Decision-making of blockchain development in consortia

By

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Dutch Blockchain Coalition
connect and create

TU Delft

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Abstract

Blockchain consortia uphold value-addition through collaboration between organizations, by exploring, prototyping and innovating together. Blockchain technology presented itself as a new solution to the sharing of data proofs since 2008, with certain components such as smart contracts and privacy-enhancing components currently at different maturity levels. Blockchain consortia do not only navigate these technical factors, but also non-technical factors of decision-criteria are employed, and if development of a blockchain-based application fails, alternative technologies are explored. With the main research question 'w*hich guidelines can aid consortium managers in their decision-making process of developing blockchain-based applications?'*, this study had the goal of contributing guidelines of decision-making processes, for aiding in the development of blockchain-applications in a rigorous manner. In order to tackle this problem, this research project performed case studies.

This study makes use of a combined analytical framework, by merging the Resource-based View and Consortium Capabilities frameworks, the latter being a blockchain-specific framework. A multiple-case study approach is followed, by which four most-different cases of Dutch blockchain consortia are analysed. This is done by firstly scoping the consortium with desk research, followed by interviewing consortium managers, with interview questions based on the combined analytical framework. Thereafter, a hybrid coding approach, and thematic analysis are applied to investigate the challenges, potential benefits and risks in the decision-making process. The inductive part of the hybrid coding approach is the exploration of groups and factors of the deductively identified challenges, potential benefits and risks, which led to the creation of the Blockchain Consortia Guidelines, that presents guidelines on the inductively identified factors: *Knowledge Transfer, Technology and use-case, Security, Funding and Economic Considerations, Organization and Vision*. The guidelines were validated by interviewing managers of two additional blockchain cases, yielding a high level of recognition of the guidelines provided. Adaptation of certain guidelines was necessary, and implemented with the critique provided from partial recognition and non-recognition of guideline elements. This increased the external validity of the observed factors and decision-making guidelines. The scientific contribution of this research lies in providing top-level factors, the corresponding groups on the middle level, and guidelines on the bottom-level. The resulting factors and groups when compared to the existing literature (Consortium Capabilities framework), show that *Knowledge Transfer, Funding and Economic Considerations,* and *Organizational*, are additional aspects on the factor level that are given insufficient attention in the Consortium Capabilities framework.

A limitation is that the interview data did not allow for yielding a (blockchain consortia-oriented) process-based framework as a final deliverable due to insufficient relationships between decision-making and factors in the combined analytical framework. Nonetheless, the rich qualitative data

allowed for practical guidelines to be developed. Another limitation is a skew in the data towards potential benefits mentioned by managers, which is an indication that a self-serving bias, social-desirability bias, or a combination of these is present. Addressing these limitations is proposed when undertaking future research. A possible future quantitative study could be an analysis on survey data, gathered from a large sample size in terms of the number of blockchain consortium managers, to aid in recognition of the guidelines, and thus validate the factors, groups and individual guidelines.

Contents

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1 Introduction

This chapter will introduce the topic by providing background information, followed by a problem exploration, explained in both societal and scientific settings, in which the underlying motivation for this research will be discussed. The scientific relevance sub-chapter entails the literature review performed in order to identify the knowledge gaps.

1.1 Background information

With the emergence of blockchain technology in the 21st century, the application of the technology towards replacement of certain current business processes has come into question. A blockchain is an immutable ledger which is used to transact information over nodes on a network of computers in a distributed manner. Blockchain technology was first pioneered by Satoshi Nakamoto in 2008 with the creation of Bitcoin, a decentralized system for digital transactions of cash (Nakamoto, 2008). This system is operated by nodes which are run on computers, which solve a complex mathematical problem in order to generate a 'block', which consists of a record of transactions between individuals (Sarmah, 2018). Proof-of-Work is the term used to describe the first blockchain consensus mechanism developed, of proving to other parties that computational power has been used to solve the aforementioned complex mathematical problem (Gervais et al., 2016), and thereby enabling consensus in generating the block. Other examples of types of consensus mechanisms that have been developed since, are Proof-of-Stake and Proof-of-Authority. A new block is added to the previous block in order to form the blockchain, resulting in a type of ledger of information. Important to note is the difference between blockchain and distributed ledger technology (DLT). Blockchain is a subcategory of DLT (Agmon and Kallir, 2022), however, DLT is a distributed database in the form of a ledger, managed by multiple people without necessarily using the aforementioned system of blocks. Studies have shown an increasing number of solutions that blockchain-based applications offer (Dib et al., 2018), in both an inter- and intra-organizational setting. A data-sharing solution is simply defined by a digital system that enables the sharing of data between multiple parties. Some of the applications of blockchain include data traceability, process automation, supply chain management and governance for numerous industries such as finance, energy, healthcare and logistics, however challenges of development and implementation present themselves with these new innovations. Organizations often initiate or join existing consortia as an exploration approach for innovations (Crupi et al., 2020). A systems approach towards innovation dictates that adoption of new innovations often depends on the embracing of new organisational practices (Ortt & Smits, 2006), which inherently means that new decision-making processes must be established for consortia which have an ambition to develop and adopt blockchain-based applications. This therefore also counts for organizations that desire to develop blockchain-based applications.

Decision-making is defined as the process that an individual or multiple actors undertake in order to make choices regarding a decision, supported by the gathering of information and assessment of alternative options. The importance in addressing decision-making lies in the new decision-making processes that are developed with the adoption innovation. Prospect Theory is the foundation of modern decision-making, which highlights three psychological biases that individuals experience when making decisions which involve risk and uncertainty (Kahneman & Tversky, 1979). The first bias, *certainty*, highlights that individuals tend to overweight options that are certain and risk averse for gains. Secondly, the *isolation effect* bias occurs in decision-making when individuals focus on differences between the available options. Thirdly, the *loss aversion* bias emphasizes individuals' psychological preference towards loss minimization when compared to the emotional feeling of acquiring gains. However, Prospect Theory is not used in this research. The applicability of Prospect Theory to this thesis is not appropriate due to the fact that it was developed for individuals, rather than group formations such as consortia, which have social complexities and hierarchical decision-making structures, which calls for investigation into decision-making in a consortium structure.

This research project is conducted in close collaboration with the Dutch Blockchain Coalition (DBC), a cooperative association that enables research and develops use cases for blockchain in the Netherlands. The mission of the DBC has the goal of increasing decentralisation of digital infrastructure and accompanying partners through the development of use-cases. Partners of the DBC cover all three categories of the triple helix model of innovation, namely educational institutions, private companies and public organizations. In the coalition, not all of the partners participate in every blockchain-application initiative. Therefore, sub-groups of partners actively conducting projects together are named consortia. Often, the final implementations of working products, go beyond the DBC. During exploration of blockchain technology, DBC has observed certain consortia as a whole, and individual consortium partners having difficulty in developing blockchain-based applications on the project-level. These blockchain projects by consortia can be observed in its entirety in order to form a case, which can be studied in order to learn from them and apply this knowledge for future projects. As decision-moments are a key aspect that set the course of a project, the importance of researching decision-making processes for the DBC is highlighted. Therefore, this study analyses innovation on the project-level. Another important distinction to be made is the difference between a blockchain consortium and consortium blockchain. While a blockchain consortium is defined as a cluster of organisations collaborating on an initiative to develop a blockchain or a blockchain application to be used between organisations, a consortium blockchain is a type of operational blockchain which organisations with consortium membership utilize in full effect. Both past and current blockchain projects conducted by the DBC and its partners, and Dutch blockchain projects outside of the DBC and its partners will serve as case studies for this thesis.

1.2 Societal relevance

Trust between organisations, such as businesses, government agencies and educational institutions is a challenge due to the transfer of value or transactions of confidential data, which may spread outside of the intended environment. Public blockchains typically employ 'transaction finality', meaning that an initiated transaction cannot be undone. The business sector on the internet is in need of technologies which adds trust in relationships between businesses (Trim and Lee, 2019), and blockchain developments may aid in this, but little is known about the trust-enabling dimension of blockchain, due to the relatively short history and awareness of blockchain. In addition, blockchain can enable the elimination of intermediaries, which could signify a substantial cost saving for most businesses. The automation element of a blockchain may reduce the chance of human error. Furthermore, smart contracts have particular relevance in business operations. Smart contracts are programmed actions between two or more actors on a blockchain which execute once a set of pre-defined conditions have been met (Zheng et al., 2020). Smart contracts generally do not have legal significance (Rikken et al., 2023), but they can still be important for business environments, as they can reduce the need for labour in preparing and executing a simple and redundant transfer on a blockchain, which will save costs for an organization as labour is more expensive in this regard. With this variety of potential improvements of different business functions, the DBC wants to conduct research into how decision-making processes for blockchain-based applications are conducted, in order to improve future decision-making processes. This means that these businesses will have a clearer path forward concerning improvement of organisational functions. In this thesis project, two conditions of the scope are that the consortium has been founded and that said consortium has passed or is at the stage where blockchain is being explored, with the goal to base certain applications. Therefore, for this investigation, the act of a former or ongoing exploration phase for blockchain by the consortium is necessary to enter the decision-making process.

The broader significance of this research lies in investigating the use of blockchain-based applications used between organisations, which will aid consortia that the DBC engages with, and other consortia, to consider certain factors in the decision-making process for fostering success of the initiative. Managerial departments can make use of guidelines for decision-making, to successfully develop interorganizational blockchain-based applications, and this is the focus of this thesis.

1.3 Blockchain architectures

Organisations initiating a blockchain in a consortium format must make a decision on the type of blockchain architecture that they wish to develop and deploy. This section lays the foundation of different types of blockchain architectures on which blockchain applications can be based on. As the organisation of authority and level of centralisation are the variables for categorising the configuration type, arguments are presented with strengths and limitations for each type of blockchain architecture.

Blockchain has distinctive layers, such as the hardware, infrastructure, and application layers. The difference between the infrastructure layer and application layer in blockchain is vital. Whereas the infrastructure layer encompasses blockchain elements such as the hardware and network type, the application layer encompasses business, management and organisational related functionalities (Ullah & Al-Turjman, 2023). Nevertheless, these two layers are interconnected, as the dynamics of the application layer depend on the capabilities of the infrastructure layer. The application layer functionalities include smart contracts, application programming interfaces, user interfaces, frameworks and decentralized applications. In addition to this, a blockchain between organisations and/or individuals can be programmed in different configurations as seen in Figure 1 by Scheid et al. (2021). Important to note is that blockchain categorization can be characterized on two axes, the degree of openness, ranging from public to private, and the degree of permission, from permissionless to permissioned. This is important when considering the authority and interactions between blockchain participants. It is of importance to note that private blockchain governance is always permissioned, meaning that only pre-prescribed actors can interact with it, making it more centralized than the other two configurations. By collaboration between parties, consortia can enhance value creation through two processes, namely learning and social capital benefits (Xia et al., 2012). Whether these two benefits translate into a consortium blockchain and its applications, and how this can be implemented is of particular interest for the organisational setting of this investigation. A factor that helps in ensuring security, is that a single organisation in the consortium blockchain can be prevented from harming the interests of others (Xie et al., 2018).

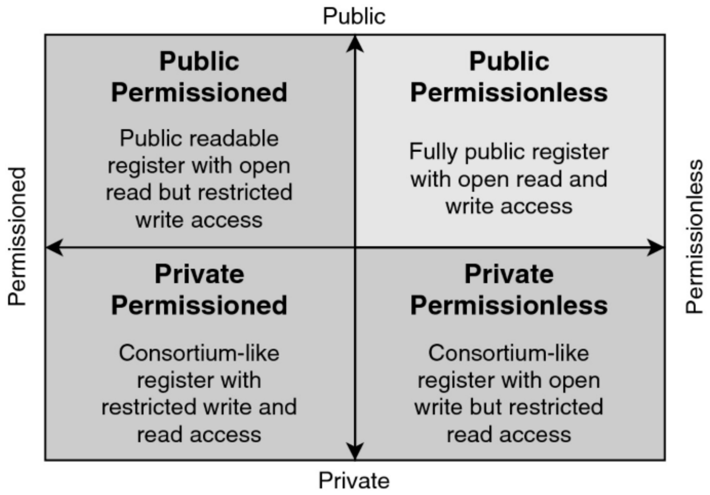

Figure 1. Blockchain deployment types. Copied from Scheid et al (2021, p. 300).

1.4 Search and selection procedure

To create an overview of challenges that arise when developing a blockchain in a consortium setting, a literature review was necessary. A Preferred Reporting Items of Systematic reviews and Meta-Analyses (PRISMA) approach is used to search, screen, and select the literature that is available on blockchain-based applications. Figure 2 shows the flow diagram in PRISMA format for the final selection of literature that will be discussed to showcase the scientific relevance (section 1.5). It includes four phases for structuring the search and selection process: identification, screening, eligibility and inclusion. For the literature review within the scientific relevance section, literature was investigated using the academic database Scopus. The literature search was started by using key words of interest with the corresponding 'AND' and 'OR' Boolean operators for refining the search. The string of key words used was: "blockchain" AND ("consortium" OR "consortia") AND ("decision-making" OR "decision making"), which lead to 50 results. The outcome of this was a very broad list of articles ranging over numerous industries such as supply chain management, healthcare, data storage and energy. However, this literature search result had an excess of papers which were too technical, referring exclusively to software programming or heavily intertwined blockchain to other technological fields such as artificial intelligence and machine learning. Therefore, the subject filters were restricted to only business, management, accounting, decision sciences and social sciences, with all document types being taken into account, which led to 16 results. Sources after 2008 were taken into account, as this was the year in which blockchain was first pioneered.

