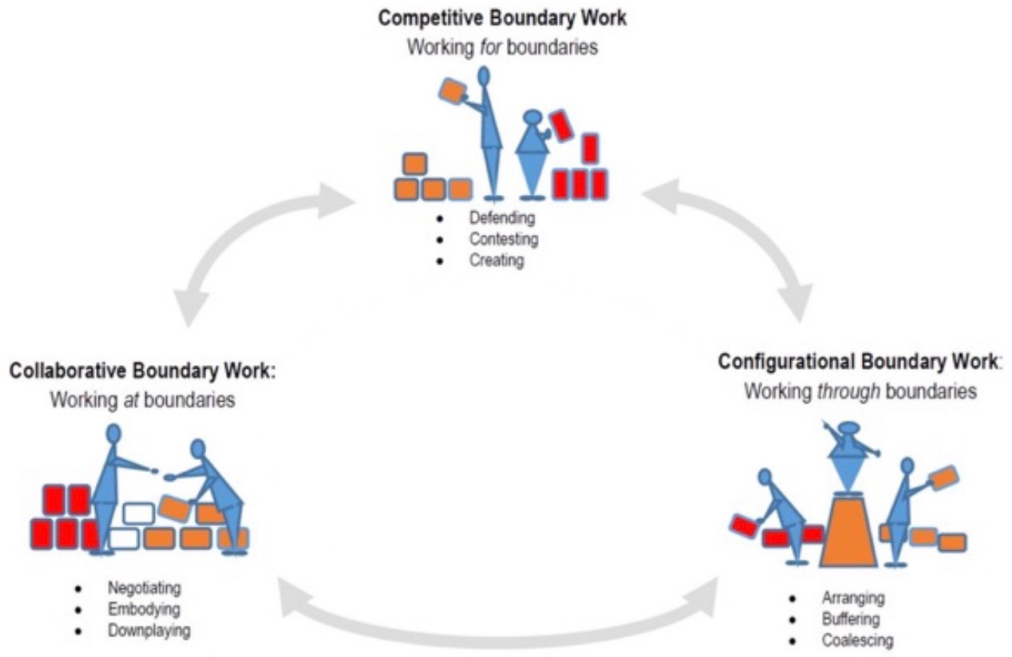

Figure 3: Synthesis of boundary work by Langley et al. (2019)

Research Gap

The review of the literature helped identify a gap in the literature on pre-competitive collaboration in the form of boundary organizations and boundary work. Although it is not a new phenomenon and highly strategic for members of the industry, pre-competitive collaboration has not yet been extensively studied in the specific context of the life sciences. Although the pharmaceutical industry is further shifting towards open innovation and organized efforts such as boundary organizations to enable pre-competitive collaboration are in place to bring unlikely allies together and make collaboration possible to accelerate innovation, not all members of the industry are equally open to this phenomenon. Consequently, this research is relevant in further understanding how pre-competitive research consortia is able to bring members of the industry together to collaborate, how collaboration happens, and with what results for public-private partnerships to ultimately

enable innovation. The specific focus on how efficient pre-competitive research consortia are in enabling collaboration and innovation represents a gap in the current body of knowledge. The core focus of this research is to shed light on the following research question: ***how do pre-competitive research consortia enable innovation in the life sciences?*** with an additional focus on the results and benefits pre-competitive research consortia generate for their industry members, the scientific community, and for the greater good. An unbiased perspective, particularly from the field of management and strategy, can bring an interesting, valuable view into boundary work and boundary organizations to facilitate collaboration and enable innovation in the life sciences.

Chapter 2: Methodology

Following the literature review on pre-competitive research consortia as boundary organizations enabling boundary work and the related key elements of this exploratory research, this chapter presents and justifies the methodology used to provide insights into our research question: ***how do pre-competitive research consortia enable innovation in the life sciences?***

Research Method and Design

The qualitative research method allows for the analysis of descriptive data – this is data that is difficult to quantify as it represents statements reported by people or observed behaviors (Creswell, 1998). This research method also allows for the use of small population samples, therefore facilitating in-depth analysis (Miles, Huberman & Saldana, 2014, p. 11). Strengths of qualitative data focus on "naturally occurring, ordinary events in natural settings, so that we have a strong handle on what "real life" is like" (Miles, Huberman & Saldana, 2014, p. 11), focusing on a specific case and "bounded phenomenon embedded in its context" (Miles, Huberman & Saldana, 2014, p. 11), where these influences are taken into account and the "possibility for understanding latent, underlying, or nonobvious issues is strong" (Miles, Huberman & Saldana, 2014, p. 11).

Given the context of our research study as mainly exploratory, the qualitative research method has proved to be the most suitable to explore our research question since it makes it possible to analyze in-depth a phenomenon of social origin through the comprehensive process that it offers. In the context of qualitative research, data collection can be carried out in three ways, namely through observation, interviews, and through secondary data sources. For the purpose of this research study, the selected methodology consists of case study research, semi-structured interviews, and secondary data, in addition to comparative research

as preferred techniques due to their relevance and consistency with the scope of the research topic – as outlined and explained below:

- **Case study research:** We decided to focus the data collection on analyzing in-depth two case studies, namely two boundary organizations facilitating pre-competitive collaboration in the form of boundary work to learn about their role in the process, the practice, process and resulting activities, benefits and challenges encountered. According to Yin (2014), "a case study investigates a contemporary phenomenon […] in its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident (Yin, 2014, p. 2). "Doing case study research would be the preferred method […] in situations when (1) the main research questions are "how" or "why" questions; (2) a researcher has little or no control over behavioral events; and (3) the focus of the study is a contemporary (as opposed to entirely historical) phenomenon" (Yin, 2014, p. 2).

  To collect the primary data for the purpose of this research study, we used a purposive sampling strategy, allowing each pre-competitive consortium a chance to be selected. Due to time constraints, we selected two organizations that fit the profile that we were looking for and that were both the fastest to respond and also available to offer a number of interviews with a diverse sample of individuals from the consortium. Interviews were conducted with executive members of the consortium and scientific officers working as permanent employees within the consortiums, as well as a handful of pharmaceutical company representatives working closely with the consortium.

- **Semi-structured interviews:** We selected semi-structured interviews mainly because of the direct contact it allows with participants, along with the flexibility it provides in the interviewing process. The researcher only gives a broad direction to the interview and has the opportunity to select We interviewed multiple actors engaged in pre-competitive collaborations, both boundary organization members representing the public sector and industry members representing the private sector,

all working together towards common goals. We used an interview guide to ensure validity of our interviews (see Appendix A) and tackle three main themes: governance, collaboration and value creation to understand the broad picture around boundary organizing and boundary work in the context of pre-competitive collaboration.

Even though semi-structured interviews can be biased since they represent a conversation in the moment between two individuals (Yin, 2014), we were able to reduce bias by asking general questions focusing on a specific facet of the topic, by asking every participant the exact same question, and by sharing the interview guide by email with each participant two days prior to the interview. We also ensured to differentiate between facts and expectations from interviewees in the data collection, also to reduce bias. All the interviews were conducted via phone due to geographical differences with interviewees being located in North America and Europe. We tested the interview guide with two interviewees prior to using it more broadly.

- **Secondary data:** To complement our primary data collection, we also used data from secondary sources such as pre-competitive research consortia websites and related links, including press releases, annual activity reports, organizational structure and governance, research agendas, project factsheets, etc. (see Table 1 below) to gain a broader perspective of the situated context of the consortia.

	Consortium 1	Consortium 2
Governance document	1	1
Research agenda	1	1
Annual reports	0	3
Press releases	2	4
Project factsheets	1	1

Table 1: Secondary data sources

Data Collection

Data collection from semi-structured interviews was conducted in 2018. Fourteen (14) semi-structured interviews of about sixty (60) minutes each were conducted in total – via phone, out of which ten (10) interviews were conducted with consortia members (Chief Executive Officers, Chief Scientific Officers, Chief Research Officers, etc.) and four (4) interviews were conducted with industry members with firsthand experience in collaborating with either one of the pre-competitive research consortium in this study, referred by the respective consortium. Collecting both the perspective of consortium and the industry members provided a complementary view into a similar phenomenon from different angles, enhancing our understanding of the overall phenomenon. In addition, the neutral, unbiased view of the researcher (M.Sc. student) and the confidentiality provided to participants in the study helped to increase the internal validity of the data, making it possible to collect unbiased views. In total, seven (7) interviews were conducted with members of Consortium 1, including three (3) interviews with associated industry members, and seven (7) interviews were conducted with members of Consortium 2, including one (1) interview with an associated industry member.

Gaining access to data from the field to conduct our interviews has proved to be relatively challenging at first. It has taken several attempts to be able to knock on the right doors and speak to the right people. Access to industry members was even more difficult, given the sensitivity and confidentiality of the topic itself. However, with perseverance and belief in the relevance of this research study, we were able to earn the trust of two (2) pre-competitive consortia (referred to as "Consortium 1" and "Consortium 2" in this paper) which were open and willing to engage and share their experience for the academic purpose of the present research. To protect the confidentiality of the interviewees, we decided not to disclose the names of the consortia in this study, although the consortia agreed to be disclosed.

Data Analysis

In conducting this research, some data analysis was conducted throughout data collection to explore emerging themes from one interview to the next and have a certain snowball effect. The data analysis required verbatim transcription of all the interviews conducted to facilitate the analysis process. This allowed for deeper dive, slicing and dicing of the data to facilitate analysis and allow for themes and sub-themes to emerge.

The entire data sets were analyzed holistically once all the data was collected, including both primary and secondary sources – given the complexity of the phenomenon and individual and organizational specificities. Once all the data was collected, the data analysis was conducted in two stages:

(1) Emergent coding and grouping of the data was conducted and emerging themes and sub-themes were identified. The data was coded and clustered in order to make sense of the entirety of the data and paint a picture – so to speak – for each case study. The most prominent and recurrent themes and sub-themes from both case studies were identified as shown in Figure 4 below along with the most relevant citations in Appendix B.

(2) Emerging conceptual framework applied to each case study in order to provide insights and further our understanding of what pre-competitive research consortiums (or "boundary organizations") do, what their role is, how they are governed, what the results of their work are, along with benefits and challenges faced along the way.

Overall, the data was analyzed through an inductive approach to provide insights into the research question and describe how pre-competitive research consortia enable innovation in the life sciences. We analyzed each consortium through the lens of the emerging framework (Figure 4) and compared insights from both case studies to draw our own conclusions with regards to types of boundary work enabling innovation to reveal similarities and differences.

Being completely new to the topic, as a researcher, I believe that this allowed me to bring a fresh and perhaps naïve perspective into the topic, approaching it with a beginner's mindset and truly extracting the essence and demystifying the core of the topic rather than getting lost in underlying intricacies and complexities.

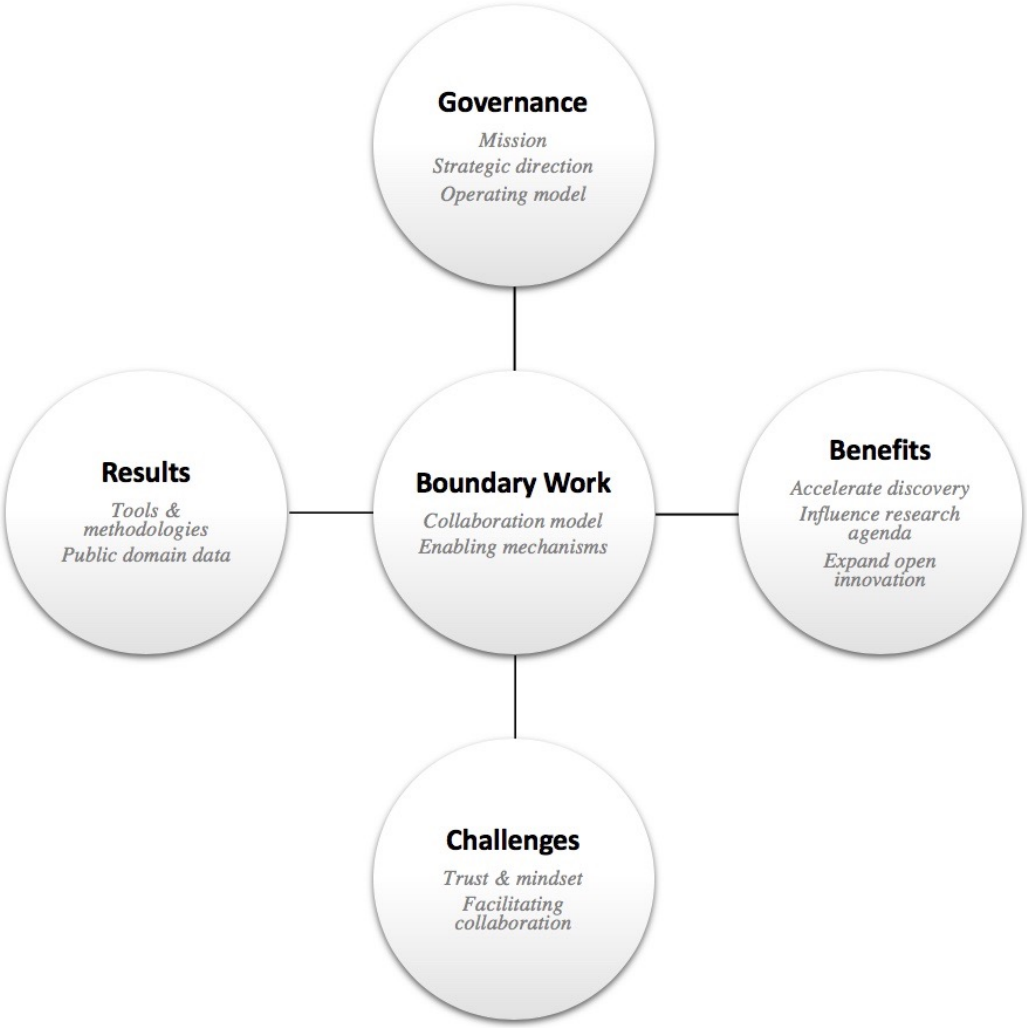

Figure 4: Emerging conceptual framework

Chapter 3: Data Analysis & Results

This chapter focuses on describing the case studies and providing an analysis of the prevailing themes and sub-themes emerging from data collection through an inductive approach, leading to the framework below. This framework describes the holistic themes and sub-themes from the two consortiums and provides insights into the research question: ***how do pre-competitive research consortia enable open innovation in the life sciences?***

Case Study: Consortium 1

Consortium 1 (or "C.1") is a North American public-private partnership established in the early 2000s to focus on highly specialized molecule structures with the mission to accelerate drug discovery. This pre-competitive research consortium has research centres at three different universities with a network of over 200 scientists contributing to different initiatives, all with the purpose of advancing early research and drug discovery. C.1 receives funding from governments, charity organizations, while industry funding accounts for most of the financial support it received from its big pharma members such as Merck and Novartis.