Several papers exclusively focussed on the infrastructure layer of a blockchain. This field orients itself more towards computer scientists, as the infrastructure layer evolves around the hardware and network of devices that cryptographically send information between nodes. The application layer is the layer that explicitly presents management, organisational and business related opportunities, which is part of the scope of this study. After reading the abstract and the key words listed in the articles, the most meaningful and appropriate articles were selected. Methodologies and discussions were read in order to assess robustness. In the end, after refinement of the searching process, 11 documents constituted the core of the literature review, whereas five documents were selected for supporting definitions. The iterative selection process across several academic databases proved valuable in identifying additional relevant sources for the review, as the PRISMA approach contributed to four articles, but more literature aided in providing a comprehensive assessment of scientific relevance.

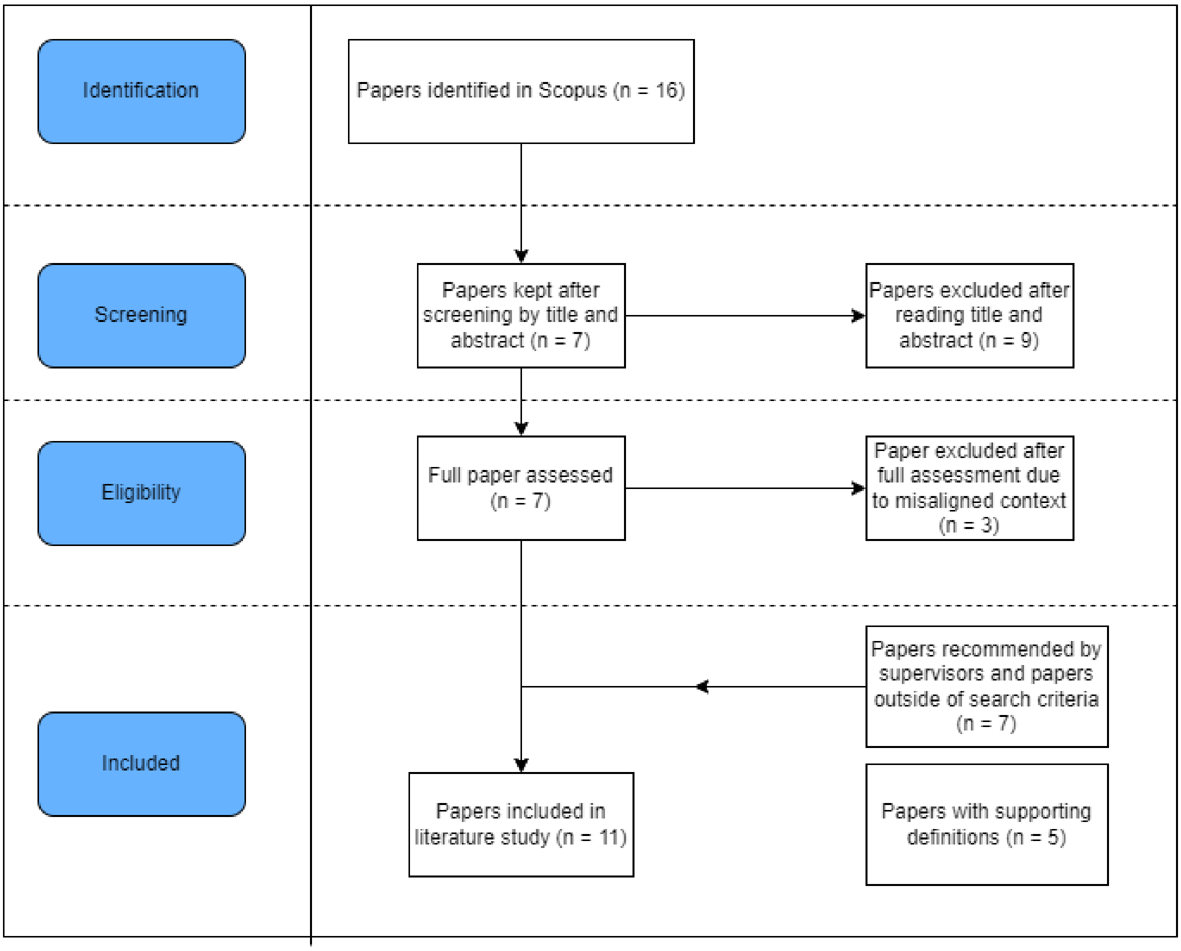

Figure 2: Literature search and selection

1.5 Scientific relevance

The scientific relevance to the problem is discussed in this section. Firstly, the literature overview is presented in Table 1. Then, it is shown how challenges can be differentiated between technical and non-technical challenges. This section highlights the challenge of organization, cognitive challenge and challenge of commercialization as non-technical challenges. For the subsection 1.5.2, the connection between technical and non-technical aspects is made towards the challenge of blockchain architecture.

Lastly, the conclusions are drawn from the literature reviewed, and the key emerging knowledge gaps are highlighted.

Table 1: Literature overview

Author(s)	Title	Publication type	Discovery
Dozier & Montgomery.	Banking on Blockchain: An Evaluation of Innovation Decision Making	Journal article	PRISMA
Wolf et al.	An analysis of blockchain versus relational databases for digitalising information flows in global supply chains using the analytic network process	Journal article	PRISMA
Weisheng et al.	Blockchain Technology for Projects: A Multicriteria Decision Matrix	Journal article	PRISMA
Rao et al.	On the quest for supply chain transparency through Blockchain: Lessons learned from two serialized data projects	Journal article	PRISMA
Ghosh et al.	Leveraging Public-Private Blockchain Interoperability for Closed Consortium Interfacing	Conference paper	Exploratory searching
Edirisinghe Vincent & Barkhi	Evaluating Blockchain Using COSO	Journal article	Exploratory searching
Lanzini et al.	Blockchain adoption factors for SMEs in supply chain management	Journal article	Recommended by supervisor
Smith & Castonguay	Blockchain and accounting governance: Emerging issues and considerations for accounting and assurance professionals	Journal article	Exploratory searching
Dib et al.	Consortium Blockchains: Overview, Applications and Challenges	Journal article	Exploratory searching
Chen et al.	Facilitating interorganizational trust in strategic alliances by leveraging blockchain-based systems: Case studies of two eastern banks	Journal article	Exploratory searching
Kouhizadeh et al.	Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers	Journal article	Exploratory searching

1.5.1 Challenge in organization

The challenge of organizing blockchain within an organization is present at both the inter-organizational and intra-organizational level. For example, a problem often found in supply chain transparency is that holistic data sharing across a supply chain is most often centrally controlled by the largest firm in a supply chain, which provides concerns with regard to ownership, privacy and data protection, as the failure is consolidated to a single party (Rao et al., 2021). With the introduction of blockchain-based applications in supply chain management, this data sharing can be distributed among all partners via nodes in order to decrease this risk. In addition, overarching transparency goals can be achieved, as a product can be tracked from the supplier till the end consumer in order to verify the legality, taxation and legitimacy of the product (Underwood, 2016). However, the theoretical study by Rao et al. (2021) highlights the need for establishing "common languages" between supply chain partners when integrating a blockchain solution for operations, which adds complexity to blockchain development for a business. Consultancy firm PwC (2019) recommends collaboration between regulators, management and auditors to address the phenomenon of how the enhanced transparency (in supply chains for example) can potentially equalize power in both an intra- and inter-organisational setting. This benefit was also noted by Ghosh et al. (2021), but they explicitly noticed the formation of a purely horizontal organisational structure. They concretely state that consortia which are formed from various authoritative domains such as companies and governments can greatly benefit from blockchain technology as it enables a purely horizontal organisational structure, because the need for trust placement in a centralized mediator is eliminated (Ghosh et al., 2021).

Edirisinghe Vincent and Barkhi (2021) observe that the party with the greatest stake in the blockchain consortium will likely be the drafter of smart contracts, which is then followed-up by the agreement or disagreement by the other consortium partners, regarding the terms of the automation features provided by the smart contract. This need not always be the largest business in the consortium. To this effect, large firms have less motivation when placed in consortium setting (Xia et al., 2012) and may therefore not be the de facto optimal blockchain consortium initiator. This raises the question of who should provide governance designs, who should disclose the risks and who should be responsible for designing and executing internal controls over the smart contracts and overall blockchain (Smith and Castonguay 2020). Edirisinghe Vincent and Barkhi (2021) recommend that businesses must consider on a case by case basis whether the governance of the company and the blockchain should be addressed separately, with clear definitions in place. This demonstrates that no coherent organizational framework exists for the division of roles in a blockchain consortium.

Dozier and Montgomery (2020) performed a study on a group of organizations within the financial services industry. The authors developed the Proof-of-Value (POV) model for decision-making. However, financial services is only one industry evaluating blockchain technology, while there are many other industries also evaluating this technology. The model nuances (of the financial services industry) involved limited the generalizability of the model towards other industries, as they have different characteristics. (Dozier & Montgomery, 2020). As decision-making is a subset of organization, this highlights the challenges still experienced in organizing cross-industry models for blockchain-based applications.

Lanzini et al. (2021) conducted a survey-based study to explore the factors that influence blockchain adoption in a consortium setting for small and medium-sized enterprises (SMEs) involved in supply chain management. The study used the elements of TOE, based on technology, organizational and environmental factors, to analyse the critical innovation adoption challenges of SMEs. Based on a TOE framework, which is shown in Figure 3, the usage of the Best-Worst method showed that the organizational category played the major role in the hesitation of adoption of blockchain-based applications. The Best-Worst Method uses ratios of the relative importance of criteria, based on the assessment done by decision-makers. Managers must be supported by being informed on blockchain organizational benefits (Lanzini et al., 2021). Within the organizational category of the framework, the 'process readiness' and 'people's readiness' were shown to be the main contributing factors, demonstrating the importance of human perception towards emerging and complex technologies. However, this study was based on only 20 responses from managers, therefore more research is necessary in order to rigidly determine the trend. A common development of rapidly and newly emerging applications for an innovation such as blockchain, is that the factors within the TOE framework may change.

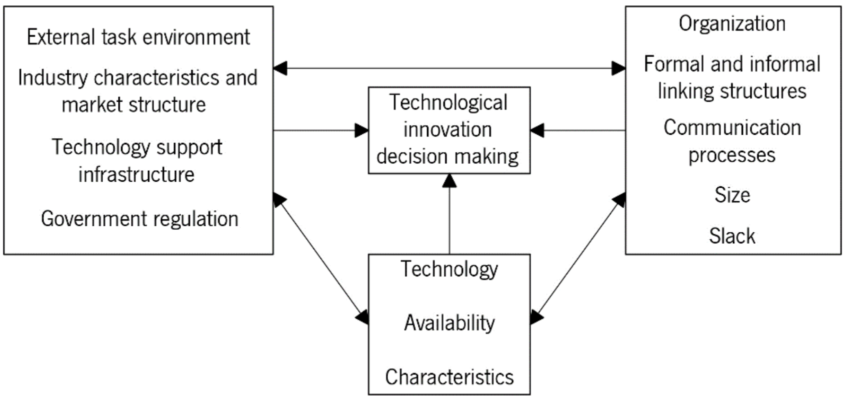

Figure 3. TOE Framework, from DePietro et al. (1990).

1.5.2 Blockchain architecture challenge

In a consortium blockchain setting, challenges were identified by Xie et al. (2018). Firstly, it is identified that there is a need for rapid upgrades of node systems when updates are necessary for the consortium blockchain. This may burden SMEs further, as the technology is not yet mature and needs intensive knowledge building on servicing nodes. In order to mitigate this, Xie et al. (2018) recommend a service-friendly system to enable low-cost upgrading. However, this is also mitigated by the possibility of SMEs joining as application users, or instead of as a node runner. Nonetheless, this does not account for the challenge of the associated extensive financial burden on non-technical costs, such as use-case and application development sprints, consortium membership costs, resource costs, administrative overheads and opportunity cost for SMEs.

Private permissioned blockchains limit their applicability solely to private consortia, as data is not communicated outside of the network. This limits the connectivity to service providers who wish to use their established business network deliver to consumers (Ghosh et al., 2021). For this challenge, Ghosh et al. (2021) suggest interoperability between two separate blockchains, a private and public variation. However, this creates added complexity and risks errors that software engineers and managers may commit when handling multiple blockchains.

1.5.3 Cognitive challenge

As stated by Smith and Castonguay (2020), the cognitive challenge in the technology is in organisations wanting to change to blockchain technology to automate corporate governance and internal control assessment, but lack the ability to transform their mindset from a single company to a collaborative commerce setting. This highlights the need for research into factors that play a role in interactions between individuals in consortiums when adopting blockchain. Managers that utilize a consortium blockchain are challenged with the system boundaries of smart contract elements built on the blockchain, as their organisation is not the sole verifier of transactions (Edirisinghe Vincent and Barkhi, 2021), again pertaining cognitive barrier in collaboration for this technology. As smart contracts automize the enforcement of the terms in a predefined program, they enhance security and minimize transaction costs associated with manual interaction of a blockchain, which is an appealing construct to managers who wish to optimize business practices with partners.