C.1 is governed by a Chief Executive Officer selected by a board of directors and scientific committee. It has embraced an open innovation model from the beginning, requiring the open part of research to be shared in the public domain as soon as possible for use by the broader network and global scientific community, ensuring quality documentation for research replication. Public domain data includes methods for successfully conducting structural analysis of proteins and cell biology. C.1 also provides tools and reagents to maximize the impact of its work. C.1 does not take any proprietary claims nor does it file patency claims.

Based on secondary sources, C.1 represents a successful model of pre-competitive collaboration bringing top notch scientific expertise, the best brains from around the world,

proven methods and tools, combined with extensive experience and know-how in enabling pre-competitive collaboration between industry and academia.

Analysis: Consortium 1

In this section, we analyze the C.1 case study through an inductive approach, focusing on the emergent themes and sub-themes from the collected data along with relevant citations (see Appendix B), from governance and boundary work to results, benefits and challenges encountered in practice.

1. Governance

Consortium 1 operates as a boundary organization with governance being a significant theme that emerged from the case study, focusing on the mission of C.1, its strategic direction as well as its operating model. As highlighted by O'Mahony & Bechky (2008) in their study on software development, governance is a way for C.1 to establish pluralistic control to manage boundary work as explained below, through a clear mission, strategic direction and operating model.

1.1 Mission

First of all, the mission of Consortium 1 is to focus on protein structures which are a core element of early drug discovery process and one that C.1 members highlighted as "tedious". However, it is a highly important area of focus that is of interest to multiple partners in the industry. Consequently, C.1 was "initiated by pharma" and created with the mission and expertise necessary to solve for this specific challenge for the industry and create better tools to help validate whether a target is a potential drug candidate or not. This removes unnecessary cost, time and resources, along with high risk of failure in the early stages of research. There is a common understanding within C.1 as well as its industry partners that

the mission of C.1 is to contribute to drug discovery, specifically focusing on protein structures as a core expertise.

Due to its scientific expertise and its positioning in both academia – where knowledge is created, and in the industry – where drugs are developed and commercialized, C.1 informs its partners and sets the strategic direction of the consortium, which influences and determines the research agenda that the entire consortium along with its partners will focus on. According to its pharma members, C.1 brings vision and visionary leadership to inspire and influence others to join on a common mission towards a common vision in the precompetitive space.

The role of C.1 is to introduce new ideas, to bring them to the table, spark the interest of pharma members, collect their feedback, influence and build interest, which ultimately determines the strategic direction of the consortium, along with resource allocation.

1.2 Strategic direction

Even though C.1 is a non-profit organization, it is highly strategic in nature, operating as a business, scanning the horizon to be at the forefront of scientific research and up to date on needs emerging from the industry which is recognized as uncommon among academic labs by its scientists. Some of the questions raised by scientists working in C.1 include efficiency gains, cost saving, as well as accelerating the research process. C.1 is also strategic in its resource allocation. It has the freedom to start or stop projects, depending on their progress, and does not hesitate to reallocate resources where there is a potential higher degree of success for instance, in discovering a new drug target or develop a new tool or methodology to support drug discovery.

Consortium 1's Board of Directors defines the strategic direction while the Scientific Committee defines the research agenda. C.1 operates with a planning horizon of 5 years, continuously evolving and reinventing its research mandate to stay in tune with emerging

needs to be tackled in the precompetitive space, otherwise deemed too risky. Strategic direction determines what partnerships are built, what expertise is required, and what collaborations will be necessary to tackle emerging challenges.

According to pharma members, C.1 also brings vision and visionary leadership to inspire and influence others to join on a common mission towards a common vision. They recognize "a need to think about where else we can go [and] what C.1 presented us with is a platform for us all to come together and to really be able to try to quickly evaluate a whole new space", therefore planning seeds for collaborative innovation. C.1 equally plays an influential role in determining the guardrails that enable open innovation by making it a requirement to share data and publish the results in the public domain, accessible to the global scientific community.

Furthermore, C.1 focuses on activities that generate threefold value – for the public, industry and academia. This value generation principle drives the strategic agenda, research focus, and project prioritization, along with the complexity of the challenge requiring multiple parties to get involved a work together towards a common goal in a pluralistic setting. C.1 primarily focuses on the complex challenges that only one party cannot solve alone, and collaboration is required to bring complementary expertise and additional resources. The strategic agenda is shared transparently with all industry and academic members, along with the statement of value generated.

1.3 Operating model

The operating model of Consortium 1 emerged as a major theme from our data collection, particularly with regards to membership, neutrality and the way it operates to enable collaboration. Becoming part of the consortium means buying into open innovation.

As suggested by a C.1 executive, "we have a minimum financial investment that we require from a company to be a member […], so it kind of limits it to big pharma". Once a company

pays the same membership fee as everyone else, they get the same rights and responsibilities as everyone else. As highlighted by a C.1 executive, "membership is a matter of who puts the money in". However, a significant minimum financial investment is required, which limits it to big pharma companies, hence enabling access to additional resources such as tools and expertise, including chemistry which is the expertise of the pharma members. Afterwards, C.1 distributes the funds to different projects based on need. C.1 is entirely responsible for selecting the projects and resources allocation, both monetary and in-kind. C.1 is praised for selecting its people well, operating with an extensive network of scientists mainly based in North America and Europe, but also all around the world. The responsibility of the consortium is to match the right scientist with the right project to ensure the right expertise is allocated in order to yield the best outcomes for all the parties involved and maintain the trust of its pharma members.

Membership also requires compliance with the practice of open innovation and publishing research results in the public domain. Once the results have been validated and tested for reliability, C.1 requires them to be published in the public domain for use by the entire scientific community. In fact, a pharma member highlighted that "C.1 is on a religious mission to have everything in the public domain".

To be able to convince big pharma players into becoming members and by extent – contributing funding into a common bucket towards research, C.1 seeking legitimacy with dominant actors such as the top big pharma companies e.g. Pfizer, Novartis, etc. This helps to build C.1's influence by sending a clear message to other companies that "Look, company X has joined, and they really think that this is valuable and worthwhile. You should probably consider this, too" – as we gathered in a testimony from a pharma member working in collaboration with C.1. Consequently, to protect its legitimacy, C.1 is highly selective of companies it chooses to partner with, restricting membership to big pharma who can contribute the membership fee.

Although there is not one clear, emerging common definition of "pre-competitive" within the consortium and its members, one C.1 member explained that "the dividing line is biology; chemistry is the competitive park". This is a core principle of C.1's operating model which enables all pharma partners to take a similar risk in biology. "If C.1 is wrong, everybody is wrong. And so, you have no disadvantage in being wrong".

In order to enable collaboration between pharma members and clarify intellectual property (IP) rights, C.1 has "created a very clear box where everything in the box is open and there are very clear rules about what is in the box and what is out of the box" and making it clear to all the members. C.1 does not take any IP and C.1 scientists do not file for patent of the resulting science and innovation, hence the importance of making the rules clear to all the parties involved.

C.1 is also recognized for its neutrality. For pharma members, C.1 is a "credible, neutral partner". which is a critical position to enable precompetitive collaboration between unlikely alleys. This position allows them an understanding of the "rules of the game" (Appendix, …) and ensuring the conditions for being in the consortium are applied to all the members (e.g. requirement to publish research results as soon as possible in the public domain) to preserve trust and integrity.

From an industry member perspective, "generally, we recognize, within any company, [that] we don't have all the necessary expertise to do everything we want to do and pre-competitive consortia become a way for us to share the risk and share resources to solve a common problem that we know that we can't solve on our own". Consequently, "pre-competitive consortia provide us with that umbrella, that protection to be able to engage in sharing information" in a way that enables collaboration and confers protection of individual interests.

2. Boundary Work

2.1 Collaboration model

Operating as a boundary organization, C.1's collaboration model focuses on what Langley et al. (2019) described as "configurational boundary work" (or "working *through* boundaries"), which refers to "managers, institutional entrepreneurs, or leaders [reshaping] the boundary landscape of others to orient emerging patterns of competition and collaboration, often combining elements of both" (Langley et al., 2019). In the case of C.1, this takes the form of *buffering boundaries* "to accommodate collaboration between […] actors with competing interests" (Langley et al., 2019) – the actors being the pharma partners. C.1 is "an ideal environment that bridges industry with academia", operating "a lot like industry […] because we're milestone-driven and deliverable-driven and we have to deliver our structures, our assays, our probes every quarter".

From an industry perspective, what pharma partners are seeking is "common ground" and a scope that is "worthwhile to collaborate" on with "both partners [getting] enough out of it". This way, they can "reap the benefits jointly and in the few cases where there's enough positive result in the clinic, then there's still plenty of space for companies to then modify this compound, make it even better and then compete […] basically pushing the limit of pre-competitive further", as well as accelerating discovery while also creating competition at later stages. However, C.1 focuses on the early stages of drug discovery where competition does not benefit anyone. From a C.1 executive perspective, "because pharmaceutical companies are very good at chemistry, they feel confident that even though this part of working on a drug target is out in the open", "we're able to help them narrow down which diseases and which drug targets to focus on" and "they see substantial value in that". In a nutshell, from C.1's point of view, "we have access to [pharmaceutical companies'] expertise in chemistry […] and they have access to our expertise in terms of biology."

C.1 is set up as a non-profit boundary organization which provides its very unique, neutral position which is essential to enable collaboration between unlikely allies and for innovation to emerge. According to an industry member, C.1 is "kind of a matchmaker to pursue both the interests of the public and private side – which is a very critical position". Another industry member further added that "it [is] very important to have this credible neutral ground [in C.1] because they understand the rules of the game, how to engage, knowing that everything that you do is going to be published. […] The organizational aspect is really unique. This position of being in academia but having very much a mindset of what industry needs and an open door to academics as well as industry scientists. I think that is unique and is very, very enabling." Likewise, industry members "generally […] recognize [that] within any company, we don't have all of the necessary expertise to do everything we want to and pre-competitive consortia [like C.1] become a way for us to share the risk and share resources to get at a common problem that we know that we can't solve on our own."

How does C.1 attract and retain the best scientists to help solve the complex challenges in scope? As opposed to scientists working in industry, from the C.1 member perspective, working in academia confers more academic freedom to pursue research without the pressure of commercializing. In their own words, "as long as you find something interesting and you can publish it, it's of some use to a disease or […] a model, [it is] still valid information", whereas scientists in industry have to drop any pursuit that is not bound to have commercialization potential. For scientists working in academia as part of C.1, this confers the added benefit of not having to apply for grants individually and conform to science grants. Therefore, it seems that scientists working in C.1 have additional benefits that come in the form of academic freedom, funding to pursue their research without the burden of apply for grants, empowerment with regards to their work and an opportunity to not only conduct top notch research but to have real impact in accelerating open innovation and drug discovery. These are some key incentives which enable C.1 to attract and retain the best minds and top expertise to conduct its research activities.

Within C.1, a project is defined jointly with pharma members and partners. As per a data point collected from C.1, "with our partners, we decide what our project is and decide the scope of what's out. We focus on high-level outcomes like a crystal structure or a chemical probe or an acid cell – that's a deliverable and that's going into the public domain". This is negotiated and decided upon jointly. Moreover, from an operating standpoint, C.1 operates "a lot like industry because [it is] milestone-driven and deliverable-driven and [they] have to deliver […] every quarter" as a testimony suggests – which equally facilitates the collaboration with pharma members by adopting similar ways of working and creating "an ideal environment that bridges industry with academia". As highlighted by an industry member, "I think what has allowed C.1 to continue on as it has up to this point is the fact that it has succeeded, it has been able to deliver on its original vision." What also supports C.1's success is its ability to oversee project progress, make decisions along the way as to maximize resources, and reconfigure accordingly, as a collected testimony indicates: "By working on multiple projects at the same time, we let the success at each stage decide which ones we continue. And sometimes we make hard decisions: "You know what? As exciting as this may be, as alluring as it may be, we're not getting anywhere with it, so let's continue with the successful ones and at least for now shelf the not-so-successful ones".

Another way through which C.1 enables collaboration is by recognizing its value and leveraging the strengths and expertise of its partners. In the words of a C.1 executive, "everybody, every lab, every scientist has their specialty [and] instead of replicating somebody else's specialty and maybe just be mediocre at it, we will work with people who are good at certain methods, certain techniques that we have not mastered in our lab; we define everyone's role very precisely so that we can accomplish our goal much faster". Due to the fact that C.1 works on "important scientific areas of study", it is able to form collaborations and attract the interest of the best scientists around the world. Moreover, C.1 emphasizes the diversity of expertise it is able to bring around the table, namely "chemists, biologists, venture capitalists, pharma guys, academics", which they describe as a "really cool mix".

In addition to the scientific expertise present in C.1 and its scientific community, C.1 recognizes that pharma members equally appreciate their "program management, the way [they] do science and [manage] collaborations [and] the superior methods and […] processes" which encourages trust, credibility and funding for research purposes. The collaboration model that C.1 uses is an enabling factor in itself and "[pharma members] see an advantage in working with [C.1] because of that".

2.2 Enabling mechanisms

Two mechanisms through which C.1 facilitates collaboration are mediated revealing and enabling multiple goals – mechanisms described by Perkmann & Schildt (2015). From C.1's perspective, the pharma partners "they collaborate with each other to decide what C.1's priorities should be, but on a scientific level, they collaborate individually with [C.1]". To ensure transparency and enable further collaboration between its pharma partners while equally maintaining trust, C.1 holds monthly meetings where project status updates and data is shared "in a sort of anonymized way in which all the companies can see progress on different targets, but they don't know who's sponsoring that research from the different companies", as indicated by a C.1 executive. This enables multiple goals to co-exist in parallel which maintaining transparency, trust and protecting pharma partners' strategic interests. As well, to preserve anonymity and mediate revealing of information, C.1 uses the term 'pharma partner' to refer to companies involved. In this way, they also make sure that they preserve members' trust. This is only valid while the work is in progress prior to publishing. "At the end, everybody knows which company worked on it, but in the meantime, the rest of the companies don't [know who is working on what].

As stated by a C.1 member, "we work independently with each pharma partner so that the pharma partners don't work with each other. They all work with us." This allows for mediated revealing between pharma partners and "because they all working with [C.1] on related projects, [this enables C.1 to] build expertise [and] what is working with pharma A is actually used as well […] with pharma B, C, D and E, etc." as suggested by a C.1 scientist. As a result,

C.1 plays a pivotal role in not only in enabling collaboration, but also in disseminating knowledge and expertise when and where it is needed to continue to validate tools and methods and accelerate discovery.