A cognitive connection can be drawn to the technology, which is made clear and explained later after introducing the blockchain component of privacy enhancing techniques. A multitude of privacy-enhancing cryptographic techniques may yield the desired privacy level for organisations in a consortium setting (Dib et al., 2018). However, this comes at the expense of increased computational time and Dib et al. (2018) interestingly note that the developments of using a multitude of privacy-enhancing cryptographic techniques on public blockchains will likely be a source of innovation and development in terms of privacy for improving enterprise blockchains. This key observation by blockchain software engineers demonstrates the importance of patterns of collaboration and communication between blockchain software engineers and managers on the topic of security. This is because managers make a decision and trade-off between the desired level of privacy and transaction speed, depending on the application type. Chen et al. (2023) acknowledge the importance for organizations to fully comprehend the technical features and affordance of blockchain in specific contexts before utilizing the technology. Managerial changes are also needed in the process of blockchain development (Chen et al., 2023).

The study by Chen et al. (2023) identifies that developing blockchain into an organization has the added benefit that the mechanism builds a heuristic image around the organization due to the organization's willingness and open commitment to be reliable and trustworthy. However, the study is only based on two banks and their respective blockchain networks, which does not give external validity. In addition, the study acknowledges that "knowledge gaps still exist with respect to how organizations would benefit from this technology to build interorganizational trust" (Chen et al., 2023). Finally, Kouhizadeh et al. (2020) identifies the psychological challenge in pre-emptive negative perception of the technology, for blockchain development by organisations, which has the ability to greatly influence the project and be a significant cause to discontinuation.

1.5.4 Challenge of Commercialization

Wolf et al. (2023) emphasizes that a product might be highly technologically capable, but obtaining buy-in from key stakeholders is often the bigger challenge, which impacts the ability to commercialize blockchain. Therefore, commercial usage is a significant aspect, and it is often not the sophistication of the technology that determines the fate of a technological initiative (Wolf et al., 2023). Weisheng et al. (2022) also pertain to the challenge of commercialization, by highlighting the importance of organizations needing to dissect their existing business models before using this radical technology. Blockchain is more about implementing novel business technologies and philosophies (Penzes et al., 2018), rather than just about using new software. Therefore the in-depth relationship between blockchain systems and project performance is called into question.

1.6 Conclusion

This chapter draws conclusions based on the studied literature in the focused sub-chapters. Furthermore, the key knowledge gaps are presented.

Challenges to adoption of blockchain-based applications reside partially in the organizational category, or subcategories of organization, supported by Lanzini et al. (2021), Chen et al., (2023), Walsh et al. (2021), Smith and Castonguay (2020), Dozier and Montgomery (2020), and Edirisinghe Vincent and Barkhi (2021). Given the desire for business circles to automize certain business processes, increase trust in their environment and reduce operational costs with the use of blockchain technology, the factors and mechanisms contributing to collaboration on this front remain unclear. This questions the framing of blockchain as a data proof sharing mechanism, which highlights the decision making necessary by managers to comply with privacy laws and other regulatory aspects, when building applications on blockchain infrastructure. On the other hand, the use and development of privacy-enhancing techniques on public blockchains is an area of innovation that may translate to and improve both private and public blockchains, an example being zero-knowledge proofs. Organizations that wish to initiate and develop a blockchain consortium need to know about the organizational challenges, which is currently limitedly addressed in literature, and therefore presents a knowledge gap.

The challenge on a blockchain architecture decision is also identified as a knowledge gap for the success of a blockchain project by consortia. Connected to this, the role of how SMEs can be involved and maintained regarding node participation costs and other consortium participation costs is highlighted. Another knowledge gap identified is the topic of how cognitive challenges related to blockchain in a consortium setting can be tackled. Individuals lack the ability to transform their mindset from a single company to a collaborative commerce setting (Edirisinghe Vincent and Barkhi, 2021). This is not only present on the inter-organizational level, but also on the intra-organizational and individual level. This is because, as collaboration and communication between blockchain software engineers and managers on the topic of security is difficult, due to managers making a decisions and trade-off between the desired level of privacy and transaction speed, but "knowledge gaps still exist with respect to how organizations would benefit from this technology to build interorganizational trust" (Chen et al., 2023). The continued pre-emptive negative perception of blockchain also still presents itself as a relevant influence to decision-making (Kouhizadeh et al., 2020). The last knowledge gap identified is that of the commercial challenge which is the lack of knowledge on buy-in factors for key stakeholders, when compared to the knowledge already available on technological capability of blockchain (Wolf et al., 2023). Resulting from this, how organizations dissect their existing business models, or section of these business models, to accommodate for blockchain is unclear. With this in mind, managers lack guidelines of decision-making processes necessary to develop blockchain-applications in a rigorous manner. In order to tackle this problem, this research has the main objective of developing guidelines, in order to contribute to the knowledge gap in decision-making processes that has been identified.

2 Research framework

2.1 Introduction

This chapter builds on from the background information, societal relevance, and knowledge gaps from Chapter 1 to construct a research framework that guides the design and methodology of this thesis. Firstly, the knowledge gaps are re-iterated in this section, followed by the introduction of the main research question in section 2.2. Then, the research approach is detailed. In continuation, the sub-questions of this research are presented, including the research method needed to answer each sub-question. As discussed in section 1.6, the knowledge gaps on how certain blockchain-specific challenges should be tackled were divided into four components:

- Challenge in organization
- Blockchain architecture challenge
- Cognitive challenge
- Challenge of Commercialization

To guide this research, the visualized approach of Figure 4 in section 2.5 is followed.

2.2 Main research question

Arising from the knowledge gaps identified in the Scientific relevance section 1.5, the following main research question is formulated:

Which guidelines can aid consortium managers in their decision-making process of developing blockchain-based applications?

The objective of this research is to provide guidelines for blockchain consortium managers, based on factors that influence decision-making. This will provide practical advice for navigating the complexities involved in developing blockchain-based applications within consortia. The following section frames the research approach for answering the main research question.

2.3 Research approach

In order to answer the research question and complete the objective for this project, a well-defined research approach is necessary. Firstly, the unit of analysis is defined as the consortium. Qualitative research is chosen, opposed to quantitative research due to the need for exploring information that cannot be enumerated. Specifically, qualitative research can yield detailed empirical data in a real-life setting, in which human behaviour and social interactions between stakeholders plan an important role for the decision-making process. In addition, the opportunity presented by the DBC, to facilitate short channels of communication, and proximity to managers involved in decision-making, proves indispensable. The units of observation for this research are the interview transcripts that will be produced and previously available documents of the case. This research uses cross-sectional case studies to investigate the development of a blockchain-application within a relatively short time frame, with the qualitative data collected by interviewing managers who were involved in the decision-making process for developing a blockchain consortium initiative being between December 2023 and January 2024. In addition, interviews for two 'validation' cases were performed in February 2024 which are used to validate the guidelines created based on the initial cases. The major advantage of a cross-sectional case study approach in this setting is to identify the wide array of challenges, potential benefits and risks that blockchain consortia are subject to. This will provide insight into factors that affect the decision-making process of blockchain consortia.

2.4 Sub-questions

Sub-questions are formulated to decompose the main research question and aid in answering it:

Sub-questions:

1. *What decision-criteria for choosing blockchain and what potential technological alternatives are available to consortia?*

The first sub-question explores how consortia can use certain decision-criteria to choose between different data sharing solutions and what alternative systems to blockchain are available for consortia to employ, in the case that the blockchain consortium does not come to fruition with developing a blockchain-based application. Technical and Non-technical factors will be explored in how they play a role in choosing a system. Therefore, the objective is to investigate and discuss blockchain system decision-criteria available to consortia, and alternative technologies that can be developed in case of discontinuing of blockchain-exploration. The deliverable of this sub-question is to provide the decision-criteria that blockchain consortia align to for choosing blockchain, and highlight the alternative technologies available to consortia.

2. *Which analytical frameworks are available to consortia to manage decision making for the development of blockchain-based applications?*

The second sub-question is answered by a literature review of the available models, as the question addresses the available literature on existing frameworks. The research method is by searching for and studying the available analytical frameworks on Web of Science and Scopus. The objective of this sub-question is to select an analytical framework based on the problem definition, taking into account that it must be contextually-appropriate to consortia. The relevance of this sub question is the guiding analytical framework to be used for interview questions made to managers for gathering the empirical data necessary of sub question 3. The sub question will deliver an analytical framework by which to construct the case study design of this research.

3. *What case study design can be employed to uncover factors in decision-making of blockchain-application development?*

This sub-question is answered by developing a case study approach, a case selection procedure and an interview question list, that allows for the collection of qualitative data, in line with the chosen analytical framework in sub-question 2. The objective is to develop a structured and contextually appropriate case study design and protocol for the analysis of the use cases to discover the factors that play a role in the decision-making process for consortia developing blockchains.

4. *What factors emerge from challenges, potential benefits and risks in development of blockchain-based applications managed in the decision-making process?*

This sub-question is of empirical and exploratory nature. In order to reconstruct the factors in the decision-making process, the challenges, potential benefits and risks to blockchain consortia are collected, which is best performed by multiple case studies as it allows for an in-depth analysis into multiple sectors and application types. To perform the case studies, managers will be subjected to interviews. These individuals must have been part of decision-making processes in blockchain consortia, therefore the formal job title or manager type is not of great importance, so product owners, innovation manager, CEO, etc. all pertain to the same overarching 'manager' actor. The access to cases and interviewees is granted and facilitated by the DBC, due to their extensive connections to organizations in blockchain consortia. Firstly, desk research makes an initial scope of each case, which includes documentation such as DBC research reports and publications on the websites of the selected blockchain consortia cases. Then, in-depth information is obtained by interviewing blockchain consortium managers involved on an individual basis. By identification of patterns, in terms of the challenges, potential benefits and risks in the performed case studies, factors that affect decision-making will arise, and the sub-question will be answered outright. This will inherently enable the completion of the final sub-objective, the creation of a consortia-oriented guidelines framework for decision-making.

5. *Which guidelines can be designed for managers in consortia to aid in decision-making of development of blockchain-based applications?*

This research question builds on from the challenges, benefits, risks and resulting factors identified in the previous research sub-questions, to the extent that the objective is to construct guidelines to help managers make informed decisions and navigate the development of blockchain-based applications. Additionally, the objective is to validate the designed guidelines using two additional cases, named ‘validation cases’. Following this, the original guidelines must be improved by implementing any critique to advice in the guidelines provided by the interviewees in the validation cases.

2.5 Research flow diagram

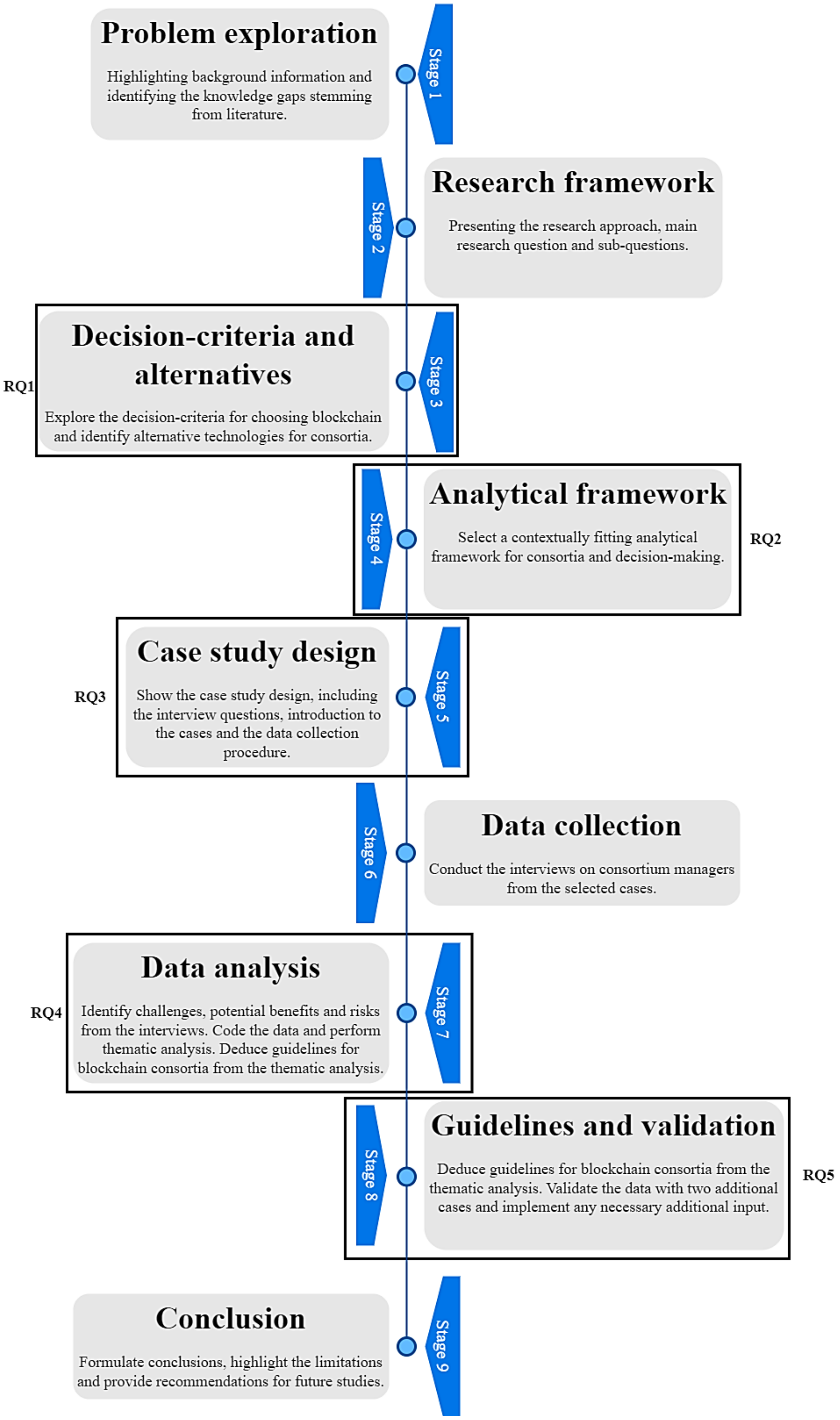

Figure 4: Research flow diagram

3 Blockchain application choices: Decision-criteria and post-exploration alternatives

The corresponding research sub-question for this chapter is:

1. *What decision-criteria for choosing blockchain and potential technological alternatives are available to consortia?*

The research method to answer this sub question entails a literature review on decision-criteria for blockchain and an overview of alternative technologies to blockchain, by which consortium members can construct solutions to tackle certain organizational challenges if the blockchain exploration or prototyping phase is not successful. For this reason, two separate sections deal with the respective aspects of the sub-question in this chapter, but both utilize a literature review as the research method. The sub-deliverable are blockchain-specific criteria that consortia can use for alignment, and decide whether blockchain is appropriate. This is important for the final deliverable of this thesis as it determines whether the guidelines are applicable to the consortium. Section 3.1 firstly introduces the motives for using blockchain, which serve as decision-criteria for consortia to initiate blockchain exploration. The section follows by arguing for the use of non-technical criteria in deciding to explore blockchain for basing applications. In section 3.2, central and shared databases are introduced as a dimension by which data sharing architectures are distinguished, but other systems of categorization are also argued for.