As well, C.1 members take into consideration and adapt to the specific needs of their pharma members to manage the collaboration: "we scientists in C.1 wouldn't mind being able to talk freely, but some of the companies -- not all -- don't want to reveal their interests […] to their competitors." They also adapt to the ways different companies interact with C.1 for different purposes: "Different companies interact with us in different ways. Some companies we do work together on very important projects that might eventually someday lead to a drug discovery. […] part of what we do is supposed to catalyze that sort of activity." On the other side, from the industry perspective, a testimony highlights the need for somebody who embodies boundaries: "there has to be someone who's passionate about it or it's going to fall apart… who's willing to take the leap and push it through the through, to manage the fights that might come up between some different groups or labs, to be able to have a vision just to sell." Consequently, C.1 members also have a role in absorbing and solving any tensions that may occur, and continuously adapting to the demands and needs of individual pharma members to enable collaboration and innovation.

3. Results

3.1 Tools and methodologies

Consortium 1 contributes data, tools and methods to the broader scientific community in the public domain in order to further iterate and validate tools and methodologies and as a result, accelerate innovation and increase knowledge across the community. As highlighted by an industry member, the goal is to "generate data that's useful to the community at large" and "do it faster and cheaper together, and probably more complete" by tapping into existing resources somewhere else rather than shouldering the burden individually. By publishing generated data into the public domain, C.1's rationale is: "you can either try to increase your

rate of success – which you cannot guarantee – or you increase the frequency of trials. In other words, we try to do things faster – which we can guarantee. As a result, you succeed and fail faster, and you get your real discovery faster as well." Hence, by downplaying boundaries between consortia members but also between consortia members and the broader scientific community, C.1 is able to further enable collaborative innovation and real discovery through the datasets, tools and methods it publishes for broad testing and use.

Through collaboration with industry partners and the best scientists in academia, C.1 is able to forge collaboration on topics of interest at the pre-competitive stage which results in tools and methodologies to support drug discovery, publishing research results and data in the public domain for broad use in the scientific community, as well as capability building and knowledge creation.

3.2 Public domain data

C.1 sets "high standards [along with] internal checks and balances [and] internal people to review data before it is [published]" in order to ensure quality of the data in order to reproduce research results. C.1 insists that "scientists make detailed materials and methods descriptions available so that anybody else can reproduce the data". This enables not only further verification and validation of the tools and methods produced to "eliminate the amount of time for everybody to optimize their scientific methods" and be "more efficient that way"., but also reproducibility of research results which is a "key aspect". An industry members praises "the quality of the reports is really good, so it is typically possible to reproduce this ourselves".

Beyond the immediate scope of C.1 work, the general idea is to "make the chemical tools produced [by C.1 and its pharma partners] available to the community at large [and encourage] anybody [to] use these [tools] to further interrogate the function of [the proteins and publish their work". This highlights the overarching results and impact of the open innovation happening within C.1. From the pharma perspective, a member praises the fact

that "[C.1] wouldn't just create structures, they'd also create [tools and make them] available to many and then anyone can use those IP-free [tools] to generate new data. I think that's really the power of it, it's not just the first level of information creation, but then enabling […] building tools that can be put out to the community to […] amplify that information creation", ultimately for the greater good. Furthermore, pharma companies can "read what [others] have published using [the] tools [created within the consortium] and this is informing them in terms of which of these proteins A, B, C or D is actually the most promising candidate for drug discovery and where they want to spend their [money]".

4. Benefits

4.1 Accelerate discovery

Ultimately, C.1 also recognizes the benefits of "collaborating in the open makes things easier, we can exchange information and reagents more quickly" which accelerates discovery and potentially development and commercialization of new drugs reaching patients.

A major benefit of open innovation at the pre-competitive stage is that "instead of doing their own research, which they did in the past – every pharmaceutical company would do their own research in biology and characterizing drug targets – so they're repeating each other and all spending millions, they decided: "You know what? If we all invest in C.1 it's cheaper for us, the risk is lower". Therefore, this lower risk of failure and potentially lower cost for the members involved.

4.2 Influence research agenda

Membership enables pharma members a privilege position in influencing the research agenda of the C.1 with an ability to steer research focus towards their own strategic priorities and what they could benefit the most from considering their resources and capabilities. Membership also enables a first mover advantage in obtaining the benefits of the

collaboration and being the first to make use of the tools, methods and technologies delivered as a result of boundary work with the added benefits of acquired knowledge, expertise and valuable resources gained in the process as opposed to non-members who can only benefit from the results of a research study if and once they are published in the public domain without additional intangible benefits. Membership also provides pharma members with a front-row seat in collaborating closely with top experts in academia where knowledge is created, acquiring practical and tacit knowledge and developing their capabilities and expertise by being actively involved in the process. Membership equally means an opportunity to tap into an extensive network of top scientists with the added benefits of building trust and lasting relationships that could equally be leveraged beyond the scope of work or membership.

4.3 Expand open innovation

As emphasized by an industry member, C.1 is on a "religious mission to have everything in the public domain". How does C.1 do this? First of all, to support discovery, C.1 leverages the best brains and expertise through its growing network of scientists, mainly based in North America and Europe, but also all around the world. C.1 engages the right complementary expertise, builds new partnerships, cultivates new collaborations, continuing to push the boundaries of pre-competitive collaboration to lead to new discoveries. As an industry member said, "they really select their people well as it is completely on their side who gets funding, who they include as members from the university side", etc. In addition, in their own words, C.1 has "become so good at what they do that in some cases other labs are compelled to work with us" and really "exploiting each other's strengths". Again, in their own words: "everybody, every lab, every scientist has their specialty. So, instead of replicating somebody else's specialty and maybe just be mediocre at it, it will work with people who are good at certain methods, certain techniques that we have not mastered in our lab. And we define everyone's role very precisely that you can accomplish your goal must faster." It is in this sense that C.1 is enabling boundary work to support collaborative, open innovation. As well, to ensure data quality and research reproducibility, C.1 insists that

scientists make detailed documentation and method descriptions available in order for anyone else to be able to reproduce the data, hence raising the standard for reproducibility in the scientific community.

5. Challenges

5.1 Trust and mindset

While the C.1 model is based on open innovation, a main challenge faced within the collaboration is lack of trust and mindset to embrace open innovation more broadly. C.1 is facing "a tough time convincing people that open innovation is a good move", particularly in academia, which it considers "counterproductive to be protecting your work" and not wanting to publish as soon as possible "to generate as much interest as possible […] and get people to follow up on it". However, according to its members, C.1 is starting to "see fewer people who disagree with [the open innovation] approach in the industry," recognizing that "pharma is quite keen about open models". Furthermore, as we have seen in the review of the literature, building trust to enable collaboration between consortia members is a persisting challenge in this pluralistic setting. This is exactly what C.1 is equally experiencing, having to compose with building trust between its members to truly enable and facilitate collaboration. It takes time to earn and build trust.

5.2 Facilitating collaboration

What equally takes time is acquiring expertise in managing boundary work in the specific context of the life sciences. As a well-established boundary organization since the early 2000s, C.1 has a significant advantage and experience in facilitating collaboration compared to more newly established organizations. C.1 is able to leverage its acquired expertise to successfully deliver on its vision as it continues to build trust with its members, establish credibility and sustain relationships over time. With regards to organizational challenges, ownership, communication, and coordination are some of the challenges that C.1 is facing in

facilitating collaboration. Ownership has proved to be a challenge when many members are around the table and "it's difficult for any one member to have ownership". From an industry perspective, a member highlighted that the big challenge is coordinating the effort within the consortium given the different priorities and interests of each of the multiple members. "Holding those folks together and creating a singular vision for them that actually keeps them together can be particularly challenging".

Case Study: Consortium 2

Consortium 2 (or "C.2") was established in late 2000 to support research in Europe, funded by government bodies as well as the pharmaceutical industry. The research agenda is informed jointly by industry partners, the European government and its scientific members, executive office, and academic institutions. C.2 focuses on several areas of research such as target validation for new drug in line with World Health Organization (WHO) Priority Medicines (World Health Organization, 2013), improving the way clinical trials are conducted, as well as developing programs to include the voice of the patient in R&D.

C.2 stakeholders include research groups, biotechnology and pharmaceutical companies with membership via a Europe-based association, patient foundations, and of course, academic partners (Hunter, 2011). Its initial research focus was twofold: neurodegenerative diseases and safety pharmacology, both highly costly for healthcare systems in Europe. To scale up collaboration, since the open data access to pharmaceuticals helped researchers all across Europe it was decided then to level up this cooperation. Resulting data is made to be an open data for all researchers in Europe with aim to promote the region as most scientifically advanced and make the region outstanding in terms of pharmaceutical R&D to lead medical innovation.

Stakeholders contribute to research in different ways, both monetary and in-kind such as providing funding, reagents, preclinical data, clinical data, samples and expertise. The primary research focus was to develop and validate techniques involving in preparation of

new pharmaceutical dosage form to improve compliance and improvement in the ability to predict safety and efficacy of new pharmaceutical leads. The impact of C.2 in R&D was in all phases of drug development such as in discovery research, preclinical development, translational development, clinical development and pharmacovigilance. In every parameter safety and efficacy of drug is evaluated for its further submission to regulatory agencies for marketing authorization. The structure of C.2 governance includes several committees responsible to implement different programs towards its mission. Scientific body is responsible to provide scientific advices to the governing board. Since its beginnings, C.2 has extended its portfolio of research topics into chronic obstructive pulmonary disease, diabetes, respiratory disorders, pain management, and cognitive disorders.

Analysis: Consortium 2

In this section, we analyze the C.2 case study through an inductive approach, focusing on the emergent themes and sub-themes from the collected data along with relevant citations (see Appendix B), from governance and boundary work to results, benefits and challenges encountered in practice.

1. Governance

Similar to Consortium 1, Consortium 2 operates as a boundary organization with governance being a significant theme that emerged from the case study, focusing on the mission of C.1, its strategic direction as well as its operating model. As highlighted by O'Mahony & Bechky (2008) in their study on software development, governance is a way for C.1 to establish pluralistic control to manage boundary work as explained below, through a clear mission, strategic direction and operating model. Let's see what it looks like in practice within C.2.

1.1 Mission

The initial intent for setting up Consortium 2 as a pre-competitive research consortium was to "help the pharma industry and [academia] working together and sharing information [to] support research […] in a different manner than [it has been done]", based on the industry's realization that the "model they had wasn't working […] in terms of transforming results into actual products". Moreover, it was "clearly accepted by some actors that they [couldn't] carry out everything on their own […] not only from a financial point of view, but also from a scientific point of view", making clear the need to "speed up the drug development process", to "gain in terms of budget, in terms of time, in terms of science because of so many failures in the past." Likewise, from the industry perspective, the conclusion that triggered the creation of Consortium 2 was the "need to redefine the boundaries of what is pre-competitive, so that we stop failing in parallel and start succeeding together".

Therefore, the mission of C.2 is to serve the need for pre-competitive collaboration to drive efficiency in the early research process and leverage collective resources. The measure of success towards this mission – as indicated by a C.2 member – is: "if we haven't moved the needle on improving the way in which we do R&D, then I don't think C.2 has been a success". The fact that C.2 projects "need to deliver something that is going to impact upon the way we do drug development [which has] always been an essential piece of our projects.

1.2 Strategic direction

With regards to its strategic direction and research focus, Consortium 2 is aligned with World Health Organization priorities. "Our strategic research agenda […] basically sets the framework for the types of project" that C.2 focuses one. Likewise, this strategic research agenda dictates the research focus of industry members working with the consortium. An example of strategic focus where pre-competitive research in the form of public-private partnership is necessary highlighted by one C.2 member is Alzheimer's disease and the financial burden it represents for society. "If C.2 did not exists, I that after the failure of

spending 8 billion euros from the pharma sector, pharma is not going to work on Alzheimer's diseases [because] it's too risky for them". On the other hand, "the public side can work on Alzheimer's research, but that's not going to get translated into use unless the private sector is there". This is a clear example for the type of research where public-private partnerships working at the pre-competitive stage are necessary, otherwise "I don't believe they're doable without them" as indicated by the same C.2 member.

From an industry member perspective, C.2 "plays a very important role because they scan the horizon, they talk with the academic community [and] bring to our attention things that we should scan". Therefore, C.2 has a highly strategic role in scanning the horizon and engaging with academic communities to bring to the attention of industry partners high priority topics to be tackled, in line with the strategic research agenda. Furthermore, an industry member recognizes that without "the political institutional support [that C.2 has], this would become just a collaboration as usual and would not bring the level of disruption and breakthrough innovation that's needed" referring to C.2 positioning within the European government.

1.3 Operating model

From an operating model perspective, core and center to C.2's operating model is that it has "fully implemented the concept of open innovation." In defining the space that C.2 and its members work in, different members define the pre-competitive space slightly differently, with a common denominator being the willingness to share data. One member defines it as "a space at any given time where companies are willing to share all of the data coming out". Another member defines it as the space "where the industry partners are ready to work together, express the willingness to work together and share data, not only between themselves, but also with the public partners". From an industry partner perspective, they "know what precompetitive is when we see basically anything where competitors would agree to work on together".

A good C.2 project is "one where you really must have collaboration between public and private partners". With open innovation in mind and the need to share data, this implies that when members agree to work together on a specific challenge, "they sign a consortium agreement [which is] a contract where it regulates how they share data, who owns the results, how they make decisions in the consortium, how and what do they do if there's disagreement, […] how they disseminate results, their publication policy, [etc.]". In addition to the consortium agreement, there is an upfront agreement that "no intellectual property will be taken by anyone in the consortium on any result obtained in that project". However, "the results that are generated during the course of the project are normally jointly owned, owned by the generators and if it's jointly generated, then [the results] are jointly owned". There is an interesting realization from the industry side that "if you share data, you leverage much more knowledge than you would be able to generate alone; if you do the screening of patients together, you don't spend money on screening the patients and by the way, the patient would be screened only once rather than being screened 20 times by 20 different companies. So it's ultimately less costs for the companies and it is leveraging a lot of knowledge".

With regards to membership, it is worth noting that C.2 is not designed for all types of stakeholders in the life sciences sector. C.2 is exclusively for members who can make significant in-kind contributions such as human resources, knowledge and expertise towards high-impact research studies as per the strategic research agenda, as well as buying into the open innovation framework, share data to accelerate knowledge generation. With regards to contributions, "50% is intellectual, people's time, [full-time employees] that are present in pharma companies [as well as] biobanks" or similar resources towards research projects. In-kind contribution confers industry members decision-making power regarding what they want to work on – "normally a challenge or an area where there is a problem or a question that a single company cannot address by itself. This could be everything from better diagnostic or prognostic of biomarkers in a disease area." The C.2 strategic research agenda includes "big healthcare challenges" such as chronic diseases, obesity, neurodegeneration, antimicrobial resistance, Ebola, etc. The role of C.2 and an advantage for its partners is that

C.2 plays a very important role in scanning the horizon and engaging with academic communities to bring to the attention of industry partners high priority topics to be tackled.