3.1 Blockchain decision-criteria for consortia

This section presents decision-criteria, in the form of motives, which consortia can align themselves to for determining whether to initiate the exploration of blockchain-based applications. This is presented as an initial step for consortia to justify the necessity of blockchain for their project.

In a multiple-case study on 19 blockchain consortia by Bauer et al. (2023), the authors apply a socio-technical information systems artifact perspective, developed by Chatterjee et al. (2020), to analyse the reasons for managers in blockchain consortia to use blockchain technology. This study does not present decision-criteria based solely on technical factors of the consortium, and the need for a multidisciplinary approach is underscored and further discussed in the latter part of this paragraph. The motives for engagement in blockchain, along with the interaction mechanisms between them are shown in Figure 5. Input and output motives are shown as providing a feedback loop process, whereby consortia iterate their motives based on goals that have not been met. Importantly, the distinction between phases is made, in a two-dimensional basis: the exploration phase and the prototyping phase. Therefore, the decision-criteria and motive depend on the stage of the project. The initial motives discovered for consortia, as seen in Figure 5 are *technology innovation, political positioning and business goal*, while motives during prototyping are *information tokenization, technology enabling* and *governance necessity* (Bauer et al., 2023, p. 11-16). The *technology innovation* motive contains both technology-push (experimentation and opportunity seeking) and market-pull (domain-specific problems/needs) components. The *business goal* can be either humanistic or economic, meaning that the outcome can bring social or financial benefits for the consortium partners. If a consortium exhibits at least one of the components (such as ‘trust' in *governance necessity)* within the motive as a key driver, for all motives, the consortium decides to initiate blockchain exploration, as the motive-based decision-criteria have been fulfilled. A drawback of this framework is that it does not provide the explicit motives for managers choosing non-blockchain systems for data sharing, and what alternative system this should be, after exhausting their blockchain exploration and prototyping as an option for data sharing. As discussed, the initial phases are the exploration phase, followed by the prototyping phase. The DBC model for project phases in chronological order is as follows: Intake, Design, Pilot, and Launch preparation phase. When comparing the Bauer et al. (2023) phases with the DBC phases model, the exploration phase is analogous to the Intake phase, while the prototyping phase pertains to both the Design phase and Pilot phase, but the DBC model dissects it into two separate phases. The DBC phases model expands the scope by finalizing the governance model of the consortium, delineating the Chater of the consortium, and presenting the plan of the initial minimum viable product, in the Lauch preparation phase.

The 2006 paper by Ortt & Smits discussed in section 1.1 mentioned the importance of embracing new organizational practices as a factor in the adoption of innovations. However, the presence of complementary products and services, a consistent marketing mix, presence and development of supply chains and customer groups are additional non-technical factors that need to surround the innovation in question (Ortt & Smits, 2006). This highlights the importance of how non-technical factors significantly affect the effectiveness of an information systems’ adoption. As data sharing solutions are viewed as a subset of information systems, it highlights the utility behind using the non-technical motives of the framework from Bauer et al. (2023).

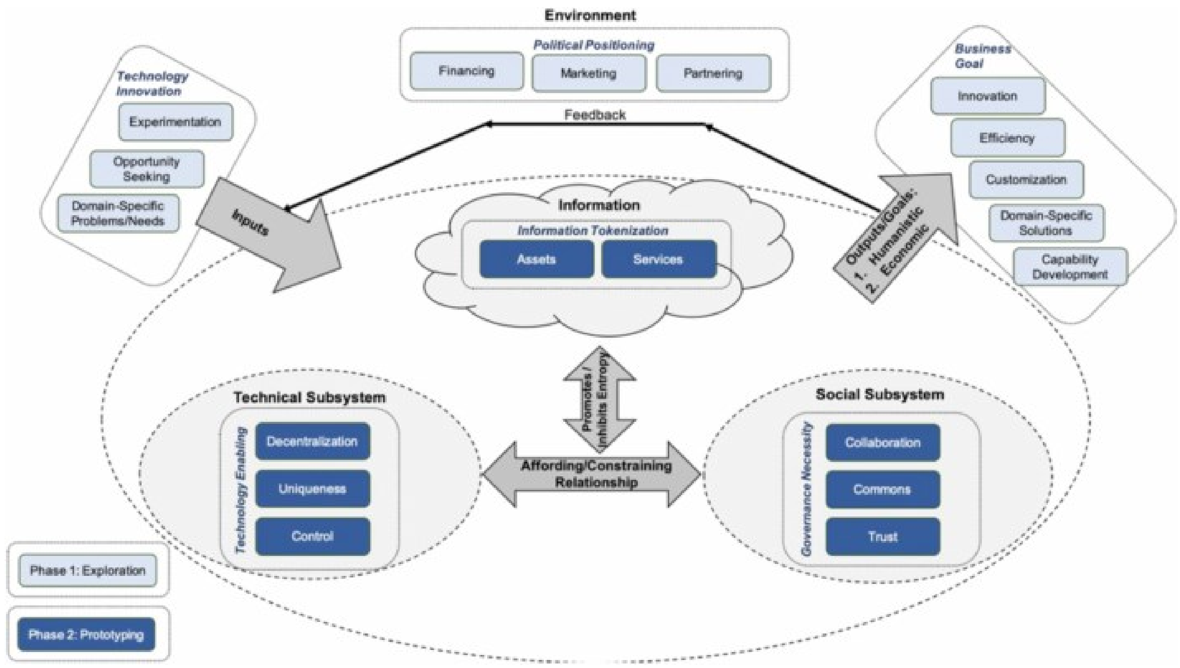

Figure 5. Development of motives for engaging with and developing a blockchain information system over time. Copied from Bauer et al. (2023), p. 16.

3.2 Alternatives after blockchain exploration

While blockchain presents a novel manner to share proofs of data and data itself, there are scenarios in which alternative technologies are chosen by consortia. Knowledge about the alternative systems which serve as a base for applications is necessary in order to answer sub-question 1, and the relevance stems from the need for consortia to pivot on their infrastructure choice to successfully bring the product to market. Due to the inherently uncertain nature of a consortium (Meißner et al., 2022), coupled with the uncertainty of the radical innovation that blockchain is, a consortium may not have selected the optimal technology to base their applications on given the changing setting. Another reason a consortium may need to switch to an alternative to blockchain is due to maturity changes in rival technologies which occurred during the blockchain exploration process. A literature review by Koens and Poll (2018) analysed and aggregated 30 different schemes which modelled whether blockchain or an alternative technology was optimal, given a particular scenario. The paper then proposed a new method based on three models. The classification of alternatives is presented in Figure 6. All of these systems are defined as Database Management Systems (DBMS). Having explored the difference between DLT and blockchain in section 1.1, DLT is further explored as an alternative for consortia in this chapter. Other types of DLT's, apart from blockchain, are Directed Acyclic Graph (DAG) structures and Federated Byzantine Agreement (FBA) structures. The immediate higher grouping of the DLT category presents the distributed databases category, as shown in Figure 6. An example of a distributed database, other than DLT is a distributed relational database, defined by a database that is spread across different but interconnected computer systems (IBM, 2021). The intuitive difference between central databases and distributed databases is that data is centrally stored in the former and data is stored in a distributed manner in the latter. Meanwhile, central ledgers and distributed ledgers share the nature of interdependency of transactions of different participants while the degree of centralization differs. The paper by Koens and Poll (2018) highlights the limitation of the absence of the concept of trust in their scheme. This also relates to governance of a blockchain, as the paper focuses solely on levels of centralization for data storage, while the level of centralization for governance is not discussed. In addition, their scheme of questions does not include non-technical questions, such as economic incentives, which is a vital aspect for a consortium. The inclusion of more DLTs in the blockchain alternatives model is also mentioned as necessary future work. The paper does not explicitly cover third-party alternative solutions that are provided by cloud services. This may be of particular interest to consortia with limited availability of R&D facilities for in-house development of data sharing solutions. This also applies to SMEs, as they have less disposable capital for development of in-house solutions when compared to large corporations.

While the dimension of centralized databases versus decentralized databases is a way of organizing the options for blockchain and its alternatives, another dimension presents itself in first-party solutions versus third-party solutions. Third-party cloud specialist services are gaining popularity as a solution to outsource data sharing solutions, for basing blockchain applications. An example of a cloud service which offers data sharing solutions such as data protection, threat analyses and risk analyses of data is Amazon Macie, by Amazon Web Services (Galvez and Gurses, 2018).

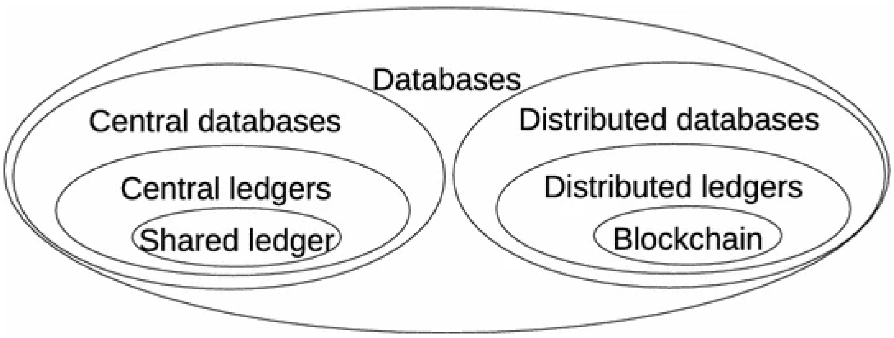

Figure 6. Classification of database technologies. Copied from Koens and Poll (2018, p. 116).

In Figure 7, models by Koens and Poll (2018) are shown, displaying the end states of their decision-making process for determining the database-type a consortium can adopt. DLT, blockchain, central databases and traditional forms of data sharing such as email/spreadsheets are explored and categorized. However, it does not account for a private permissionless blockchain configuration, as visualized in **Error! Reference source not found.**. The key proposition of such a configuration is that any individual can initiate a node to join the private permissionless network, but other nodes will only acknowledge its existence, but not share any data. This can provide decentralization with controlled access, as participants make themselves known at a later moment. Ultimately, the contribution in Figure 7 is in the provision of dividing database options into a structured approach.

A. Model 1 end states

1. DLT is a good fit.
   (a) Use BC.
   (b) Let's talk.
2. DLT is not a good fit.
   (a) Don't use BC.
   (b) Problem of standards.
3. BC may be a good solution.

C. Model 3 end states

1. Consider alternative approaches.
   (a) Central database. suitable
   (b) Encrypted DB.
   (c) Managed DB.
   (d) Consider email/spreadsheets.

B. Model 2 end states

1. Public permissionless DLT.
   (a) Public BC.
   (b) Permissionless BC.
   (c) Public permissionless BC.
2. Public double permissionless DLT.
3. Public permissioned DLT.
   (a) Permissioned BC.
   (b) Public permissioned BC.
   (c) Hybrid BC.
4. Private permissioned DLT.
   (a) Private BC.
   (b) Private permissioned BC.
5. Private double permissioned DLT.

Figure 7. Model end states for blockchain alternatives. Copied from Koens and Poll (2018, p. 118).

3.3 Conclusion

This chapter has addressed the first sub-question: *What decision-criteria for choosing blockchain and potential technological alternatives are available to consortia?* This chapter has identified a multidisciplinary decision-criteria scheme to the consortium context of this thesis, relying both on technical and non-technical factors. Distinction between the exploration phase and the prototyping phase is vital, with motives for engagement in blockchain projects shifting based on these stages, highlighting the dynamic nature of decision making. Section 3.1 answers the first part of the question, about the decision-criteria for choosing blockchain. It is answered by providing the six motives that consortia must align itself to: *technology innovation, political positioning, business goal, information tokenization, technology enabling* and *governance necessity*. A consortium must exhibit at least one of the components within the motive as a key driver, for all of the motives, to initiate blockchain exploration. Section 3.2 answers the second part of the first sub-question concerning alternatives. The alternatives are cloud services, data spaces, federated architectures, centralized databases, or distributed databases that may be DLT's but not a blockchain system.