Another important aspect of the C.2 operating model is its "ability to act as a neutral platform," making sure that "everybody coming into a project [is] treated the same way, with the same set of rules, with the same set of expectations" – as highlighted by a C.2 member. Another member equally emphasizes that "one thing that C.2 has is we're neutral, we're not the pharmaceutical industry, but we're also not the academic […] what we often say is that we're a neutral broker or honest broker or a neutral third party." The realization is that "for the most part, [pharma members] have the same goals, they want to move the science forward, they want to deliver an output that in the long-term will have a benefit for patients and for healthcare [and] our role [as C.2] is to bring it all together [and] to manage it". Furthermore, C.2 members take it upon themselves to role-model and ensure that they are "very transparent, very open and very honest" in the way they conduct their work as this sets an example and standard for others.

2. Boundary Work

2.1 Collaboration model

The collaboration model within C.2 is defined as "totally co-creation" and "multidisciplinary" by one of its members, to facilitate collaboration and enable open innovation. Once a project has started, "it's no longer the public and the industry; it's one single consortium where everyone is mixed together and is working together" as stated by a C.2 member. In this way, all the expertise necessary is present within the consortium which represents a new way of working to deliver new outcomes. C.2's role is then to "follow the project lifecycle [through] regular assessments on the outputs of the projects in terms of their deliverables and their results and achievements". C.2 also follows "the financial reports as well as the way through the project close […] basically, every part of the project from the initial idea through the finalization at the very end". C.2 also "oversees the merging of the

public and private" and "facilitates collaboration […] opening new models of information within the companies and this is having an impact the way in which they are working and [they] know this from feedback". Hence, through its acquired expertise in facilitating collaboration, C.2 is able to influence the ways of working of different companies to improve the way research is conducted. In addition, C.2 also brings in external partners as necessary, such as "academics, regulators and health professionals and health agencies because they bring in the skills and other perspectives [and] they're working together [and] learning from each other".

In order to agree on the work to be done, as an industry member mentioned, typically a company will choose to speak up and expose their "vulnerabilities" or "problem", knowing that other competitors might have the same problem. This invites others into the conversation in order to check if the same problem exists and there is common ground to create a project worth tackling in a consortium. In the process of facilitating collaboration, 2 seizes the opportunity to open up and experiment with new ways of working which impacts the way competitors work together. In their own words, "we're actually putting many competitors around the table and we are making them work together; that just changes the dynamics and it evolves the field completely differently. It's a change of mindset, a change of culture." To ensure progress and success, C.2 is accountable for project outputs, deliverables, results and achievements, as well as the financial report and resource utilization.

C.2 and its members work across the entire value chain. For instance, in the Alzheimer's disease portfolio of projects, "the entire value chain from early discovery to delivery [including] business models and reimbursement models" is tackled. This provides C.2 and its participating members oversight over the portfolio with an ability to "connect them [and] a significant step" towards moving the needy in early discovery in this research area, as indicated by an industry partner. The collaboration model includes scientific officers working in C.2 with almost all of them having "Ph.D. and have worked as scientists prior, in a university or pharmaceutical companies […] so they know and understand very well the daily lives of the people working in the projects [which helps] to manage the projects" which

engage “experts with different backgrounds” This is recognized by an industry member that the work of C.2 is really about “putting the brains and the efforts and the energies together”.

2.2 Enabling mechanisms

First and foremost, C.2 provides “a platform where industry members and academia can meet [and] collaborate in order to […] succeed together where [they] were failing separately before”, as highlighted by a C.2 member. C.2 has acquired expertise in facilitating collaboration between unlikely allies for 20 years, positioning itself as highly proficient in enabling collaborative innovation. Therefore, C.2 facilitates several strategic groups and led by industry in specific domains of disease interest and it is “within those groups [that] the companies agree to start working on a particular topic”. These strategic groups operate on the basis of “self-assembly” or “coalition of the willing” with a pharma partner taking the lead and asking others “who would like to join us?”. Therefore, industry members are empowered to voice their problems, take the lead and invite others to join and self-assemble around common problems towards common goals. From an industry member perspective, this creates “front runners clubs […] that would de-risk the field for the others,” referring to companies leading certain projects and reducing risk for others, ultimately “for the entire sector”.

Secondly, as highlighted by an industry partner, C.2 “[breaks] down silos between competitors to make them collaborate more, the silos between sectors to make different industries to change their business models in order to become partners where it brings value to all of them and then breaking the walls between the public and the private sectors including between the regulated and the regulators still within the scope of their roles and responsibilities to enable the health authorities to […] enable innovation”. This creates “new mechanisms for working together that do not create conflict of interest and identifying common interests between industry agendas, health agendas and science and regulatory agendas”. In addition to collaboration together, C.2 also becomes a space for public and

private partners "to redefine their agendas together [and create further] connectivity between public and private", as highlighted by an industry partner.

While overseeing different projects and strategic groups and witnessing projects coming to completion and having an impact, C.2 is "learning a lot about what makes a project successful, and the importance […] of having a very clear goal because when you have a massive five-year project with a huge budget and lots of partners, inevitably some things aren't going to go as planned." Therefore, C.2 is able to leverage these learnings from one project to another and drive efficiencies and what a pharma member calls "operational excellence" in the way that projects are delivered.

3. Results

3.1 Tools and methodologies

A key result of C.2 boundary work is the creation of tools "to help in the development of new drugs" and "methodologies that would lead to creating drugs". C.2 is also working closer with patients and "doing projects which aim at seeing how [they] can integrate patients in [the] R&D process much faster, much earlier", as highlighted by an industry partner.

3.2 Public domain data

Sharing data in the public domain is a requirement for being part of C.2 in addition to sharing data and collaborating with competitors as part of C.2 project work which is becoming "more and more accepted because the landscape has changed" from a C.2 perspective. Hence, by making open innovation core of its pre-competitive research work, C.2 is "making data and resources available to the wider scientific community" beyond its immediate partners and companies involved.

4. Benefits

4.1 Accelerate discovery

Both C.2 members and its industry partners recognize the value of collaborating to solve common challenges. Collaborating even more in the pre-competitive space jointly with public and private partners "would avoid duplication, it would accelerate knowledge generation [by leveraging academia] and translation [by leveraging the pharma companies]". The public sector alone "[does] great science, but [it's] not always good at translating the science [into] innovation. Collaboration further allows to "de-risk, accelerate and cut costs" linked to the research and development process ["which is very costly, very lengthy and very risky"] and this is where the value is for the industry. Additional benefits include "acceleration of processes [and] avoiding late failure".

4.2 Influence research agenda

Since C.2 operates in line with World Health Organization priority medicines which dictates its strategic direction and research focus, this ensures value for the public in helping to focus activities. Within the guardrails set, it is then "up to the [pharma] companies to define where they're willing to work and collaborate" and it is up to them "to agree to work together [on the] chosen topic". From an industry member perspective, C.2 has a "very broad research agenda" which provides leeway to define the topics to work on,

4.3 Expand open innovation

Another benefit of being part of C.2 projects is that "by multiplying [collaboration], the partners [become] less reluctant [to be involved in C.2]" over time. "One of the big achievements of C.2 was actually showing that the companies could work together" whereas back in 2006-2007, the common belief was that "it wouldn't be possible for companies to act pre-competitively". C.2 was able to break through this skepticism to expand pre-competitive

collaboration and open innovation by building "confidence and trust […] between the different partners". One thing that C.2 members noticed is that "top people in the pharma companies and scientists doing the work [are now] convinced of the value of working together".

5. Challenges

5.1 Trust and mindset

In the early days of C.2, there was a "huge amount of skepticism […] because the companies weren't used to talking to each other, they weren't used to talking to academics, academics weren't used to talking to big pharma [so] there was a lot of uncertainty" which led to lack of trust. Since C.2 has been working with its partners for a long time, "trust was built gradually", yet it is still "one of the biggest challenges" along with "really creating a space for collaboration" and having a "common language between the different stakeholders [because they do not] all necessarily speak the same language nor trust each other."

With regards to mindset, according to a C.2 member, "everybody who gets involved in a C.2 project recognizes the value in dialog and exchange because [the challenge at hand] is a common challenge, usually it is a challenge that the industry faces, but it is a challenge for the research community, and for the drug development community, for patients and healthcare providers. [Therefore] everybody comes into the project with the mindset and willingness to work together in order to address this challenge." Having the right mindset is key for success.

5.2 Facilitating collaboration

Facilitating collaboration is still "tricky" within C.2 according to a member. One of the challenges in facilitating collaboration – linked to trust – is to "build confidence in the different actors because they might recognize the challenge, but sometimes they're a bit

scared about working with everybody". From the industry perspective, C.2 needs to become "more business practice friendly", being described as "very bureaucratic" at the moment. It requires "more flexibility to enable completely new ways of working." However, overall, members recognize that there has been a shift and "an evolution in [the] understanding of pre-competitive space" as a space where "you can collaborate and you can get all the benefits from the results that come out".

Theme	Sub-theme	Consortium 1	Consortium 2
1. Governance	1.1 Mission	Improve identification of potential drug targets	Improve the R&D process
	1.2 Strategic direction	Defined by consortium Scanning the horizon Financial investment required	Defined by the World Health Organization Scanning the horizon Resources investment required
	1.3 Operating model	Open innovation Restricted to big pharma Neutral platform	Open innovation Mostly restricted to big pharma Neutral platform
2. Boundary Work	2.1 Collaboration model	Similar to industry Matching expertise to projects Project scope is defined jointly	Built around public agenda Matching expertise to projects Projects are industry-led
	2.2 Enabling mechanisms	Mediated revealing Enabling multiple goals	Self-assembly Co-creation Oversight
3. Results	3.1 Tools and methodologies	Tools Methodologies	Tools Methodologies
	3.2 Public domain data	Open to the scientific community Research reproducibility	Open to the scientific community Include patient voice
4. Benefits	4.1 Accelerate discovery	High impact	High impact
	4.2 Influence research agenda	High influence	Medium influence
	4.3 Expand open innovation	High impact	High impact
5. Challenges	5.1 Trust and mindset	Embracing open innovation	Embracing open innovation
	5.2 Facilitating collaboration	Communication Coordination Ownership	Confidence Bureaucracy

Table 2: Summary of findings

Chapter 4: Discussion

Following the analysis of both case studies, in this section, we discuss the findings from Consortium 1 and Consortium 2 to further shed light into the research question: ***how do pre-competitive research consortia enable innovation in the life sciences?***

First of all, with regards to governance, both consortia are not-for-profit organizations on a similar mission to increase efficiency and productivity in the research and development process and create tools and methodologies to improve the way drug discovery is conducted, particularly in the early stages when potential drug targets are identified. While both consortia have a strategic role to play in scanning the horizon for opportunities to identify challenges fit for a consortia-type of approach – namely, requiring a public-private partnership, each consortium has a strategic agenda which informs its research focus. In the case of C.1, the research focus is defined with its members along with its board of directors and scientific committee, strongly influenced by visionary leadership from C.1 executives. In the case of C.2, the strategic research agenda is defined by the World Health Organization since C.2 is positioned within the European government. This positioning is the main difference between the two consortia in terms of strategic direction. Nonetheless, both consortia have significant leeway to engage their members on topics of interests and no mention of any restriction in this sense has emerged in data collection.

The operating models of both consortia are also similar with regards to open innovation, although C.1 seems to be requiring open innovation more strongly than C.2. This nuance was captured in the wording that consortia members used when discussing "open innovation" such as it being a "religious mission" in C.1 and "recommended" in C.2. Another nuance is in terms of membership. C.1 requires a minimum financial investment which limits membership to big pharma. On the other hand, C.2 mainly requires in-kind contributions, which also restricts membership to big pharma, yet to a lesser extent given that C.2 receives

public funding to conduct its research. On a similar note, both consortia act as neutral platforms and are highly valued for their position of neutrality by their members.

Secondly, in terms of enabling boundary work, the collaboration model in C.1 is slightly more heavily influenced by industry, being milestone and deliverables-focused which is rather built around the public agenda in C.2 and industry members take the lead on projects of interest. This could be due to the fact that C.1 receives funding from its members while C.2 receives public funding. In C.1, projects are defined jointly with the pharma members, whereas in C.2, pharma members are expected to expose their challenges and engage other members in joining forces to jointly tackle common challenges within the scope of WHO priorities. Similarly, both consortia play a significant role in matching expertise from academia and the scientific community with the requirements of the different projects to ensure that the best expertise is best allocated when and where needed. Importantly, both consortia bring extensive expertise in managing and successfully facilitating collaboration between competitors and between industry and academia, which brings significant value to enabling open innovation in this pluralistic setting.

With regards to enabling mechanisms to conduct boundary work, the approach is slightly different and grounded in the collaboration model that each consortium applies. In C.1, pharma members work directly with the consortium, but they do not necessarily work directly with other pharma members. Therefore, C.1 has a significant role in mediated revealing and enabling multiple goals to ensure trust and transparency, with the benefit of oversight of all projects and cross-pollinating learning and expertise. In C.2, since the projects are industry-led and driven by the public agenda, pharma members work directly with each other and are expected to share information as agreed at the start of a project with the added benefit of jointly owning all the outcomes of the projects they are involved in. Therefore, C.2 requires self-assembly around projects along with co-creation and it has an important role in oversight across the portfolio of projects.

In terms of results generated through collaboration in the pre-competitive space, both consortia have an enabling role in ensuring that tools and methodologies that support drug discovery are created and made available to the extended scientific community which further allows for testing and validation to lower risk of failure and increase potential for successful discoveries. The added benefits for consortia and its members are the significant learning and capability building that happens in the process which confers an advantage for its members directly involved in the development process. Moreover, C.1 is particularly focused on taking extra measures to ensure research reproducibility while C.2 is keen on further including the patient voice into the R&D process.

An overall benefit of pre-competitive collaboration and public-private partnership is a means to accelerating discovery. Since drug discovery is a highly risky phase, C.1 and C.2 contribute to accelerating discovery through open innovation and collaboration which reduces risk for all parties involved, leverages the best brains from the scientific community, and yields significantly better results that one party could not achieve alone. In this process, an advantage for C.1 members is a high degree of influence over the research agenda, while C.2 members have moderate influence over the research agenda given that it is high level established by WHO. Ultimately, by fostering collaboration, both consortia are able to expand open innovation more broadly by showcasing what is possible, what the benefits are, and converting more scientists and industry members into believing that open innovation is the way forward to improve R&D efficiency.