This is important for the final deliverable, as alignment in the form of having chosen blockchain is a precondition for receiving guidelines specifically meant for blockchain consortia. The next chapter uses the assumption that a consortium has aligned themselves with the motives presented in this chapter, to find a fitting analytical framework for this research.

4 Analytical framework design for case analyses

The research sub-question central to this chapter is:

2. *What analytical frameworks are available to consortia in order to manage decision making for development of blockchain-based applications?*

This sub-question will be answered by means of a literature review on the available analytical frameworks. The objective is to develop an analytical framework by which the case studies can be analysed in the context of decision-making processes. The importance of this sub-deliverable is in identifying and framing the case study design for collecting qualitative data. Firstly, section 4.1 presents the search and selection procedure, followed by comparing and contrasting of several analytical frameworks in terms of appropriateness towards achievement of the research objective and the key characteristics of consortia. Frameworks that are non-technology specific are explored, followed by the scoping into exploration of a blockchain-specific analytical framework. The Resource-based View will be presented as the overarching analytical framework chosen, followed by the additionally chosen Consortium Capabilities framework for a basis of analysis. In section 4.2, the combined framework that was formed will be revealed, to be used in the next chapter, which was synthesized by merging of analogous components in the two aforementioned chosen analytical frameworks.

4.1 Overview of analytical frameworks

In this section, the requirements of the analytical framework is presented, followed by argumentation for several frameworks for the purpose of selecting the one that is most fit-for-use given the requirements. Also, the selection of an analytical framework is inherently dependent on the research design and must be adapted to conform with the context of the study (Goldsmith, 2021). The selected framework must satisfy the following four criteria: it must be fit to analyse inter- and intra-organizational decision-making, while being relevant for project-level innovation, needs to address factors for decision-making processes, and must be a strategic management framework. The need for it to be a strategic management framework is by logical reasoning, as a systematic and integrated plan of action designed to achieve a specific goal or set of objectives is required. In addition, consortia often face dynamic internal and external environments (Crupi et al., 2020) and this requires an approach to ensure the continuation of the consortium activities. The searching procedure highlighted a multitude of strategic management frameworks in literature (Schilling, 2023; David et al., 2023; DuCoin, 2023). The next paragraphs discuss three frameworks, the Blue Ocean Strategy, Porter's Five Forces, and the Resource-based View, as potential analytical frameworks resulting from the aforementioned literature, and that fulfil the four predefined criteria.

Blue Ocean Strategy

The Blue Ocean Strategy (BOS) is the parallel execution of multiple strategies to form a synergized approach to capturing uncontested market space. The parallel strategies are differentiation and low cost, in order to stimulate new demand and create a new market space (Chan & Mauborgne, 2005). Successful execution of the BOS creates a highly competitive advantage, however this does not align with the main value proposition of consortia, which is collaboration and creating value, and not competition which leads to capture of uncontested market space. In addition, consortia often collaborate to address industry-wide challenges, which involves open and vocal communication between organizations about possible solutions to the challenges, while the inherent competitive nature of the BOS encourages the protection of internal information and a focus on self-development.

Porter's Five Forces

Another framework which can be used for decision making processes is Porter's Five Forces. The analysis comprises of an industry-level assessment of the competitive rivalry, supplier power, buyer power, threat of substitutions and threat of new entries in order to create a broad perception of environmental forces (Porter, 1979). The framework is used by firms to understand their competitive position within the industry. While the framework can be adapted to define a consortium as a single entity, much like a firm, Porter's Five Forces do not account for internal factors of a consortium, which is essential towards the project-level innovation of a consortium. In addition, consortia often span several industries, adding to the difficulty of applying Porter's Five Forces as an analytical framework for this study. Similarly to the BOS, the competitive nature of the framework means a hindrance to the main value proposition of collaboration for consortia.

Resource-based View

As previously mentioned an analytical framework often needs to be adapted to conform with the context of the study (Goldsmith, 2021). By extent, the components, which are sub-themes and concepts of an analytical framework, are the elements that must be adapted. The Resource-based View (RBV) framework states that a firm's sustained competitive advantage is based on its resources being valuable, rare, inimitable, and non-substitutable (VRIN) (Barney, 1991). While the competitive advantage component is similar to the BOS, the flexibility of the resources and capabilities allow for an alternative construction towards a consortium-relevant dimension: collaboration. As this study does not frame a single firm, the RBV can be extended to a multi-organization system and applied to consortia. It is directly related to decision-making processes, because decision-making for combining resources becomes significant in the strategic planning of a consortium. The Select Committee on Science and Technology (CEST) (Parliament of the United Kingdom, 1998) recognizes in a memorandum that consortia bring value towards a "collaborative advantage". Therefore, in Figure 8, the RVB is adapted to convey the key benefit of a consortium, collaboration, instead of the aforementioned strategic advantage. The next paragraph explains the framework in more detail. Lastly, another reason why this framework is appropriate for this study is because consortia and the organizations comprised within the consortia have direct control of their decision-making process for acquiring and maintaining resources and capabilities that are VRIN.

The RBV framework is a management framework that focusses on the internal resources and capabilities of an organization, and the characteristics of these two aspects (Barney, 1991). If the organization controls and manages resources and capabilities of VRIN nature, a competitive advantage ensues, followed by sustainment of the competitive advantage, as shown in Figure 8. As explained in the previous paragraph, the RBV can be extended from a single organization to a consortium, as the resources and capabilities that are collectively owned by the consortium can fulfil VRIN characteristics in the same way that it can for a single organization. Resources can be tangible, intangible or organizational, while capabilities can be tangible, intangible, information-based organizational process or intermediate goods. The previous paragraph also argued how competitive advantage translates to collaborative advantage in a consortium setting. For example, a resource of a certain consortium partner may be a patented technology, and a matching capability for this resource (controlled by another partner) is R&D expertise, which together form an advantage in collaboration for the consortium.

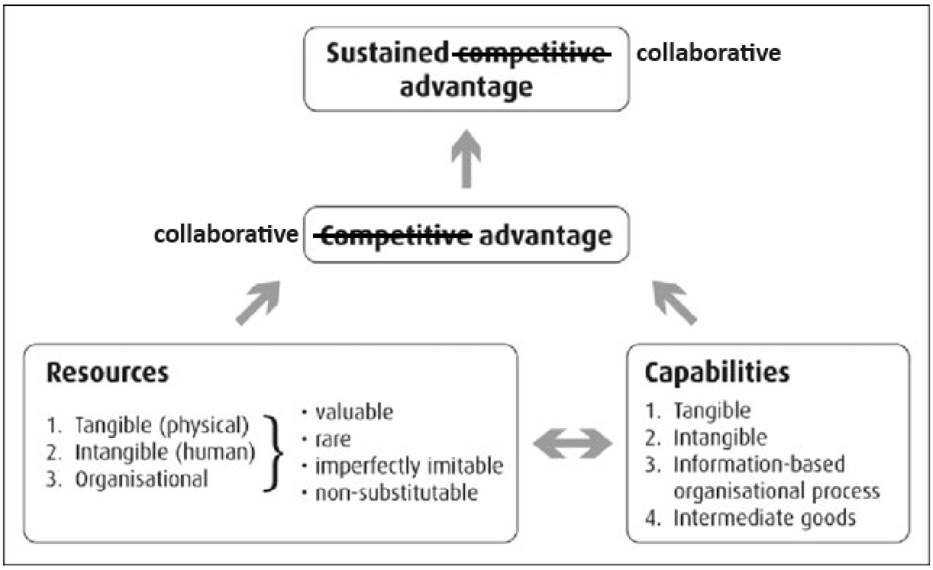

Figure 8. The Resource-Based View. Modified from Hack et al. (2012, p.4); based on Barney (1991) and Amit & Schoemaker, (1993).

Consortium Capabilities Framework

Literature on blockchain consortia-specific decision-making frameworks is highly scarce. Kaufman et al. (2021) present a Consortium Capabilities Framework (Figure 9), giving an overview of conditions for success, consortium capabilities and the subsequent outcomes for a consortium adopting blockchain-based applications for a specific use case. The paper does not explicitly state that the foundation of the proposed capabilities is based on the capabilities of the RBV framework. The competent framework highlights key factors for consortia to consider when making decisions, but does not mention factors that contribute towards conditions for failure of a project, nor factors for a condition for a successful failure, further defined in section 5.1. Decision-making processes are not explicitly covered. The concept of trust between parties of the consortium is not explicitly covered, while 'collaborative mindset' allures to this, the latter can be present while still maintaining a state of distrust.

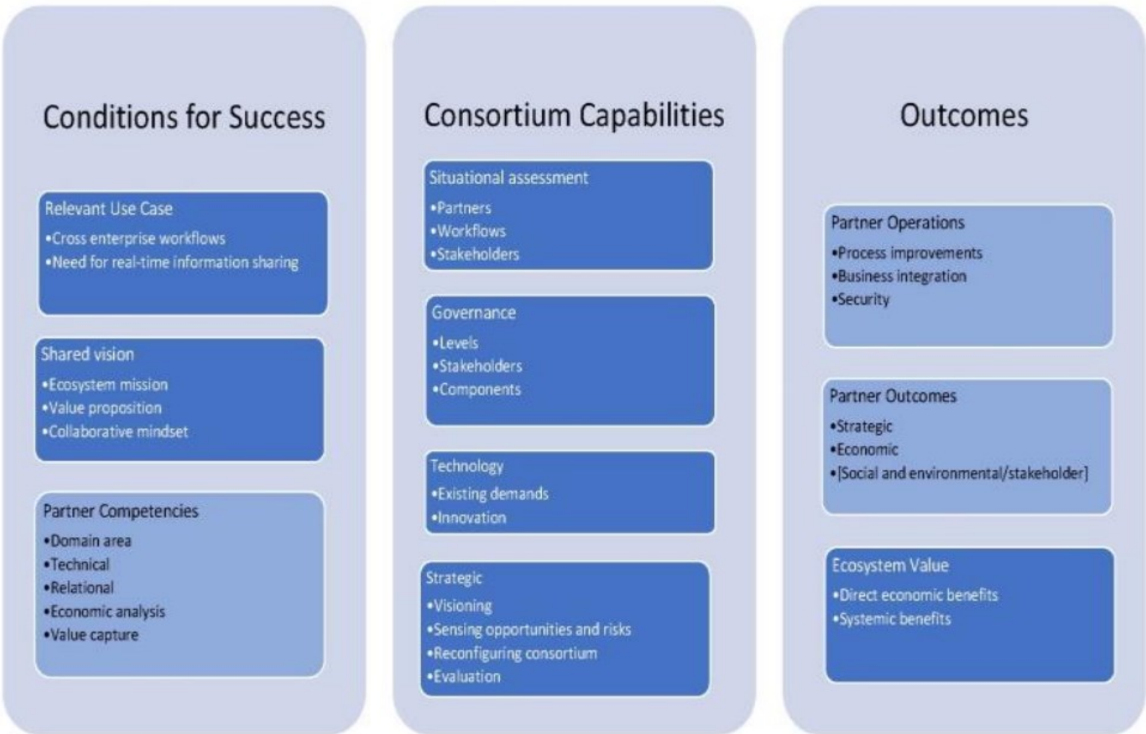

Figure 9. Consortium Capabilities Framework. Copied from Kaufman et al. (2021, p. 3).

4.2 Combined analytical framework

The two chosen analytical frameworks can be combined intuitively, as shown in Figure 10. The motivation behind this combination comes from the provision of added value in including a broad dimension of strategic management (the RBV framework level) and a blockchain-specific strategic management dimension (Consortium Capabilities framework level). The 'Outcomes' within the Consortium Capabilities framework can be directly paired with the 'Collaborative advantage' section of the RBV framework, as 'collaborative advantage' and 'sustained collaborative advantage' are outcomes provided by the RBV framework, given that VRIN resources and capabilities are present. These 'Outcomes' are an elaboration on outcomes resulting from the effect of combining 'Conditions for Success' and 'Consortium Capabilities' within the Consortium Capabilities framework. Following this, 'Consortium Capabilities' is analogous to 'Capabilities' in the RBV framework. For example, the 'Governance' capability component in the Consortium Capabilities framework frames the governing capability of the consortium, which is intuitively an intangible capability in the RBV. 'Conditions for Success' describes the moderating variable, which is symbolized accordingly in Figure 10, as it moderates the effect of resources. Resources have a specific outcome in specific conditions, which highlights the need to include 'Conditions for Success' as a moderating variable.