Certain challenges still remain, and both consortia are similarly faced with various degrees of lack of trust and a mindset that is not fit for true collaboration. Both consortia emphasized the need for building and sustaining trust as a key element to enabling collaboration and by extent, innovation. We deduct that trust is the foundation to enabling this type of collaboration in the first place. Although significant progress has been made since each consortium was initiated to lower the level of skepticism, trust and mindset continue to present challenges in facilitating collaboration. Moreover, additional challenges in facilitating collaboration were flagged in both consortia. In C.1, communication to keep

everyone on the same page can be challenging. As well, ownership by pharma members can sometimes be lacking. These challenges could be linked to the way C.1 operates and how it enables collaboration. In C.2, given its positioning within the European government, the consortia can be described as bureaucratic and maintaining confidence of its members as well as the public can be a challenge in this pluralistic setting. However, in spite of these challenges, we conclude that the value of innovation is intrinsic in the work that both pre-competitive consortia are striving towards and there is room for improvement in each respective model to enable even further innovation.

Conclusion

The purpose of the present research study was twofold: (1) to explore the concepts of boundary organizations and boundary work in the life sciences, and (2) to further our understanding of pre-competitive research consortia in the life sciences along with the results and benefits they deliver. Through the in-depth exploration and analysis of two relevant case studies, we are able to contribute insights to answer our research question: ***how do pre-competitive research consortia enable innovation in the life sciences?***

To answer the research question, we identified that pre-competitive research consortia operate as boundary organizations as a means to an end: to enable collaborative innovation. To do so, they establish governance in the form of a clear mission, strategic direction to guide their research focus, and through an operating model that enables them to fulfill their mission such as through membership criteria, open innovation, and positioning themselves as neutral entities, exemplifying openness and transparency. As entities, consortia also have a strategic role in scanning the horizon to be at the forefront of emerging medical needs.

Governance enables boundary work through a collaboration model and enabling mechanisms that are conducive to collaboration in the specific context of pre-competitive collaboration in the life sciences – which brings competitors and academic around the same table to exchange and share information towards common goals – preserving the trust of their partners while reaching multiple goals. A key element of pre-competitive collaboration is the role of consortia in bringing expertise and leveraging a network of scientists to match expertise to project needs in order to reach the best possible outcomes. Because pre-competitive research consortia work on the most complex challenges in drug discovery that no single entity can solve alone, they are able to spark the interest of top scientists from around the world.

Resulting boundary work yields new tools and methodologies that aim to accelerate discovery of new potential drug targets and consequently, drive productivity in the research

and development process. Embracing open innovation, the tools and methodologies created along with the data generated are made available to the scientific communities beyond the boundaries of the consortia which leads to further testing and validation by a broader community. Moreover, consortia and members involved closely in projects are able to acquire valuable knowledge in the process, both towards the R&D process, as well as in better enabling collaboration to produce the best possible outcomes. To be successful in facilitating collaboration with industry members, consortia also adopt their practices, namely by being milestone and deliverables-driven which has proved effective for at least one of the consortia we studied.

By working together towards the same goals, bridging industry and academia and delivering results, pre-competitive research consortia enable innovation not only in the form of tools, methodologies and knowledge, but also by accelerating discovery providing opportunities for members to influence the research agenda, creating competitive advantage for their members while defraying risk, continuing to expand open innovation broadly, and ultimately, slowly but surely changing the paradigm of innovation through mindset shift by showcasing what is possible when competitors are working together. With this, new opportunities may arise such as expanding networks to new geographical areas and domains of expertise, raising the bar for patient-centricity in the research and development process, and altogether redefining "pre-competitive" research to expand open innovation and collaboration.

Implications for Practice

The present research study supports our understanding of boundary organizations and boundary work in a highly competitive, complex and pluralistic setting, further shedding light into this practice and related processes to validate current beliefs and provide insights into where to consider investing resources to derive greater benefits from pre-competitive research to enable collaborative innovation. This research also showcases strategies currently used and examples that have proven effective and are worth experimenting with in different

contexts and informing organizational design when establishing a new consortium or reorganizing and existing one.

This research also provides a few watch-outs to consider for practice such as investing in building trust as foundational to sustain this type of collaboration over time. Moreover, this study can provide practical insights into addressing pressing medical needs and leveraging collaboration as a means to accelerate discovery when it is most needed as it is the case in a global pandemic when a safe and efficient vaccine is quickly needed in order to save lives and restore economic activity.

Limitations

Considering that research is an exploratory study on a topic that has not been studied extensively from a management and strategy perspective, this master thesis provides a broad overview of boundary organizations and boundary work in the context of pre-competitive consortia operating in the life sciences. However, it does not provide concrete recommendations, nor strategies or tactics to enable collaborative innovation, but merely ideas and directions for future research. Taking this as a starting point, the topic is worth exploring since it appears clear that pre-competitive collaboration will continue to generate interest to increase R&D productivity and drug discovery.

Given the challenges we experienced in gaining access to the field in the first place, a more thorough research design – incorporating observation as a research method would be necessary to holistically grasp the phenomenon of boundary work as it unfolds in reality, capturing and understanding the complexity of the phenomenon through team dynamics, member's behavior and practices. This would contribute further depth and insights into the topic with further implications for practice.

Lastly, considering the small sample of the present study, we are not able to verify external validity and therefore we are not able to confidently generalize our findings. Further studies

with more representative samples are necessary to be able to generalize more broadly across pre-competitive consortia operating in the life sciences.

Future Research

In the quest to increase R&D productivity, maximize output and ultimately innovate in order to bring new products to market to meet the most pressing needs, boundary organizations and boundary work will likely continue to intrigue public and private members across different sectors and industries. To further shed light into different angles of this topic of interest and further provide practical recommendations, future research is necessary into the role of boundary organizations in fostering collaboration, building trust among competitors, collaborating across global networks taking into consideration individual interests, as well as into value creation to identify the impact of collaborative innovation has had thus far and that it can have going forward.

Future research could also validate the findings of this study with other pre-competitive research consortia in the life sciences as well as other sectors in order to identify best practices and recommend a collaborative open innovation model and/or organization design that would be conducive to enabling innovation with speed and confidence. Moreover, the research study by Langley et al. (2019) could be validated by further exploring and understanding pre-competitive consortia leveraging boundary work to enable open innovation in the life sciences.

With a global pandemic unfolding and a burning platform to increase innovation and collaboration to move faster than ever before in order to maximize resources and bring novel vaccines and therapeutics to market, it could also be interesting to explore the practices and processes that may have been adopted as a result, and what new concepts and theories may have emerged in drug discovery and beyond.

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Appendix A

Interview Guide (60 minutes)	
Introduction	Research objectives, scope of the interview, confidentiality agreement
Context	Tell me about your role in the consortium.
PART 1: Governance	Tell me about the consortium: • How was it created? Why was it created? • What exactly does the consortium do? • How is the consortium managed?
PART 2: Collaboration	Tell me about the collaboration that the consortium enables: • How is the consortium enabling collaboration? • What are some of the strengths and weaknesses of the collaboration? • How do you establish project representation? • How do you attract new members? • How do you manage intellectual property? • How do you collaborate with your members and partners? • How do you establish trust to enable collaboration? • Can you share an example where collaboration was particularly fruitful? What were the premises of this collaborative effort? What worked well? What didn't work so well? • Can you share an example where collaboration was not so fruitful? What were the premises of this collaborative effort? What worked well? What didn't work so well?
PART 3: Value Creation	Tell me about the value created by collaborating pre-competitively: • How does the consortium generate value? • What enables the consortium to generate value? • How do you define "value"? • Could you provide examples of projects that created the most value? The least value? • What is the value created by collaborating pre-competitively? • What kind of resources are deployed by each member? • How complementary are the resources exchanged between the consortium and the collaborators? • What interests do collaborators share? • What value do you generate collectively?
Conclusion	Anything else that you would like to add? • How do you see the consortium generating more value moving forward? • What is your vision for the consortium?

Appendix B

Themes, sub-themes and verbatim citations from collected data *(blue = consortium perspective, green = industry perspective)*			
Theme	Sub-theme	Consortium 1	Consortium 2
1. Governance	1.1 Mission	i. it was created in order to ensure that protein structural information was in the public domain and that companies had freedom to operate ii. it was initiated by pharma, but I think several of public funders also recognized the need to solve 3D structures of human proteins that would support drug discovery and it was such a tedious task of interest to multiple groups that it was well suited for a consortium type of approach iii. started with protein structures and then evolved into using those proteins and structures to develop chemical probes, which are, you know, part of the beginning stages of early drug discovery, the tools to validate whether a target or potential drug iv. now, we're even doing disease models, models of disease from human patients' cells basically because no single organization understands human biology and human disease well enough that they can do all of this themselves. v. I totally am convinced that the interest of C.1 is genuinely to contribute to drug discovery.	i. let's help the pharma industry and [academia] work together and share information. And second, let's support research […] in a different manner than we do right now ii. there was this convergence on the one hand within the pharmaceutical industry the realization that the model they had wasn't working iii. they realized this isn't working, you know, in terms of transforming results into actual products and things in the long-term and getting things to market. So, there was a lot of will both in the industry and on the political side to do this, you know, which obviously was a big help. The other thing [C.2] has is the scale because we've had very big budgets iv. it has been clearly accepted by some of the actors that they can't carry out everything on their own, they can't have all, not only from a financial point of view, but also from a scientific point of view. They do not necessarily have the knowledge and know-how, we need to go along the process and we need to speed up the drug development process. So, there was clearly this need if we

			would like…, we need to gain in terms of budget, in terms of time, in terms of science and we may learn from each other, so that was (…) because there were so many failures in the past. v. We started to come to exactly the same conclusions: "We need to redefine the boundaries of what is precompetitive, so that we stop failing in parallel and start succeeding together". That was the basis for setting up C.2. vi. if we haven't moved the needle on improving the way in which we do R&D, then I don't think C.2 has been a success.
	1.2 Strategic direction	i. we kind of almost have to reinvent ourselves every four or five years to say: "Now, we're going to do this new thing" ii. we evolve our scientific mandates every few years and we try to do the same thing with processes as well. You know, can we go cheaper somehow? Can we go faster somehow? How can we become more efficient? That's really important. I think that's uncommon in academic labs. iii. we figure out what we think will be important in the next five years. That's key, right? What's important in the next five years and what, then, open science gets that other people can't get. iv. we're kind of always changing and looking at ourselves critically and bouncing ideas off of the company representatives. So, it's interesting that the company representatives don't come in to us and say: "Right, we need to be doing this in the future", but it's more we	i. our strategic priorities are aligned with the WHO priorities, priority medicines ii. C.2 is encouraging companies to remain active in certain areas or to contribute in certain areas because C.2 can be a model to share risk. iii. things like neurodegeneration and dementia, these things that are obviously going to have huge financial burden to our society, they already have. That's not going to go down until we find a way to manage these situations, these diseases better. And I believe that the public-private partnership in these is crucial because if C.2 did not exist, I know that after the failure of spending 8 billion euro from the pharma sector, pharma sector is not going to work on Alzheimer's disease, they're going to (…) of it because it's too risky for them. And the public side can work on Alzheimer's research, but

			get a sense of what is valuable to them and what sort of activities really resonate with a given company and how many of those companies then will come to the board with ideas about a certain initiative or, you know, strategy for future scientific activity and then we, you know, bounced those ideas off the board members and see to what extent it resonates.		that's not going to get translated into use unless the private sector is there. So, I think this is why you…, you know, I know that for certain things we don't need public-private partnerships, but for these things you absolutely do need public-private partnerships. And I don't believe they're doable without them.
		v.	Well, does it make sense to continue in this direction? Because these projects are really not going anywhere, so maybe it's time to change, you know, to abandon certain projects, just shelf them and spend more resources on areas that are more likely to lead to success".	iv.	if you look at the public value, that comes at different levels. The first level is straight from the strategic research agenda, which in fact dictates what type of topic industry have to come up with.
		vi.	Consortium 1 brings in a lot of this open science and there are other organizations that are embracing the open science concept and sharing data before publication.	v.	our legislation is quite clear on the goals, the strategic research agenda is quite clear on where we work. But also, a lot of it is the people, I mean, our lawyers, we have intellectual property lawyers whose job is to check everything is fair and correct. You know, we have scientific officers
		vii.	But, actually, you know, [pharma members] rely on us to select the area […] if we get three ideas, they'll say: "I like idea number 2". But they don't come up with the new ideas. Very rarely do they come up the new ideas.	vi.	In terms of the scientific focus, we have an important document called our strategic research agenda and this research agenda, that basically sets the framework for the types of projects and the areas that we can launch those projects.
		viii.	in human genome, we wrote a paper [...] three years ago we wrote it about how it's a really understudied area of science. We had companies come in, we convinced them [...] and so there we have a project, we'll have six companies and us tackling that project together [...] So, here we had a situation, right, where we wrote a paper three years ago saying: "This is where the Venn diagram is going to be". And the pharma joined in, the public joined in,	vii.	the C.2 office plays also a very important role because they also scan the horizon, they talk with the academic community even more than we do, so they would bring to our attention things that we should scan.
				viii.	without this political will, the political institutional support this would become just a collaboration as usual and would

			now there's a big, you know, large biotech company in that area.	not bring the level of disruption and breakthrough innovation that's needed.
		ix.	it's more like where we want to be in 10 years and then how does one operationalize getting to that point in 10 years. What kind of partnerships do you need? What kind of money do you need? Do we have the expertise? Do we really want the expertise internally or can we collaborate?	
		x.	I always try to find the Venn diagram of value, in quotation marks, for the public. […] It's to identify those spots of science where it requires multiple people to get involved, but everybody thinks it's important. And those are…, when we choose the areas to work on, that's why we choose them.	
		xi.	Part of my job is to think of what the Venn diagram will look like in five years, convince the people now that that's going to be cool	
		xii.	To continue to monitor sort of the pulse, the needs of the companies and what, in the precompetitive realm, is going to be viewed valuable by them. I think we know how to do that now, we've done this for long enough.	
		xiii.	what allows a project like this to get going, initially, is the vision. It's the idea that people see what their original authors want to do, and they see that they want to be part of it, that they've convinced them that this is something worthwhile	
		xiv.	I always have this Venn…, series of a million Venn diagrams in my head where: "Well, I know what industry wants". That's a skill I have. I know what	

		academia wants, that's a skill I have. And I know what government wants, that's a skill I have. And always trying to find ways in which we have a project, I can see it in my head: "That's the area we should do because everyone will think that's cool and nobody can do it". xv. but it's only going to go so far and there's a need to think about where else we can go. And what the C.1 presented us with was a platform for us all to come together and to really be able to try to quickly evaluate a whole new space.	
	1.3 Operating model	i. membership is simply a matter of who puts money in. They just put in the same amount of money as everybody else and then they get the same rights and responsibilities as everybody else. ii. if a new member joins us, they've got to buy into the whole openness. They've got to pay the money and it's not a small amount of money, it's not a 100 000$, 20 000$... this is a big decision. And so, because it's such a big decision, they put a lot of thought into what they're getting into and they appreciate what the purpose of the organization is. iii. we have a minimum financial investment that we require from a company to be a member of the C.1, and so it kind of limits it to big pharma. iv. we have a huge breadth of activities going on and, you know, a lot of great scientists, so we kind of find the right match between, you know, our scientists	i. I would say that C.2 fully implemented the concept of open innovation ii. you can't define the precompetitive space. My definition, quickly, it's a space at any given time where companies are willing to share all of the data coming out in order for them to play a competitive play iii. there is an intellectual property framework within each consortium can agree amongst partners to work. So, we have…, and the whole spectrum of intellectual property agreements that consortium members would agree to. iv. no intellectual property will be taken by anyone in the consortium on any result obtained in that project. So, this is an agreement upfront that no IP is going to be…, not patents are going to be filed in that project. v. the public side are receivers, they're beneficiaries of our funds and they can

			expertise, so we kind of work in areas that in general, you know, are important scientific areas to study. So, there are certain areas we just don't work in and, you know, the funders know that, so we don't go there, but of the broad areas that we do work in, we try to find the right match.		use those funds to essentially do anything as long as it's integral to the objectives of the project.
		v.	C.1 brings in a lot of this open science and there are other organizations that are embracing the open science concept and sharing data before publication.	vi.	where people are willing to share all their knowledge, share all their data, accelerate the knowledge generation piece
		vi.	We created a very clear box where everything in the box is open and there are very clear rules about what is in the box and what is out of the box, and so I think by making it clear to and show the participants what's in the box and what's out of the box makes it very clear for competitors to work with one another.	vii.	the strength of C.2 is the projects need to deliver something that is going to impact upon the way we do drug development. You know, so impact has always been very strong for C.2, it's always been an essential piece of our projects
		vii.	we don't take IP. Everything that is put into the X, it's very clear that our scientists will never file for patent.	viii.	it is the companies that decide the areas that they want to work in and it's not just: "Oh, this is a nice area, I want to work in". Normally, it is a challenge, it is an area where there is a problem or there is a question where it is not possible for a single company to address that by itself. This can be everything from better diagnostic or prognostic biomarkers in a disease where you need to get everybody together and just kind of get a more rational approach
		viii.	becoming part of the consortium means at least that there is no wall [wall of distrust, wall of not sharing] and their scientists get excited, they get access to stuff that maybe if they'd gone through their legal channels would have taken them 6 months, 12 months to do	ix.	the projects we support, so they are initially initiated by the industry (…) all together. So, they discuss together, they are already ready to work together and when they are ready to invest resources and after we consult with a scientific committee (…). Do we invest also public money in this area?
		ix.	some are completely closed where their consortia generate information and they share it, but don't they share it with the rest of the world. Other are sort of partly open where they share their data amongst the consortia for a certain amount of time and then they make it public, but in the C.1 our information goes public pretty	x.	the precompetitive area is where the industrial partners are ready to work together, express the willingness to work together and share data, not only

			quickly, as soon as we validate that it's reliable and of use to the community.		between themselves, but also with the public partners.
		x.	we have two things; we have the board of directors and then we have a scientific committee.	xi.	before they start a project, we oblige the consortium to sign a consortium agreement where they detail how they will manage IP within the framework imposed by C.2.
		xi.	the board of directors I think they more look at finance, strategic directions.		
		xii.	drug discovery involves biology and chemistry. I would say right now it seems like the dividing line is biology in precompetitive, chemistry is the competitive park.	xii.	per definition these projects are often complicated and not easy.
		xiii.	investing in an entity like C.1, so basically, it's almost like your agreeing in a passive way with other pharmaceutical partners, we're all taking the same risk in biology here. That was, if C.1 is wrong, everybody is wrong. And so, you have no disadvantage in being wrong.	xiii.	the projects, they sign a consortium agreement, so all partners amongst them sign a consortium agreement and the consortium agreement is a contract where it regulates how they share data, who owns the results, how they make decisions in the consortium, how and what do they do if there's disagreement, how that escalates, how they disseminate results, their publication policy and the number of meetings, due dates for reports and so on.
		xiv.	the biggest difference is for C.1 it is almost a religious mission to have everything in the public domain where for industry that is not the case. For us it's a means to an end, this open science, but at some point, there has to be this transition from open to proprietary. But for C.1, that doesn't exist	xiv.	the results that are generated during the course of the project are normally jointly owned, owned by the generator and if it's joint generated, then they're jointly owned.
		xv.	I think generally we recognize, within any company, we don't have all of the necessary expertise to do everything we want to, and precompetitive consortium become a way for us to share the risk and share resources to get at a common problem that we know that we can't solve on our own.	xv.	we were really created to put together public-private collaborative projects to tackle some of the challenges that are common to a lot of people in drug development and to really help them, you know, to develop solutions. So, that's the precompetitive element, you know, it's shared challenges.
		xvi.	it's science that they do. I mean, they really select their people well. It's completely on their side who gets	xvi.	challenges are not just shared by the pharmaceutical industry, but also, you know, the academics working in drug research and areas where you can't…,

			funding, who they include as members from the university side, so they have a high scientific standing that is good and of course also the choice of proposals, the projects that they do, the choice of topics that are pursued.		the problem couldn't be solved by just one sector on their own. So, even if a group of pharma companies come together and work together, they can't solve it on their own
		xvii.	this is not a novel model for pharma to engage in and I think the idea is that, you know, we see value in collaboration and in fact I think in many ways if it weren't for issues of IP and other sorts of things, we would welcome the opportunity to collaborate with other companies much more frequently than we do. And precompetitive consortium provides us with that umbrella, that protection to be able to engage in that sharing of information. I think it's just natural as scientists that we want to be able to collaborate.	xvii.	run the projects according to these rules. In terms of the scientific focus, we have an important document called our strategic research agenda and this research agenda, that basically sets the framework for the types of projects and the areas that we can launch those projects.
		xviii.	a lot of these precompetitive consortium are designed like this where the knowledge stays largely trapped within it and only the paying members… and it's only whenever maybe they decide to eventually publish something that the rest of the world finds out about it.	xviii.	there are very advanced sectors like semiconductors who actually understood that much earlier than the pharmaceutical industry and started to collaborate to redefine what precompetitive means for them. They would still be competing on the market, but there's a place where they said: "It makes no sense to waste money and time in doing in parallel certain things if we can join forces and leverage more brains and more resources into resolving some of these problems, which actually would just accelerate what is our final goal; getting the right products to our consumers
		xix.	the money that comes to C.1, we distribute the money to different partners based on need	xix.	we don't define the precompetitive, we know what precompetitive is when we see basically anything where competitors would agree to work on together is precompetitive.
		xx.	you have this neutral position somehow with [C.1], kind of a matchmaker that is to pursue both the interests of public and private side, which is a very critical position.	xx.	If you share data, you leverage much more knowledge that you would be able to generate together. If you de screening of patients together, you don't spend
		xxi.	[C.1] is collaborating a lot with academics outside of direct members of [C.1] and it was very important to have		

		this credible neutral ground because they understand the rules of the game, how to engage, which is everything that you do is going to be published, so they could really be sure that this is handled this way. But it's also a condition, if they work with C.1, they have to publish		money on screening the patients and by the way the patient would be screened only once rather than being screened 20 times by 20 different companies. So, it is less costs for the healthcare system, it's less costs for the companies and it is leveraging a lot of knowledge.
			xxi.	a good C.2 project is one where you really must have collaboration between public and private partners. So, if it is something that either industry could also do alone or that public bodies could do alone where all it needs is just funding, then it's not a good C.2 project.
			xxii.	The C.2 model is very, very different in the sense that several companies have to agree upfront to work together, so collaborative…, you know, between pharmaceutical companies, which actually in 2008 was very rare. They had to agree to work together and share all of the data that would be produced during the lifetime of a project. Not only amongst themselves…, so here you have, you know, Eli Lilly and GSK and Merck and Pfizer and so on that sharing data together, but also agreeing to share that data with the public sector partners that were brought in to try and accelerate the generation of knowledge in a particular area.
			xxiii.	50% is intellectual, people's time, FTEs that are present in pharma companies. They also contribute consumables that are used in the projects that are…, those activities that are performed, the research things that are performed in

				industry. So, consumables, FTEs. Resources that they might contribute like chemical (…) or biobanks or datasets or whatever, those are resources that are made available
			xxiv.	it is an institutional public-private partnership between a sector that made strong commitments to work with the European Institution. And to me, that's one element. There are many public-private partnerships which are based on the co-funding. C.2's based on collaboration, Of course, we contribute, we co-found, but we are committed to working together.
			xxv.	It's our ability to act as a neutral platform and I think that, you know, at the C.2 office we try to protect that role as much as we can because I think in that sort of everybody coming into a project and then treated the same way, with the same set of rules, with the same set of expectations. So, it's very clear what needs to be done.
			xxvi.	we're going to tackle some of the big health challenges (the aging population, chronic disease, obesity, diabetes, neurodegeneration, antimicrobial resistance, Ebola, all of these things) we need platforms in which we can collaborate internationally, and I think that is a huge value to the society and particularly to researchers.
			xxvii.	in C.2 in particular we are bringing together pharmaceutical companies that form a coalition of the willing
			xxviii.	one thing that C.2 has is we're neutral, so we are not the pharmaceutical

			industry, but we're also not the academics, so we…, what we often say is that we're kind of either we're a neutral broker or honest broker or a neutral third party. So, you know, that's one important element in the way that we bring the people together and obviously they have to be then ready to work together and share […] when they work together they realize that for the most part they do have the same goals, they want to move the science forward, they want to deliver and output that in the long-term will have a benefit for patients and for healthcare. And so, I mean our role is to bring it all together, to be there in case of problems and to manage it. xxix. neutrality is probably the key to it
2. Boundary work	2.1 Collaboration model	i. you don't want to or don't need to overlap in everything the thing that you do, but both partners need to get enough out of it so it's worthwhile to collaborate. And this judgment of where that common ground is and where it's fine to go in different directions, that you can't… there's no recipe for that, that needs time and development. ii. his argument then is: "Why don't we pull all the resources, take the best brains from industry, from academia and do such initial evaluation in clinic jointly?" iii. And then, of course, reap the benefits jointly and in the few cases where there's	i. it's totally co-creation ii. where the public-private partnership happens at the project level because they then work together on a full proposal and it's no longer, you know, the public and the industry, it's one single consortium where everybody is mixed together and is working together. iii. we follow the project's lifecycle. So, we do regular assessments on the outputs of the projects in terms of their deliverables and their results and achievements. And we follow the financial report team as well and all the

		a positive result in the clinic, then there's still plenty of space for companies to then modify this compound, make it even better and then compete for their basically pushing the limit of precompetitive further. iv. I think the reason why if they feel that we're working on a part of the science where competition not only doesn't benefit them, in fact it doesn't make sense at all. This is because we're working on a drug target characterization part, so because pharmaceutical companies are very good at chemistry they feel confident that even though this part of working on a drug target is basically out in the open at the C.1, their chemistry expertise will allow them to stake out a very strong intellectual property position anyway. So, instead of doing their own research, which they did in the past, every pharmaceutical company would do their own research in biology and characterizing drug targets, so they're repeating each other and all spending millions they decided: "You know what? If we all invest in C.1 it's cheaper for us, the risk is lower". And yet we're able to help them narrow down which diseases and which drug targets to focus on. I think they see the value in that, I think they see substantial value in that. v. academics are no less competitive than, you know, the professional realm, you know, the industry realm. It's just the rewards for being good at what you do are somewhat different, so obviously tenure is important	way through to the project closes. We follow basically every part of a project from the initial idea through the finalization at the very end. iv. we run the evaluations, we identify the experts that sit on the independent evaluation panel. And then, we do stage 1, stage 2, then whenever we have, you know, identified the entities to receive funding, we oversee the merging of the public and private, you know, so the industry coming onboard, and they form a full consortium. v. We facilitate collaboration, and so on facilitating collaboration we are opening up (…) models to information within the companies and that is having an impact in the way in which they are working and we know this from the feedback we get from the companies that, you know, they've stopped using animal models that, you know, they've been using for 20 years because once they put all the data together, it's clear they're not working. vi. we are willing to work together on this challenge and we're willing to commit this resource and we need to bring an external partner", so people who aren't pharma companies. And this is why, you know, our projects involve academics, regulators and health professionals and health agencies because they then bring in the skills and the other perspective and then within the projects everybody has agreed to work together because they recognize the challenge and they recognize the

		vi.	ambitions are similar, but they're just realized somewhat differently. And the path in academia is very simple; you publish, you discover new things faster and you publish them faster than other people, and you're rewarded for it. And so, until recently a lot of academics thought the way we share our science openly would be (…) to their career success.		work together. And then, when they're working together, their learning from each other and they're informing each other.
		vii.	the organizational aspect and I think that is really unique, this position of being in academia, but having very much a mindset of what things we need and an open door to academics as well as industry scientists. I think that is almost unique and is very, very enabling.	vii.	we are working across the entire value chain. We are not picking one part of the value chain, we are not a biomarker consortium, we are not an outcomes consortium, we are looking at the entirety of the value chain and by connecting various projects, so that allows us to look at all facets of one problem. Let's take Alzheimer's. We have 15 projects on Alzheimer's addressing the entire value chain from early discovery to delivery and business models and reimbursement models. Each of those 15 projects alone would just be an interesting project, but because we can connect them, because we are in the context of the same scheme, we can create – and I hope that this will be visible because we start seeing results – a significant step
		viii.	it's an ideal environment that bridges industry with academia, so we're not…, we actually operate a lot like industry, like pharma because we're milestone driven and deliverable driven and we have to deliver our structures, our assays, our probes every quarter.	viii.	our scientific officers I think pretty much all of them have Ph.D. and have worked as scientists prior to a university or pharmaceutical companies and SMEs and things, so they know and understand very well the daily lives of the people working in the projects and I think that helps as well to manage the projects as well.
		ix.	By working on multiple projects at the same time, we let the success at each stage decide which ones we continue. And sometimes we make hard decisions: "You know what? As exciting as this may be, as alluring as it may be, we're not getting anywhere with it, so let's continue with the successful ones and ate least for now shelf the not so successful ones".	ix.	it is putting the brains and the efforts and the energies together.
		x.	there is freedom as long as you stay within the general…, you've got to do…, provide whatever is needed in terms of milestones and progress through the deliverables and milestones. I think there	x.	people actively working on the project, so it's experts with different backgrounds that conduct assays in their