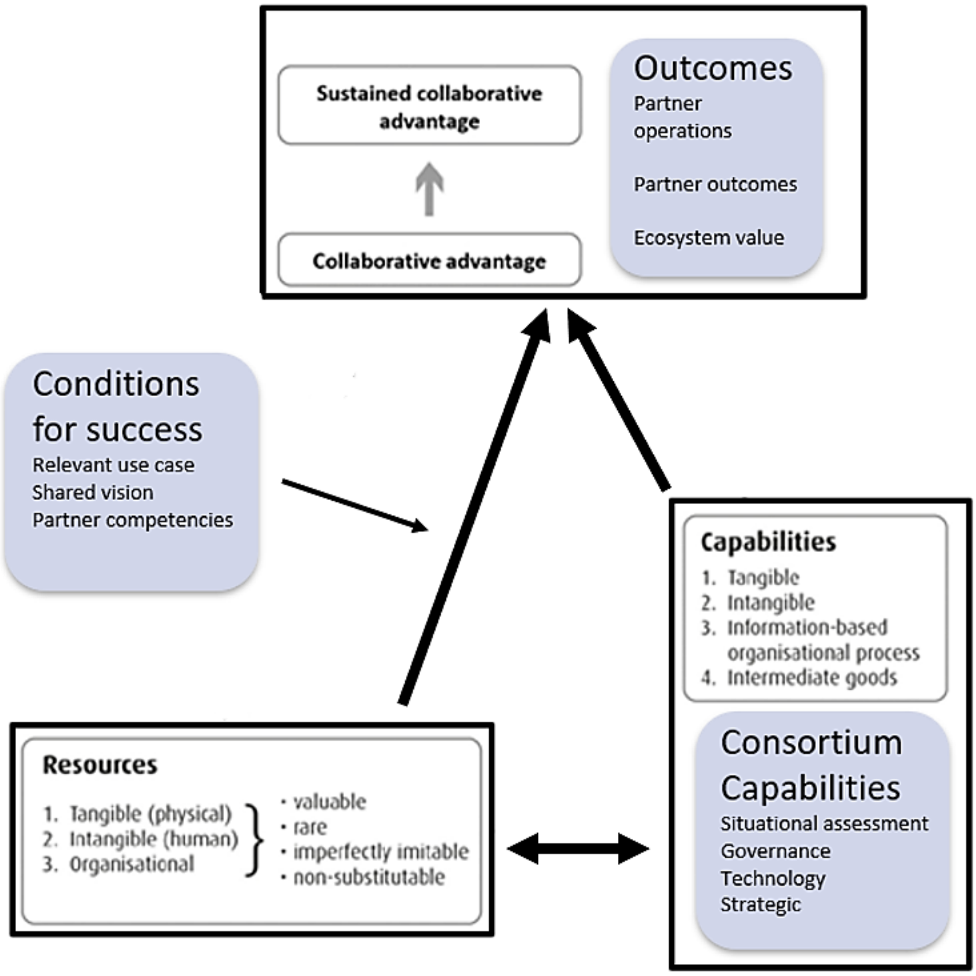

Figure 10. Combined Consortium Capabilities and RBV framework.

4.3 Conclusion

Sub-question 2 was addressed in this sub-chapter: *What analytical frameworks are available to consortia in order to manage decision making for development of blockchain-based applications?* Two analytical frameworks, the RBV and Consortium Capabilities frameworks were combined into a singular framework due to the strong similarities observed between them, which answers this sub-question outright. The RBV framework was adapted to consortia by changing the outcome from a 'competitive advantage' to a 'collaborative advantage', in order to reflect the key value proposition of all consortia, which is collaboration, in order to create value. The importance of this analytical framework lies in guiding the analysis with blockchain-specific components, as this is needed for the context of this research. The combined framework is used in this chapter for providing a visualization of the interconnected nature of the components, and subsequently useful for the next chapter to enable the retrieval of empirical data for case studies, by creation of interview questions for participants.

5 Case study design

The relevant sub-question to this chapter is:

3. *What case study design can be employed to uncover factors in decision-making of blockchain-application development?*

In Chapter 4, the analytical framework for the case studies was developed. The combined analytical framework is now used in this chapter to develop the case study design. The research method used to undertake a contribution towards answering of the sub-question is by means of case studies, including a case study approach to analyse four empirical case studies. This chapter first of all explains the steps taken to design the case studies in section 5.1. The case selection approach is presented in 5.2, which aids in providing the logic in the selected cases with the use of three dimensions. The cases are also shown on a high level in this section. The following section, 5.3, provides further descriptions on the selected cases. Finally, section 5.4 explains and argues for the structure of the interview protocol, such as the relevance of the semi-structured interview approach, the categorization of the interview questions posed to the candidates, and the interview questions list.

5.1 Overview of case study approach

A multiple case design approach is chosen for the major benefit of increasing external validity, when compared to a single case design (Quintão, 2020). The differing context for each case enables intricacies to be studied rigorously and independently. A most-different case selection approach (also called "method of agreement" (Mill, 1843)) was used to select the cases. This approach is used because the primary objective of the most-different cases approach is to carefully choose cases in such a way that the only consistent pattern observed is the relationship between a particular explanatory variable and the outcome variable across multiple cases (Seawright and Gerring, 2007). In this research, the outcome variable pertains to the outcome of the project in terms of the level of success, measured by an operational blockchain system, delivering added value to the consortium. By ensuring diversity among all relevant explanatory variables except for one, the confidence in the significance of this specific variable in explaining the outcome is strengthened (Seawright and Gerring, 2007). Four cases that provide the highest degree of diversity were used, with at least two managers interviewed per case in order to not only triangulate information between cases, but also increase reliability of information by triangulating information between managers of the same project. The interview data was also triangulated with documents from desk research, which comprised of a mix of whitepaper reports, information displayed on the consortium website, progress reports, and consortium meeting reports. The DBC facilitated access to the desk research documents that were necessary for the case analyses, and aided in providing rapid access to managers of consortia. The combined analytical framework of section 4.2 provides the scope for structuring the interview questions to be posed to the managers.

5.2 Case selection approach

This section describes the case selection process, followed by an introduction to each case. With the exception of the JuicyChain project, the DBC was directly involved in each of the cases as a partner. The role of the DBC varies from a supportive partner role in Hyfen, to a more active role in decision-making for the consortium such as in the uNLock initiative and the Future Mobility Data Marketplace. Preliminary information on 13 projects was gathered, from which four were selected as cases to base the multiple case study on. The four selected cases are shown in Table 2, and the rest of this section details the rationale behind choosing these cases. Preliminary information consisted of the dimensions used for case study selection, which are presented and discussed in the last two paragraphs of this section. With the most-different case selection approach, each dimension is varied to the extent that there are no similarities on any level of the cases, in terms of the dimensions. For example, one of the projects, 'JuicyChain' was selected in favour of 'Renewable Fuels' as they are highly similar in their application, which is offering supply chain transparency. In addition, a prominent bias that must be limited is that of convenience sampling bias. Convenience sampling is the act of sampling participants based on their accessibility or availability, which in this case would mean sampling only cases in which the DBC have participated in as a partner, and are current, which enables very short communication channels and fast access to information. As seen in Table 2, two cases do not include the DBC as partner listed in the 'partners involved' column, limiting the effect of convenience sampling. The rationale behind the selected cases is discussed in the remainder of this section.

Before the dimensions are taken into consideration, cases must have involved an exploration phase for blockchain to base its application(s), which has to have been completed. Therefore, for this investigation, the act of a former exploration phase for blockchain by the consortium is necessary to enter the decision-making process. In addition, it is necessary that multiple parties had been involved. Furthermore, cases need to involve organisations and managers from at least two consortium parties that are willing to participate in interviews to discuss the challenges, benefits and risks in the decision-making process.

The first dimension is the outcome type. Several outcomes types exist, a case can be deemed a success, a successful failure or a failure. A successful project is defined by a decision-making process that completes all phases of the project and an implementation of the data-sharing solution is executed successfully. In the context of the DBC 'phases' model, it means that all four phases (Intake, Design, Pilot and Launch preparation phases) were completed successfully. With a successful failure, the final architecture is not blockchain-based. The primary objective of a blockchain-based application is not achieved, but instead valuable lessons are learned on why this was not accomplished. A failure is characterized when the project does not deliver a final product, and a different technology by an outside consortium takes prevalence. Important to note is that a pilot of the product can be successful, but it does not prove overall success, as the highly controlled nature of a pilot environment does not encounter the final large-scale environment yet. Therefore, the difference between a successful failure and a failure is the notion that a successful failure can bring a non-blockchain product to market in the end, while a failure does not bring a product to market at all.

The second dimension is the application type. This defines the functionality domain in which the implemented data sharing solution solves a particular problem and presents utility to the consortium. For example, the Future Mobility Data Marketplace has the functionality of using blockchain as a way to share open and restricted data securely. The third dimension entails the complexity of the consortium. This is not only defined by the number of parties that form part of the consortium before the data sharing solution is delivered to market, but also the level of regulation of the industry that the consortium operates under. Highly regulated industries, such as banking, imply higher complexity due to the implied auditing and standardization processes that are necessary in these environments.

Table 2: Selected cases

Case name	Partners involved	Initially envisaged blockchain architecture	Status (as of January 2024)	Application type	Outcome type	Sector	Complexity
Future Mobility Data Market-place	Rijkswaterstaat, DBC, deltaDAO, Esri, TNO, Future Mobility Network, Sphereon, Topsector ICT	Public permissioned	Operational application on public permissioned blockchain	Sharing options for open and restricted data	Success	Mobility	High number of partners (8), and added complexity in legal aspects
Hyfen	APG, PFZW	Private permissioned	Operational non-blockchain based application	Pension-rights transfer, with built-in regulatory compliance	Successful failure	Financial	Low number of partners, highly regulated sector
uNLock	TNO, DBC, Ledger Leopard, Leiden University, Rabobank, Deloitte, CMS, RINIS, EY	Private permissioned	Ceased operation in May 2021	Privacy preserving COVID wallet	Failure	Medical	High number of partners (9), highly regulated sector
JuicyChain	Sustainable Trade Initiative (IDH), Open Food Chain,	Public permissioned	Operational application, on a public	Transparency in supply chain of	Success	Supply chain	Low number of partners (4), low

	Refresco, Eckes-Granini		permissioned blockchain	juice products			(universally) regulated sector

5.3 Description of selected cases

This section gives further details on the dimensions of each of the cases presented in Table 2. The application type is further elaborated on, the role of the partners in the consortium is explained, and the outcome type (which is related to the operational status) is specified upon.

5.3.1 Future Mobility Data Marketplace

The Future Mobility Data Marketplace (FMDM) is a blockchain-based marketplace to find or publish datasets and AI algorithms, which researchers can use to help solve challenges in mobility systems. This case is seen as a successful initiative, as it has accomplished an operational blockchain system and current ambitions are focussed on integrating additional use-cases. The consortium has Rijkswaterstaat, DBC, deltaDAO, Esri, TNO, Future Mobility Network, Sphereon and Topsector ICT as the partners. The blockchain-based application was developed on a compute-to-data basis, whereby data ownership and control is guaranteed. The type of blockchain architecture is of the public permissionless variant. The reason for the participation of Rijkswaterstaat is due to their identification of high costs in legal staff and time necessary for sharing restricted datasets with algorithm companies. DeltaDAO is participating due to their expertise in the Gaia-X framework, which is the technical template used to base the blockchain-based application. The software specialist company Esri, is motivated to participate in order to explore new mechanisms to enable utilization of their GIS mapping software through compute-to-data. The Future Mobility Network is involved in the initiative in order to provide practical advice on mobility-specific aspects of the implementation. Sphereon's participation in the consortium stems from their technical expertise in blockchain software. The DBC and Topsector ICT are involved for structured development of the use-case and facilitate communication between partners. The FMDM aims to match supply and demand of mobility-relevant datasets and algorithms in a cost-effective way.

5.3.2 Hyfen

The case of Hyfen started as a blockchain initiative, delivering a final working data sharing solution for pension rights transfer based on a private permissioned blockchain system. However, a transition to a state-of-the-art legal framework and governance system that provides the necessary guarantees ensued, meaning that this case is deemed a successful failure based on the definition in section 5.1. The decision to transition away from a blockchain-based architecture was taken due to the high cost associated with keeping the system operational, while not creating a valuable addition to the legal framework already in place. The project was first started within APG, later becoming the spinoff named Hyfen. In addition to these organizations, the consortium consisted of multiple pension providers, with a prevalent role played by PFZW. Both partners provided industry insights, funds for technology exploration, and management staff for exploring blockchain. The reason for involvement of these two consortium members was for increasing collaboration in the pension sector and for providing customers with a faster pension transfer between providers by process innovation. The pension rights transfer provides a solution for individuals with pension rights in the Netherlands to transfer their data fast, securely and with less cost from one pension provider to another.

5.3.3 uNLock

The aim of the uNLock initiative was to deliver a blockchain-based application that provided the public with a privacy-preserving wallet-app, in order to attend events during the COVID pandemic. A wallet is defined as a digital tool for storing and accessing cryptographic keys, necessary to interact with a blockchain network. The uNLock case is seen as a failure, with several learning points gathered by the DBC and its partners. Release of the uNLock app failed, as the Dutch government decided to develop and implement the 'Corona App' nationwide instead of uNLock in order to service citizens towards safety at social gatherings. The solution entailed an individual undergoing a COVID PCR test and identification check by a medical processional, with the credentials of the test and check uploaded to the self-hosted wallet of the individual, and an authenticity verification was performed through a self-sovereign identity (SSI) system. The SSI system incorporated a blockchain element, and the blockchain architecture type was private permissionless. Then, once the individual arrived at the event location, a subsequent check of the matching identification was carried out by the venue staff along with checking the validity of the PCR test by verifying it on the blockchain element of the system. TNO's role was software production, which was outside of their usual work domain, which is software research. Rabobank was a consortium member with valuable proprietary technology to the consortium. Leiden University, RINIS and CMR provided legal expertise to the system, while Deloitte and EY provided consulting services on the technology architecture. The role of the DBC in the consortium was that of a communication facilitator, and in advocating for a decentralized digital infrastructure.