		is freedom to make the choice: "OK, what target looks interesting? What target should we work on? What kind of assays to do, to develop?"	labs, that have expertise in the different things that are required for the project, that the project needs to do. So, it's FTEs, it sometimes calls for running assays, it's equipment that needs to be bought or used, time and equipment that (…) and things like this
		xi. collaborating in the open makes things easier, we can exchange information and reagents more quickly. We're kind of a hub with…, so we're a research hub, we collaborate with individual collaborations for the nine different companies. The companies don't collaborate with each other, but on a scientific basis…, technically they collaborate with each other to decide what C.1's priorities should be, but in a scientific level they collaborate individually with the C.1 on what becomes public domain. And the C.1 also partners with academics all over the world, and so this is an avenue for the companies to readily gain knowledge and experience	xi. it's a very big topic and one where we need really a lot of knowledge generation and knowledge creation and that can be then transferred to, you know, everyone who's involved and who wants to be part of this
		xii. everybody, every lab, every scientist has, you know, their specialty. So, instead of replicating somebody else's specialty and maybe just be mediocre at it, it will work with people who are good at certain methods, certain techniques that we have not mastered in our lab. And we define everyone's role very precisely that you can accomplish your goal must faster.	xii. there's been a huge learning curve, I mean, obviously because even just from an organizational point of view when we launch our first call for proposals C.2 didn't exist as an organization
		xiii. you can see the skillsets around the team, we have chemists and biologists and venture capitalists and pharma guys and academics and… It's a really cool mix.	
		xiv. we have a huge breadth of activities going on and, you know, a lot of great scientists, so we kind of find the right match between, you know, our scientists	

		expertise, so we kind of work in areas that in general, you know, are important scientific areas to study. So, there are certain areas we just don't work in and, you know, the funders know that, so we don't go there, but of the broad areas that we do work in, we try to find the right match. xv. pharmaceutical companies are really, really good at chemistry. xvi. we have access to their (…) expertise in terms of chemistry, mostly, and they have access to our expertise in terms of biology i. when we approach pharmas, usually, you know, with… and also to get their expertise and usually their expertise are in screening, in structural chemistry, chemical material, how to improve the chemical structure of a molecule to make a better drug, how to screen at high volumes.	
	2.2 Enabling mechanisms	i. we have monthly meetings in which all the companies call into and we share data on a sort of anonymized way in which all the companies can see progress on the different protein targets, but they don't know who's sponsoring that research from the different companies. So, we just refer to 'partners', right? "We made progress on this target with a partner" and keep generic like that so that the consortia can see progress scientifically and, you know, structures, chemical probes, etc. But it's not attributed to any specific company until we…, in the case of chemical probes where we finalized and	xiii. Breaking the silos between competitors to make them collaborate more, the silos between sectors to make different industries to change their business models in order to become partners where it bring value to all of them and then breaking the walls between the public and the private sectors including between the regulated and the regulators still within the scope of their roles and responsibilities to enable the health authorities to, in turn, enable innovation. And of course, that's related to creating new mechanisms for working together that do not create

		validated a chemical probe and the company and the C.1 together agree that this is a public domain resource that we ought to give to the community and then the company is…, they get internal approval to disclose that compound and they make it available and then it's now…, at the end everybody knows that that company worked on it, but in the mean time they don't, the rest of the companies don't. ii. we just use the term 'pharma partner' instead of referring to a specific company. In that way we don't say the wrong thing. iii. different companies interact with us in different ways. Some companies we do work together on very important projects for them internally that might eventually someday a drug discovery, a real drug program. We don't really know if and when that's going to happen, but, you know, part of what we do is supposed to catalyze that sort of activity. iv. Other companies use C.1 not on mission critical projects, but on exploratory, high-risk projects they probably wouldn't pursue themselves, they just want to find out about something. And so, in those cases they're not so sensitive to somebody else knowing what they're doing v. you get changes in management with the companies and the policy may change, so we just keep it generically confidential until the probe is made public. vi. industries their only, you know, reason to exist is to actually go on and bring these compounds to patients and on the market.	conflicts of interest and identifying common interests between industry agendas, health agendas and science and regulatory agendas. xiv. the funding model that allows…, for example health authorities not to just sit on the fence and watching us from above in an advisory role, if they which so and if their responsibilities allow that and the rules allow that and if they're not in a conflict of interests situation, they can become partners. So, it goes far beyond the typical academia/company collaboration. It actually involves all stakeholders and the funding model allows for everybody to keep their own responsibilities and still to collaborate xv. very typical collaboration would be – even in the context of larger public-private partnerships – typically a company comes with a number of partners. Here, we're actually putting many competitors around the table and we are making the competitors to work together, that just changes the dynamics and it evolves the field completely differently. This is a change of mindset, change of culture. xvi. We facilitate development of programs which can bring the biggest number of companies around and we reach out proactively to technology companies, which we feel hold the keys for resolving some of these problems. And that means constant attention, a constant dialog with the companies, one on one, understanding what they want,

			So, the direction is the same and I think it's just how far you go in that direction that is the difference.		understanding and bringing, you know, sort of moderating the constant dialog and moderating that platform
		vii.	industry partners know this is how C.1 works, if we like the science, we'll find a way to work with them. Whereas academics just decide: "Well, we simply won't go along with it" and we don't end up working together.	xvii.	You typically have a company that say: "I have a problem. I see that all the companies are struggling with that, but I expose my vulnerabilities. I have a problem. I expose that to the group and I, as a company, I know who of my competitors have the same problem, but I expose here in the room and I invite you to join the conversation in order to check if we have the same problem or if the problem is slightly different and if we have some common elements of a problem or if we can agree on a common definition". Then, we create a project from that base. So, this is the most pragmatic way of doing. The other way is, you know, global heads of R&D talk to one another their new findings in science which they would like to explore and sometimes it is better for companies to do it alone, but sometimes you need to de-risk some fields like microbiome, for example, (…) pharmaceutical companies (…) like digitization, which for our sector is lacking severely behind. And then, they would agree that there are certain areas where we are completely sort of fresh and new and where we just…, you know, joining forces would help (…) and then to evolve everyone in their direction. These are the two ways, sort of bottom-up and top-down how companies join forces
		viii.	because of our open access we actually were able for forge a collaboration. Compounds moved from GSK to MIT, I provided the protein aspects of the project, characterized the protein and then I just sent the engineered protein to MIT as well. The project was complete and published in less than a year.		
		ix.	what they recognize is not just the fact that we're good at the science that we do, but we…, our program management, the way we do science and managing collaborations, they actually recognized the superior methods and our processes as well and they like it. So, in this particular case they give us funding		
		x.	they simply want to work with the best possible partners and I think – as I mentioned before – they recognize us not just for the science that we do, but the collaboration model that we use, and they see an advantage in working with us because of that.		
		xi.	there is a large investment in just management of it, certainly.		
		xii.	there has to be someone who's passionate about it or it's going to fall apart… who's willing to take the leap, you know, and push it through the tough (…), to manage		

			the fights that might come up between some different groups or labs or whatever else, to be able to have a vision just to sell… I mean, because…, I mean, even just thinking about the creation of this, you know, it may start with an idea between two people sitting at a table, but then you've got to go out and start selling it to all these other companies to get them to buy into. Someone's got to do that salesmanship.	xviii.	that why they've created the group of partners in research where we, as an organization, invited all of our pharmaceutical companies to join us to enable these discussions to actually fight, you know, like [meat busters?], that's what we do. And that's one of the ways to address these misconceptions.
		xiii.	we work independently with each pharma partner so that the pharma partners don't work with each other, they all work with us. And because they all work with us on related projects, we build the expertise working with pharma A is actually used as well when we work with pharma B, C and D and E, etc.	xix.	we work on the base of coalition of the willing, so on individual projects, it is the coalition of the willing (…) create these front runners clubs, if you wish, and that would de-risk the field for the others.
		xiv.	one of the major advantages why they lack this kind of approach that the C.1 is taking. It's open access, it's precompetitive, it's a fair game for all the pharmas because we share our data for the pharmas and then it's (…) people of the pharma, people (…) then the race is on. Let the best pharma win the race, right? Once they know the (…) the molecule shows promise, then it's up to them to develop the perfect drug.	xx.	it's one of the strengths, I think, of the C.2 model because it has them really engaged and that's when this real exchange can take place and when they're going to really work together and learn from each other if they work side by side together.
		xv.	The challenge is to be able to…, first what you're going to choose to work on because you don't want to be…, since we…, we cannot really just pick one thing and just work on that, you have to be able to manage different projects and be able to make a call at the end what would be the most valuable to move forward	xxi.	take the example of the neurogenetic disease and especially the Alzheimer's, we know that all the pharmas continue to work on their side, but they say…, and at the end they concluded that first they have to work together. So, the question how may they work together?
				xxii.	the governing board decides on the overall strategy of what C.2 should be doing and my job is to implement that strategy with my team here in Brussels launching calls, evaluating projects, monitoring the implementation of those projects, communicating the value and the research outputs and keeping the whole thing together.

			basically and not waste time and resources on other projects.	xxiii.	about 50 people whose job is to facilitate collaborations between public and private partners and to make sure that the processes and that the scheme would be operated with a maximum operational excellence, but also that public and private partners have a platform to meet and to not only collaborate together, but also to redefine their agendas together. That's about the connectivity between public and private.
		xvi.	That's where we want to go, how do we get there? … to find short term deliverables [...] at least we're on our way and we create an IT framework that's easy, it's all open, right? If you have to do it in normal project, you'd spend literally half your time on the intellectual property.		
		xvii.	managing the scientific committee, managing the states representatives group, you know, so making sure that everything works, basically.	xxiv.	it's not to just let two or three companies to do that, but to do it for the entire sector. So, we are providing a platform to all companies that wish so and all companies are part of the C.2 ecosystem one way or another. We provide them a platform where they can meet and redefine what is precompetitive and what is not and where we can collaborate in order not to remove the competition (…) neither for the competition itself, not for science, but to just succeed together where we were failing separately before.
		xviii.	but it's only going to go so far and there's a need to think about where else we can go. And what the C.1 presented us with was a platform for us all to come together and to really be able to try to quickly evaluate a whole new space.		
		xix.	we are learning a lot in terms of how (…) the (…) process throughout the early stage to discovery program, it's quite very specific and it's something that we don't… it's not the way that people are trained to think in academia in terms of being cautious about the physical and chemical properties of molecules	xxv.	we have set up a series of strategic governing groups that are led by industry and they're usually either in domains of disease interest or they're in a kind of transversal horizontal domain – and I'll give you examples of what I mean there. And within those groups, that's where the companies can agree to start working on a particular topic. We facilitate those meetings, of course, and there are…, but it's led by the industry partners.
		xx.	there are a lot of opportunities to interact and learn from others.		

			xxvi.	It's self-assembly, so somebody will…, so take cancer, for example, Novartis was a big player in the cancer arena, globally, said: "We'll take the lead and who'd like to join us?".
			xxvii.	multidisciplinarity is the name and open innovation is the name of our game and what we're creating are really open innovation platforms where the complementarity is pretty obvious in terms of…, you know, what you need not only from the academic sectors. Of course, you need the biochemists and those statisticians and genome sequencers and biologists and all the rest of it, but you also need these people who can bring new ideas and concepts to the academic world and to the industry
			xxviii.	we're seeing quite a lot of ambitious projects coming and we're learning a lot now from the first projects, which are really finishing now and really having an impact, you know. We're learning a lot about what makes a project successful, you know, and the importance, for example, for having…, I know it sounds obvious, but the importance of having a very clear goal because when you have a massive five-year project with a huge budget and lots of partners, inevitably some things aren't going to go as planned
			xxix.	we have to be very transparent in how we do things and very open, very honest. Plus, purely from a technical point of view, we need to explain how we spent our money basically.

3. Results	3.1 Tools and methodologies	i. We're taking more a standard approach in the sense of we work on a lot of proteins, so we know which method works best for the majority of proteins. So, if someone were to join C.1, regardless of their previous credentials, we tell them: "You use these methods first because we've proven them". ii. I was on the receiving end of a lot of the products of the C.1, so, you know, they would produce these tool molecules and then it was partly my responsibility to take those and actually understand the biology and whether or not they could be useful to us iii. they wouldn't just create structures, they'd also create some tool molecules, and this make this really available to many and then anyone can use those IP free to generate new data. And I think that's really the power of it, it's not just that first level of information creation, but then enabling, you know, building tools that can be put out to community to then, you know, amplify that information creation. iv. leveraging the tools that came out of C.1, but then taking that same model and adopting it for himself. v. the general idea here is that we make this clinical probes, which really are tools, chemical tools and make them available to the community at large, so together, the pharmas and C.1 are developing these chemical tools (…) protein A, B, C, D and we make them available and then anybody, a lot of people, actually, use	i. we are not creating drugs, we are creating methodologies that would lead to creating drugs. So, actually we are working much closer with the patients, we are doing projects which aim at seeing how we can integrate patients in R&D processes much faster, much earlier. ii. we're under a lot of pressure all the time to show the impact of what we're doing. But as you know, timelines in drug development are not speedy and also the thing is we are not developing new drugs, we're developing tools to help in the development of new drugs

			these chemical probes to further interrogate the function of these protein A, B, C or D. And then, these people are publishing their work that are totally outside of C.1 and related to C.1 and related to pharma, so these people outside, once they have these used that we have made together	
		vi.	the pharmas can read what these people have published using our tools and this is informing them in terms of which of these proteins A, B, C or D is actually most promising candidate for the discovery and where they want to spend their next 500 million dollars	
		vii.	we have standard methods that we encourage new scientists joining us to use, so you standardize procedures whenever possible. And so, we reduced and eliminate the amount of time for everybody to optimize their scientific methods when they come here. So, I think we're more efficient that way. And if someone next to me has found a new method that works, I nearly try to emulate and see if I can make it work for my proteins.	
		viii.	the quality of the reports is really good, so it is typically possible to reproduce this ourselves, but nonetheless not everything works the first time. So, for us it's much easier than to call directional research at C.1 and say: "How exactly did you do (…)?"	
		ix.	they can reproduce our results. So, that's one of the key aspects, I think that C.1 brings to the table because usually if pharma goes to another academic lab,	

		they don't necessarily…, they have to take a leap of faith and trust the lab based on their publications x. We actually set to ourselves pretty high standards and we have internal checks and balances often to, you know, internal people to review data before we put it out, for example, our protein structures. We insist that are scientists make detailed materials and methods descriptions available so that anybody else can reproduce the data and that's part of the output, not just the protein structures xi. you can either try to increase your rate of success, which you cannot guarantee, or you increase the frequency of trials. So, in other words, we just try to do things faster, which we can guarantee.	
	3.3 Public domain data	i. they also know that as soon as we make progress, we share the data with them. ii. the riskiest part isn't the precompetitive part where it's very difficult to protect IP-wise, so why not first of all share it as soon as possible so other people can work from your knowledge and not repeat your mistakes and also, at the same time, you know, not duplicate each other's effort. Instead of five labs working on exactly the same thing, perhaps different approaches, trying to race each other, why not, you know, work on different things and get the real goal faster. So, I think open access can do that and I think we're seeing more and more believers. iii. the whole open source software movement is predicated on having an	vii. what was always unique about C.2 it was the fact that the companies are sharing data and collaborating with each other. And then, they are willing to share that and open that up to the public partners, you know, to the SMEs and whatever. But I think that's become more and more accepted because the landscape has changed. viii. we are making data and resources available to the wider scientific community. ix. we really encourage our projects to disseminate their results, to communicate on them. One rule under is any publication that a project (…) have to be open access, so we do really encourage our projects to, you know,