5.3.4 JuicyChain (Open Food Chain)

JuicyChain is a supply chain solution for traceability of juice products in the beverage industry, based on a public permissioned blockchain architecture. The implemented application is seen as a success due to the present (January 2024) operational status of the system. The consortium was initiated by the Sustainable Trade Initiative (IDH), Open Food Chain, Refresco and Eckes-Granini. The permissioned blockchain was developed by the Open Food Chain (OFC) and is also maintained by the OFC, and offers public traceability of juice products. While the function source code is public, the branding, trademarks and user interface are maintained in closed source. This structure was adopted in order to protect the identity of the project, while the code can be validated by the public. Eckes-Granini and Refresco are bottlers of juice, which can therefore provide insights into challenges in supply chains that industry participants face. The IDH has the role of advocating for supply chain transparency and provides an advisory role in the post-initiation process. Onboarding of new consortium members and partners is a privately conducted process between the new organization and the four aforementioned consortium initiators.

5.4 Interview protocol

In the interviews, a semi-structured approach was applied, whereby follow-up questions enable the clarification to a response. The semi-structured feature of the interviews is enabled by pivoting and diving deeper into subcomponents from the Consortium Capabilities framework, depending on the real-time answers given by the participants. It leaves room for interviewees to provide information they see relevant if a subcomponent is not seen as reflective in their project. It is important to note that the List of Interviewees (with information on their function, and the timeframe of their participation in decision-making) is not included in this public report version, as this includes Potentially Identifiable Research Data (PIRD) for a small sector. Revealing data typically found in a List of Interviewees leads to trivial identification of individuals in this research. Only TU Delft supervisors had access to the list of interviewees. Important to note is that for the JuicyChain case, it was only possible to interview one manager. This presents a limitation, as data triangulation to another JuicyChain manager is not possible, and the research for this case relies on the triangulation between previously available documentation and the single interview. In connection with the semi-structured interview approach, participants were explicitly invited to talk about any issues they feel are most relevant to the case and combined analytical framework. The stop-criteria are defined as the moment when no new influencing factors (challenges, benefits and risks) are mentioned by interviewees, and when all interview questions have been posed.

The population boundary in the case study research is the managers of organisations based in the Netherlands who were involved in a blockchain initiative in collaboration with other parties. The unit of observation is defined as the interview transcripts and previously available documents on the case. Data triangulation takes place between interview transcripts, DBC findings (previously available documentation), such as whitepaper reports, progress reports, and consortium meeting reports, and information displayed on the websites of the initiatives. A quasi-snowball sampling approach is used, whereby the data collection is started with one interviewee and they may inform of other decision-makers (at the managerial level) in the project before or during the interview, with further information on project-specific decision-making processes. The interviewees must have worked or currently still work in the day-to-day decision making of the consortium as a consortium manager or similarly titled occupational position. In section 5.3, the convenience sampling bias was discussed on the case-level, but convenience sampling must also be adhered to on the interviewer-level. For this reason, easily accessible managers were not prioritized for interviewing, rather focusing on interviewing those that were central to the decision-making process and sustained a long-term role. As with all research involving human participants, ethical methodologies must be followed. For this purpose, the research approach and data handling was approved by the Human Research Ethics Committee (HREC) of TU Delft, before reaching out to any interview candidates. The HREC application entails an Informed Consent form, Data Management Plan, and HREC. The Informed Consent form (Appendix C) provides information on the participation in the interview for the candidates, so that they fully understand the nature of the activity, including its risks, benefits, and procedures, before they agree to take part.

5.4.1 Interview questions

The interviewees were asked to answer the questions shown in Table 3. The interview questions are mainly based on the components of the combined analytical framework. Each component is tested with an interview question, in order to provide a consistent gathering of data across the framework. For example, question 9 in Table 3 assesses how the shared vision of the consortium affects the decision-making process, which is fully based on the Shared Vision component within the 'Conditions for Success' of the Consortium Capabilities in Figure 9. While the RBV framework, Consortium Capabilities framework and consequent combination of these are all static frameworks, the interview questions are made to be dynamic, in order to assimilate to the dynamic nature of a decision-making processes. For example, the interview questions 5 and 7, which pertain to the RBV section of the combined framework, are made to be dynamic by asking how resources and capabilities were managed throughout the phases of the project. Not all interview questions are derived from the combined framework, as certain questions are necessary beforehand, or requires input of valuable information still relevant to the research framework of this thesis. The two background questions are asked before commencing with the framework questions, in order to build up to the knowledge and understanding of the components in the combined framework from the interviewee. Question 18 aims to gain insight into how factors outside of the control of the consortium affected the outcome (success level), while question 19 presents a reflective angle on how decisions could have been taken differently for increasing success of the project.

Table 3: Interview questions

Relevant component in combined analytical framework	Question number	Interview question
Background interview question	1	*Do you deem the project a success, successful failure or a failure?*
Background interview question	2	*What alternatives to blockchain were considered and why were they discarded/selected?*
Resources	3	*What was the resource availability per partner towards the consortium (funding and employees committed) and how did it affect the decision making process?*
	4	*What key and rare <u>resources</u> that are either tangible, intangible or organisational were identified by a partner or by the consortium as a whole?*
	5	*How were these tangible, intangible and organisational <u>resources</u> managed throughout the phases (phases 1-4, DBC model) of the project to provide a collaborative advantage?*
Capabilities	6	*What key and rare <u>capabilities</u> that are either tangible, intangible or organisational were identified by a partner or by the consortium as a whole?*
	7	*How were these <u>capabilities</u> managed throughout the phases (phases 1-4, DBC model) of the project to provide a collaborative advantage?*
Conditions for Success	8	*How did the relevant use case frame (in terms of the challenges, potential benefits and risks) the decision-making process in the development of the data sharing solution?*
	9	*How did the shared vision of the consortium affect (in terms of the challenges, potential benefits and risks) the decision-making process of the development of the data sharing solution?*
	10	*How did partner competencies affect (in terms of the challenges, potential benefits and risks) the decision-making process in the development of the data sharing solution?*
Consortium Capabilities	11	*How did the situational assessment affect (in terms of the challenges, potential benefits and risks) the decision-making process in the development of the data sharing solution?*
	12	*How did the selected governance model affect (in terms of the challenges, potential benefits and risks) the decision-making process in the development of the data sharing solution?*
	13	*How did technology affect (in terms of the challenges, potential benefits and risks) the decision-making process in the development of the data sharing solution?*
	14	*How did the consortium strategy affect (in terms of the challenges, potential benefits and risks) the decision-making process in the development of the data sharing solution?*
Outcomes	15	*What effect (in terms of the challenges, potential benefits and risks) did partner operations have on the decision-making process in the development of the data sharing solution?*
	16	*To what extent did the decision-making process allow for the fulfilment of the individual initial goals set by partners (in terms of the challenges, potential benefits and risks)?*
	17	*What values emerged from the ecosystem, enabled by the chosen decision-making process?*
Additional interview question	18	*Did external organizations/unforeseen events influence (with challenges, potential benefits and risks) the development of decision-making process in the development of the data sharing solution?*
Additional interview question	19	*If the project could be restarted from the beginning, what would you do again and what would you change in order to achieve success?*

5.5 Conclusion

The sub-question that has been addressed in this chapter was sub-question 3: *What case study design can be employed to uncover factors in decision-making of blockchain-application development?* The case selection approach was presented, based on a most-different cases strategy, selected by identification of three dimensions: the outcome type, application type and complexity of the consortium. The four selected cases are introduced, FMDM, Hyfen, uNLock and JuicyChain, highlighting the three dimensions for each case and other relevant case-specific information. Then, the data collection procedures are described in the interview protocol section, highlighting the population boundary (blockchain consortium managers in the Netherlands) and the unit of observation (primarily interview transcripts). These steps, from the case study approach overview, through to the interview protocol, answers the question. This chapter has set the stage for the methodical approach for finding challenges, potential benefits, risks, and the factors that can be generalized from these, in Chapter 6.

6 Decision-making: Challenges, benefits and risks

The relevant research sub-question to this chapter is:

What factors emerge from challenges, potential benefits and risks in development of blockchain-based applications managed in the decision-making process?

Case studies and basic statistical methodology are the research methods used in this chapter. The chapter starts by presenting the data processing and analysis methodologies in section 6.1, including a description on the hybrid-coding method, and the definitions used for the deductive coding. Following this, section 6.2 briefly discusses statistical information on the interview responses. Then, the coding results are presented in section 6.3, which partially entails the challenges encountered by consortia when developing blockchain-based applications, in the context of each case. Subsequently, the case-specific potential benefits are identified, discussed and generalized where possible, and lastly, the risks for each case are discussed and generalized in the rest of section 6.3.

6.1 Data processing and analysis of interviews

The interviews were recorded on the meeting software MS Teams, using the integrated automated transcription tool to process the answers to the interview questions. Following this, the text was corrected for erroneous speech-to-text errors when reading the transcripts. Answers to questions were then summarized in short sentences to condense the data.

A hybrid coding approach is used, entailing both deductive and inductive coding. The method is explained by Fereday & Muir-Cochrane (2006), and is explained to be an iterative and non-linear process. This method benefits majorly from flexibility, while maintaining an anchor in established theory. Furthermore, the flexibility of hybrid coding allows the researcher to code the empirical data based on emerging patterns. A downside of this method is that it is more time-consuming than a purely deductive approach, as multiple alternating stages of deductive and inductive coding is used. For this study, a qualitative data point is defined as a sentence, text segment or short paragraph within interview transcripts, entailing a challenge, potential benefit or risk encountered by a consortium. Codes were initially deductively coded into predetermined definitions of challenges, potential benefits and risks, from the qualitative data points. This type of categorization is of crucial importance and interest for consortia, as they aim to improve future practices by identifying challenges, potential benefits and risks (Gonera & Pabst, 2019). The Association for Project Management (2012) defines risks as “an uncertain event or set of circumstances that, should it occur, will have an effect on achievement of one or more of the project's objectives". This is used in this research, while making a distinction towards challenges and potential benefits, as not holding the high uncertainty level as that of risks. The formal definitions used for these three categories were as follows:

- *Challenge*: Represents an aspect of difficulty when attempting to complete an element of the project, and it has a low level of uncertainty regarding the outcome.
- *Potential benefit*: The positive outcome of the task or element is established, and it has a low level of uncertainty regarding the outcome.
- *Risk*: This category marks a high uncertainty concerning occurrence, is undefined in task difficulty, and can have an undecided positive or negative effect.

Utilizing the aforementioned definitions, the codes were then inductively coded based on the content of the perceived challenge, potential benefit or risk. The coding process is visualized in Figure 11. As the focus of this thesis lies in decision-making processes, process coding is prioritized where possible, using gerund-style wording. Descriptive and in-vivo codes are used where process codes are not possible. MS Excel and Atlas.ti were used to organize and create codes. Within Atlas.ti, the built-in 'Intentional AI Coding' tool was used, which uses the ChatGPT artificial intelligence model to suggest codes for a section of text. This tool was used to inform on possible alternative wording for codes, and always compared to the initial code made by the researcher. With this, codes were iterated and occasionally allocated a more contextually fitting code than the initially designated code. Following this, codes formed groups based on inductively identified commonalities between the codes. The appropriate guideline and advice connected to each group was drawn from the qualitative data point level and code level, which are presented and discussed in chapter 7. Finally, group titles were inductively obtained from the codes, and by linking commonalities in group titles, factors were drawn. As coding is an iterative process, codes, groups and factors were rewritten on occasions, following a feedback loop not only on the whole system as shown in Figure 11, but also between the code and group levels, and the group and factor levels.