		infrastructure for people, for individual software developers to contribute to something like Linux in an organized way. So, that's important. But I think, you know, whereas we tend to take the approach of, well, ultimately, it's about sharing the data, so let's get it out there as soon as possible iv. we came together…, none of the companies individually were willing to do this, but together, collectively, we each took a small bit of that cost, put it into a pool and built this common resource that we all value, which is just really pushing out information. You know, again they're not pushing out drugs, they're not pushing out things that we compete over, it's just information that everyone gets to benefit from. v. I think that's the ultimate goal of any of these kinds of precompetitive consortium is just generate data that's useful to the community at large. vi. the precompetitive spaces are really any of those sorts of enabling datasets, enabling tools	make their results accessible as much as we can
4. Benefits	4.1 Accelerate discovery	i. We get cool science done, it's fun having an impact. Our guys get funding where they wouldn't by themselves, get the opportunity to not have to conform to normal science grants … even though we have milestones, they probably have more academic freedom than they would have is they were to write their own grants. ii. the amount of science we don't know is vast, there's so much room for people to work in it. And our model is good	i. it would avoid duplication, it would accelerate knowledge generation and translation because you always have the private sector there. ii. really key in terms of C.2, it's the impact that comes out and the direct relevance in terms of ability to translate the results into actual practice. iii. acceleration and leveraging additional knowledge to both de-risk, accelerate

		because it's faster, it's more efficient. That's the reason. It's not that open science is a philosophical position, it's actually a business position. It gets research out there faster and cheaper. iii. when it comes to parasitic diseases, there's no profit to be made, so yet literally hundreds of thousands of children are dying around the world as long as there's no drug or no effective drug. You know, with every year of slow progress we're allowing more people to die iv. my original mandate was to help speed up the science, help come up (…) platform to do the scientific experiments faster. So, you may not succeed more often, you may fail and succeed at the same rate, you may have the same success rate, but you do it much more often, so as a result you succeed and fail faster, and you get your real discovery faster as well. v. my colleagues here, they work on human diseases, you know like cancer, inflammation and so forth with pharmaceutical partners that have programs in place. Assuming progress continues, those programs will go from beginning to end, so those pharmaceutical companies can actually take a program from target validation all the way to clinical trials and so forth. With the diseases that I work on, pharmaceutical companies only go so far, so we need someone to actually manage the process of: "OK, you have a target validated, you've got a drug lead and now let's do	and cut costs are where the value for the industry iv. acceleration of processes, avoiding late failure, standard setting and leveraging knowledge of others. So, joining forces and sharing knowledge, data and experience because this is where you don't need to redo certain things v. carrying out a research for the development of new medicine is very costly, its length, it's a very long, long process, it's risky and also because there were less and less (…) available, so it was necessary to really mobilized resources together and making sure that we are doing a good use, a right use of all these resources. vi. we do great science, but we're not always very good at transforming the science in, you know, innovation

		all the preclinical experiments and then clinical trials and so forth". vi. that is one of the really core skillsets of the C.1 and one of their core competences is this idea that they can do structural biology that they can drive novel chemistry and novel target space. vii. if we put high quality molecules out into the academic space without restriction, academia will do that work for us. And so, instead of spending, you know, our own money and years of our own time trying to understand what this protein does, and this protein does, we come together, (…) these two molecules, make them freely available, get them in 20 different labs, let people start publishing on tell us whether or not this is a (…) viii. it's not that they couldn't do it on their own, it's the idea that they can do it faster and cheaper doing it together. And probably more complete ix. it's to be able to tap into resources that are already existing somewhere else that [are inside?], that you don't have to build them up, that you can do it immediately. And again, you know, if this is isn't going to directly lead to a drug, going to directly lead to IP, if someone else if willing to help pay for it, why not accept some of their money to do it as opposed to shouldering the burden all by yourself.	
	4.2 Expand open innovation	i. for the pharma, the motivation for openness was to allow them to have freedom to operate because there were, at the time, other companies starting up…, smaller companies starting up who had	i. the strength is that by creating this more and more, by multiplying these collaborative (…), so now the partners they're less reluctant in being involved in C.2

		business models of solving 3D structures, patenting them and them keeping them as, you know, proprietary and, you know, you would have to pay then to use it. So, companies wanted to have public domain data that allowed them freedom to operate. ii. the future will be evermore collaborative, which is good news for PPPs, for the C.1 and especially the…, I mean the PPPs will do a good job, know how to handle that, it's a rather not so easy interface. iii. I'm also looking to be able to benefit from the open nature of C.1. iv. it's just a great benefit of this kind of organization is that all the stuff they do is available to the community at large, so we don't have to be a member to benefit. v. the open model provides the opportunity for us not to have to make that investment. vi. by collaborating, partnering with experts in the field of (…) biology, stem cell biology as well, we can actually make a difference that way vii. being part of the scientific network. viii. They really like [the] network aspect simply because the transaction cost between a company and a university is enormous. [...] if you're a scientist inside Apple and you really want to interact with the university system, you can't and it's really frustrating as scientists not to be able to do that. ix. being one of the partners of the Gates Foundation, now we have access to partners that previously…, never mind that we didn't have access to them, we	ii. one of the big achievements of C.2 (1) was actually showing that the companies could work together and when we've got remembered in 2006 and 2007 when this has been discussed, there were lots of people who thought it wouldn't be possible for the companies to act pre-competitively. So, there was a lot of skepticism, but I think we've shown in the program that it is possible for the companies to work together and in a precompetitive way, so I think that's a big plus. iii. as you follow the topics and as you follow then the ground preparation and then you follow the projects, and in the vast majority of cases you see the confidence and the trust built between the different partners and you suddenly…, you know, academics suddenly realize: "Oh…"…, or SMEs suddenly realize: "Oh, companies are not going to steal all of my ideas, they actually…, it is a true collaboration". iv. the big values is that we help different actors build confidence in each other to work together to address some of these difficult questions v. one thing that they noticed was in terms of the practicality to sharing and working together the top people in the pharma companies were convinced, the scientists, you know, doing the work were convinced of the value of working together, but, you know, it took some time to convince the lawyers and some of the middle management that they

		didn't even know about them. So, it's made things easier for us as well. x. you've got this huge network of individuals all generating information, data around your favorite target or your area of interest. And so, you've really amplified with very little additional investment the potential return xi. "We would love C.1 to work on target XYZ or this project, but we can't because we want to keep it closed, so this is a compromise that we have to do many times because in theory it would be great to use C.1 as a resource and ask C.1 to do things for reasons that we don't have the scale as well as they have or they have more resources and we don't have it.	should be working together and sharing, you know, proprietary information vi. you need people who see the bigger picture, the long-term vision and the long-term benefits for them and for the, you know, for science as a whole and innovation as a whole. So, there was skepticism, but as it worked they saw: "OK, this is worth doing".
	4.3 Influence research agenda	i. They get to steer the direction in which we go, so the board members like that. But, actually, you know, they rely on us to select the area […] f we get those three ideas, they'll say: "I like idea number 2". But they don't come up with the new ideas. Very rarely do they come up the new ideas. ii. by being a member of the board, we have a direct influence in what the C.1's actually doing or not doing. That's one very direct influence. And the other is to know people is much better than just reading the literature, you know, and only just wait iii. they're pushing, and they try to see what makes sense in order to draw that line, which is a line in the sand and, you know, it's moving. So, it's not so much direct	i. we, C.2, have to be working on these priority medicines. And so, that's the first value for the public. The private sector then has to agree to, you know, work together, share and all the rest of it and then, when we launch the call, the public winner of the competitive piece, they sit down and co-create the public-private consortium that has the framework of whatever the topic was that was chosen in the first place. ii. It's actually up to the companies to define where they're willing to work and collaborate. i. we probably need to do fewer things, but in a more focused way because I think we can… You know, when you have a program, people get very excited and they want to do different things, but

		influence than rather one of co-creation of this line in the sand and seeing what is (…) and being challenged also. iv. all members including public partners who are funders and private partners, they have to agree on research programs, and so the board can say: "No, C.1, you're not going to do that". And the board also determines the calls. Of course, they're always…, again, it's a discussion who's made by the C.1 themselves, but then the approval comes from the board members.	I think maybe actually we might need to do a bit less, but in a more focused way and I think that way we could drive bigger impacts ii. I think that first we need to be more focused because we have very broad research agenda, and this creates some distractions.
5. Challenges	5.1 Trust and mindset	i. a tougher time convincing people that open innovation is a good business move. The companies, some people in companies get it, governments still think that the way to value is by keeping things secret ii. specific individuals who are not comfortable with the open access model, but I would say the ironic part is we see fewer of those… we see fewer people who disagree with that approach in the industry than we see in academia iii. academics are very protective of when they publish. Whereas if you work with us, as soon as we get the data, we want to make it publicly available. And they feel that by releasing data early somebody could scoop them on a publication. iv. just think twice before making a statement and so, while I'm more excited about sharing our work, our ideas and… that's one thing in terms of mindset. So, yes, I think they are not…, they are more careful, I guess, in terms of what can be disclosed and what can not be disclosed.	i. everybody who gets involved in an C.2 project recognizes the value in that dialog and that exchange because it is a common challenge, usually it is a challenge that industry faces, but it's a challenge for the research community or if you [broaden it out?] to the drug development community or, in fact, patients and healthcare providers. And everybody comes into a project with that mindset about how to work together in order to address this challenge. ii. the first thing is…, I mean before even the technicalities is the willingness to work together. And I mean there are probably a lot people here who were really around C.2 when it started, (…). I mean there was a realization in the pharmaceutical industry of all of the low (…) had gone, so, you know, it was becoming harder and harder to develop new drugs. There are disease areas where there's still nothing, I mean things like Alzheimer's and other disorders, even diabetes, I mean people

		v. counterproductive to be protecting your work, you want to share it as much as possible to generate as much as..., commission as possible around this work and learn from what…, and get people to follow up on this, to learn from that vi. more and more people are embracing the open model. Pharma do, pharma is quite keen on open models vii. academics are not always the most trusting people. They sometimes worry that some collaborators, you know, will discover something cool and not share it viii. we scientists in C.1 wouldn't mind, you know, being able to talk freely, but some of the companies, not all, but some don't want to reveal their interests in certain targets to their competitors. They view that as somehow competitive information. So, it's really a matter of where a given company draws the line for pre-competitiveness.	are still being injected with insulin, we can't cure it iii. at the very beginning of C.2 (…) huge amount of skepticism, you know, because like you say the companies weren't used to talking to each other, they weren't used to talking to academics, academics weren't used to talking to big pharma in this way. So, I think there was quite a lot of uncertainty iv. one lady who was in one or our very first projects, she said…, you know, she was not allowed to talk to people from other companies and then all of a sudden, they were working together, talking together and, you know, sharing things. So, you know, it's been quite a culture change.
	5.2 Facilitating collaboration	i. weaknesses are more from an organizational point of view. When you have a consortium that has many members, it's difficult for any one member to have ownership. ii. there will always be miscommunication at times in any kind of large thing and so managing the potential miscommunications that you have when you have any large organization and different personality types, a lot of people are actually introverted, so they don't communicate a lot.	i. It's tricky. Like I said, there is…, we do have a lots of checks and balances, so I mean like I said right from the top the fact that the budget coming from the public and private sides is equal, our governing board is 50/50, we have the scientific committee, we have the states representatives group, I mean all of that kind of keeps us on an even key. And I mean just generally there's public scrutiny. ii. this is an institutional public-private partnership and we need to make it

		iii. lot of attention is spent to how things are communicated, putting out fires when someone think someone is not doing something right, you know, that they're keeping something secret. iv. It's easier internally, but when you have lots of partners, you know, some get pissed off at the slightest thing, you know, and some people don't ever get pissed off and sometimes, you know, we could blow up, so we spend a lot of time, you know. And luckily, people tell us, you know: "I'm having a problem with this" and then you sort it out. v. it's just our own internal barriers, you know, process that we have to get through vi. the big challenge in a precompetitive consortium, especially whenever you have a large number of academic labs at different universities, is bringing that together and coordinating that effort because, I mean the individual academic lab, each one of those essentially functions as its own small business. There isn't a hierarchy, there isn't a structure that connects each of these different groups and they each have their own priorities and then own needs as far as… I mean I think the companies…, you know, bringing companies together, we're all driven largely by the same objectives and the fact that we're signing on precompetitive consortium, we generally all have agreed to what we want, but the academic labs they can vary greatly and I think holding those folks together and creating a singular vision for them that	more business practice friendly. At the moment, it's very bureaucratic because it is under institutional rules of the European Commission, so I think we just need to have more flexibility to enable completely new ways of working. iii. the different stakeholders that are needed and just come together in a C.2 project are not used to work together. They speak different languages, they have different mindsets, different priorities, a different agenda and it's difficult to let that go and be open minded and listen and maybe change their thinking. And so, trust that there are other ways. So, that's really the challenge, to create that and this is what C.2 is trying to do, facilitate this and it's very much about understanding better what the issues are, what the challenges are from the others and being open minded and being ready to engage into this different way of approaching the problem. So, that's the beauty, I mean that's what the strength of the C.2 model iv. There are particular challenges because one of the first things that we really have to do is we have to build confidence in the different actors because they might recognize the challenge, but sometimes they're a bit scared about working with everybody. v. Trust. We are working together for a very long time, it has been a process. vi. trust was built gradually. Learning from other sectors as well, looking at where

		actually keeps them together can be particularly challenging. vii. convincing everyone to set aside some of those personal motivations while doing something that really is a collective effort, I think that can be the more challenging part. viii. The key is just communication and being able to make sure that everyone is on the same page. ix. at our board meetings there's often (…) and decisions are made around issues of protecting the C.1's reputation because it does have a good reputation for scientific (…). And, you know, sometimes projects or collaborations are turned down because (…) not be…, there is worry that the science maybe isn't at the right level, and so it could be damaging to the C.1's reputation	other sectors are failing to join forces and just building trust and having a very stable environment as an organization with a stable team that provides constant, continued support. So, it also hangs on having people who would be dedicated specifically. We're not doing that ad hoc, but whose job is to build that platform on a continued basis. vii. one is creating trust, setting trust and a common language between the different stakeholders because even if they work exactly in (…) all do not speak necessarily the same language, they do not trust each other. viii. I would say that one of the biggest challenges was and still is creating this trust between the different stakeholders and really creating a space for collaboration. For me, this is the main aspect. I would say that's the strengths of C.2 because so far we succeeded well, but it's not easy ix. we have seen is an evolution in their understanding of precompetitive space. And different companies have different ideas of what precompetitive means. x. for me, I think it is an area where actually you can collaborate, and you can all get benefits from the results that come out.