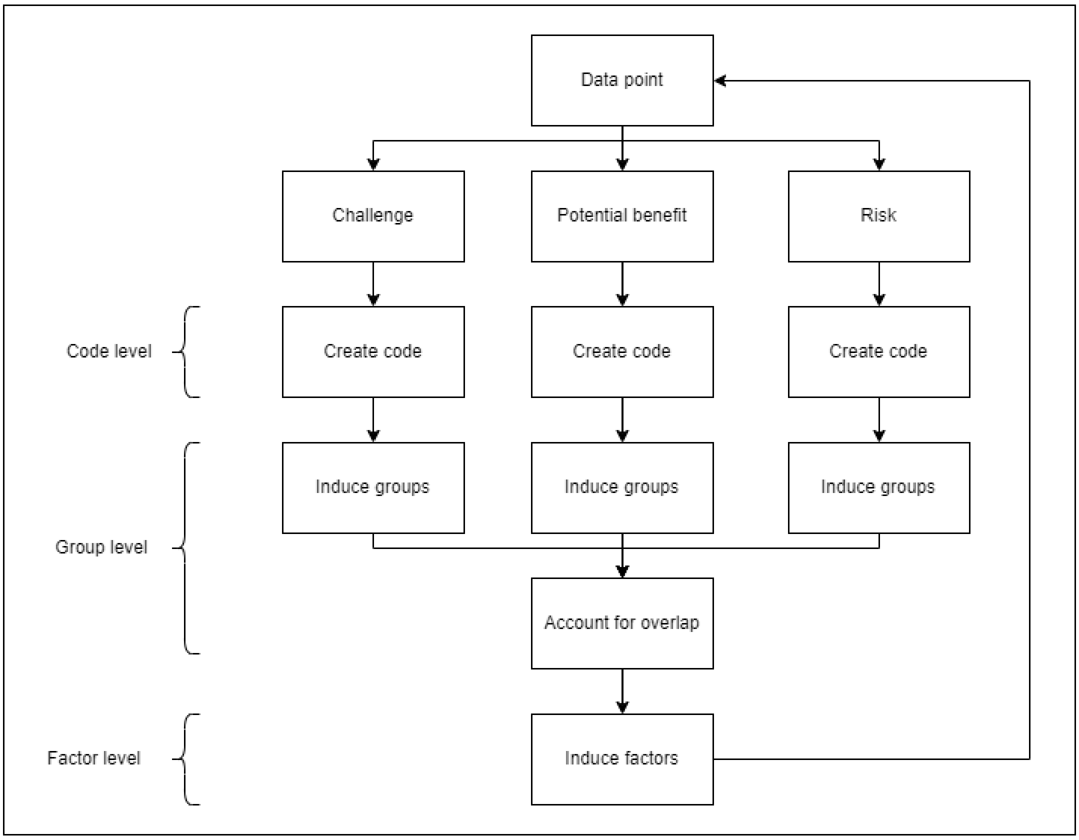

Figure 11. Hybrid coding process adopted for this study.

6.2 Statistical insights

Simple statistics were calculated from the qualitative data points, in order to inform the researcher of data trends and possible outliers. In Table 11 of appendix A, a noticeable trend in a lesser number of responses recorded for Case 3 can be identified due to it being the only case where one manager was interviewed, when compared to the other three cases which had two managers interviewed per case. In addition, a skew can be identified towards uNLock in the challenges and risks categories, which can be explained by the fact that this case is classified as a failure, and perception and awareness is increased around the recorded challenges and risks. In Table 10 of appendix A, five questions did not pertain responses perceived as a challenge, this may be explained by bias that managers may hold towards their own project's success. This will be further explored qualitatively in the subsections of 6.3. Ultimately, while certain skews are present in the qualitative data for certain cases and sections, the data is sufficiently distributed over the questions and the data was proceeded to the designed qualitative analysis approach.

6.3 Coding results

Before stating and discussing challenges, potential benefits and risks encountered by blockchain-based consortia, the coding results and the final resulting factors are presented (Figure 12). The factors are:

- Knowledge Transfer
- Technology and use-case
- Security
- Funding and Economic Considerations
- Organizational
- Vision

These factors emerged and were identified when observing the group level components, as explained in section 6.1. The factors mark the exploratory evolution of this study, making use of the rich empirical data that emerged. The subsections 6.3.1 till 6.3.3 describe and explain the rationale behind the structure of Figure 12. This figure is the outcome of the coding activities performed.

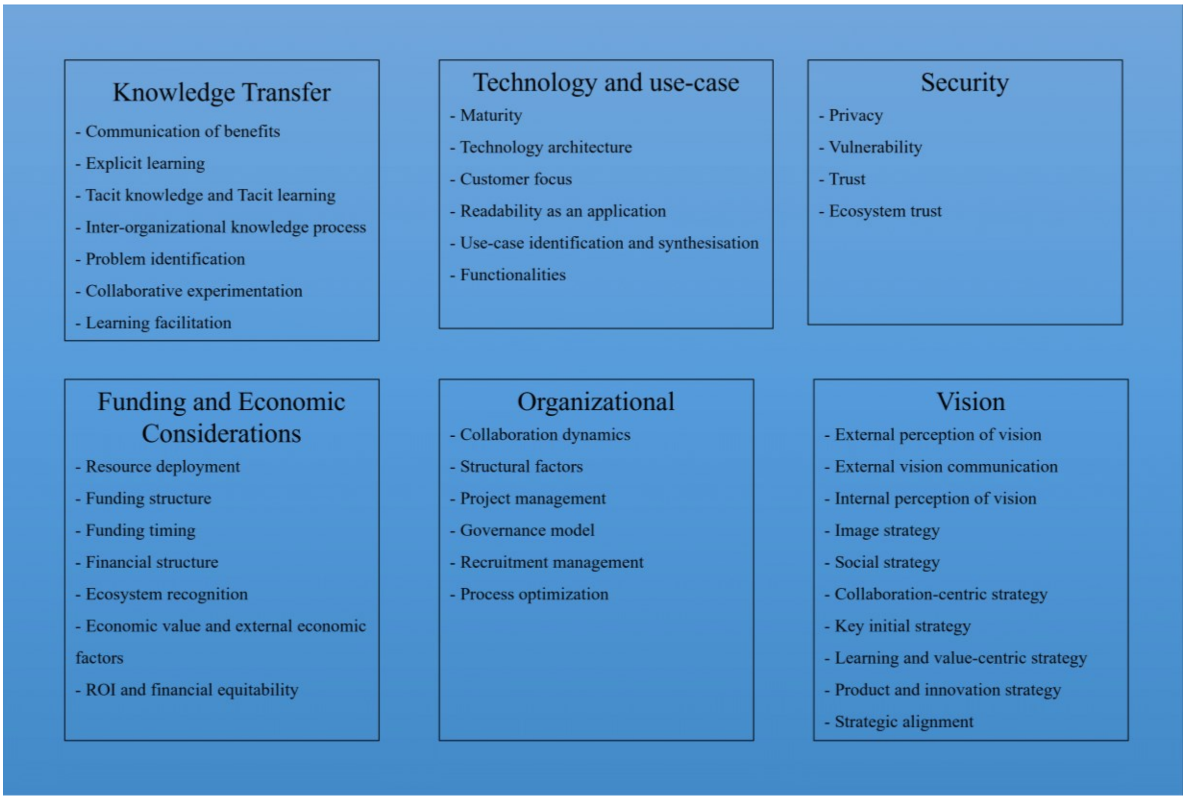

Figure 12. Coding results showing the groups in blockchain consortia decision making, organized by inductively identified factors.

6.3.1 Challenges of development

The definition of a challenge is given in section 6.1 as: *Representing an aspect of difficulty when attempting to complete an element of the project, and it has a low level of uncertainty regarding the outcome.* Using this definition, this section discusses the diverse set of challenges encountered by the four blockchain consortia cases of this multiple-case study. Table 4 shows the comprehensive codes of challenges that blockchain-based consortia face, framed by groups and factors. The rest of section 6.3.1 discusses the challenges for each of the four cases, always in relation to the codes and categorizations shown in Table 4. The ensuing tables in the rest of this chapter detail the group-level codes that are seen in Figure 12.

6.3.1.1 Future Mobility Data Marketplace

The FMDM challenges spanned all factor-level items except Vision. Noticeably, two maturity challenges were encountered. These two challenges commenced when the consortium desired to provide data via *streaming rather than via downloading* mechanisms and for private *cryptographic key management*. In the organizational factor, a challenge was observed in the *organizational evolution*, as employees reported difficulties in adapting to the way of working in a Web3 and blockchain environment. In terms of knowledge transfer processes, FMDM technical partners Sphereon and DeltaDAO reported the slow and challenging process of transferring blockchain knowledge (*domain communication and subject matter understanding*) and technical mechanisms of the platform to non-blockchain partners such as Rijkswaterstaat. In addition, legal experts struggled in learning the mechanisms of the actual datasets and AI algorithms not residing on the blockchain, instead the metadata being the blockchain proof that is shared. This aspect also shows the importance of accurate qualitative coding, as this may be interpreted as a *privacy* challenge in the security factor, however, the key process in this code is the transfer of technical knowledge to the legal experts. Security aspects were described by participants as a challenge due to the way it can limit the speed of innovation, and the time expenditure needed in order to adhere to *privacy regulations*. Finally, *funding commitment* challenges were identified, allocated within the funding structure group. Specifically, distributing equal funding responsibilities to all partners is a challenge.

6.3.1.2 Hyfen

In the pension rights transfer project leading to the Hyfen spinoff, challenges were recorded in all factors-level items except for in the funding and economic considerations factor. *Imbalances in legal* *and software expertise* between APG and PFZW meant a challenging learning curve of employees regarding new legal frameworks and software architecture. In the maturity group, an interviewee explained the challenge of *blockchain scaling encountered in 2021*, to meet the needs of the additional use case of serving a nation-wide pension system built on a blockchain system. In addition, the *interface, input and output variables* for the blockchain were additional challenges identified and inductively placed within the technology architecture group. *Privacy* was a heavily discussed and challenging issue in decision making, due to the sensitivity to critical personal financial data of customers. The project experienced *internal standardization* issues, which was inductively categorized as an organizational aspect. Specifically, the internal standardization challenge evolved around setting a standard for all partners to use, for both the data model and interface model. Internal standardization of the data and interface model was placed in collaboration dynamics, rather than structural factors as it more closely assimilates with the other codes placed in this group. The ACM (Consumer and Markets regulator in the Netherlands) required a lot of attention and information regarding the blockchain-based product, and a challenge presented itself in the form of how the *vision of the consortium was perceived* by this external stakeholder.

6.3.1.3 uNLock

In the uNLock initiative, challenges were present in all of the six factors. For the knowledge transfer factor, '*diverse opinions*' in the inter-organizational knowledge process group highlights the organizational challenge of too many managers involved in the consortium, which got in the way of effective decision making as managers presented vastly different opinions on subject matters. In the privacy group, differences in *use-case privacy concepts* between uNLock and the Dutch Ministry of Health led to diminished efficiency in decision making. Within the resource deployment group, *mobilizing resources* for certain consortium partners was the challenge identified in the uNLock case. The low speed of mobilization by the large enterprise meant a misalignment in formal decision making, and this is very closely related to the code '*large enterprise (LE) inflexibility*' in collaboration dynamics of the organizational factor. A two-dimensional recruitment management challenge was present in the uNLock case. Firstly, it was difficult to hire *sufficient full stack developers*. Secondly, it was a challenge for TNO to transform their staff from a software research development mindset to a project-based production mindset. The key challenge experienced by uNLock, based on repeated emphasis by participants during the interviews was within the external perception of vision group. The code '*technological pre-emptive negative perception'* is placed in this group as it describes how the senior management of the Dutch Ministry of Health disagreed since early on in decision making with blockchain as a proof of data sharing system, without stating fundamental reasonings. In addition, the *internalized vision* became misaligned and distorted when new partners joined with less of a socially relevant vision and more of a commercial focus.

6.3.1.4 JuicyChain

The interviews recorded challenges for the JuicyChain project in the knowledge transfer, security and vision factors. In the knowledge transfer factor, a '*lack of awareness of transparency benefits*' and '*fear of being open*' was identified for organizations interested in supply chain transparency of juice products, indicating the importance of the communication of benefits and problem identification as factors affecting blockchain consortia. These codes highlight that general business practices do not enable awareness around the benefits of displaying certain information on an open system such as blockchain. In addition, the interviewee explicitly stated that a "key challenge in the web3 domain is still communication and understanding of the domain", which is clearly an issues of knowledge transfer. *Privacy* challenges presented themselves with transparency-specific mechanisms. For example, privacy concerns arose as part of the use-case of validating deforestation-free claims for juice products, as the plantation location and surrounding forest locations are necessary parameters in order to validate these claims. JuicyChain has a vision to achieve industry-wide goals with the initiative pertaining to traceability, transparency and sustainability. However, the interviewee stated the challenge of achieving sufficient *onboarding of competitors* in order to achieve the industry-wide goals, showcasing the effect of the external perception of the vision.

Table 4: Codes of challenges for blockchain-based consortia.

Factor:	Knowledge Transfer	Technology and use-case	Security	Funding and Economic Considerations	Organizational	Vision
Challenges	**Communication of benefits** - Lack of awareness of transparency benefits - Persuading of benefits - Awareness-oriented influencing **Explicit learning** - Imbalance in legal expertise - Audit-trail demonstration **Inter-organizational Knowledge process** - Developer learning challenges/difficulties - Domain communication and subject matter understanding	**Maturity** - Blockchain scaling maturation challenge in 2021 - High volume and uptime requirements - Scaling challenges - Technological maturation (keys) - Technological maturation (streaming) **Technology architecture** - Type of input, output, interface variables - Open-source disagreement - Fundamental conflicts	**Privacy** - Privacy concerns - GDPR - Use case (privacy) development challenge - Privacy management/integration **Vulnerability** - Customization of data model - Open readability development - Security adaptation process	**Resource deployment** - Economic optimization by piloting - Mobilization process - Funding commitment process - Cost-benefit challenge - Limited funding **Funding structure** - Funding commitment process - Cost-benefit challenge	**Collaboration dynamics** - Open readability development - Workflow transformation - Cross enterprise workflow integration challenges - Large enterprise (LE) inflexibility - Domain-leadership reversion - Internal standardization - Incumbent processes **Project management** - Organizational development challenge (delivering agile team) - Commercial capability challenge **Recruitment management** - Key recruitment and training augmentation - Permissioned off-chain onboarding process - Developer recruitment process - Recruitment process - Developer recruitment process **Structural factors** - Consortium structure development - Organizational evolution, Web3 organizational difference - Insufficient organisational rigidity	**External perception of vision** - Regulator attention - Onboarding stagnation - Technological pre-emptive negative perception - Lack of shared vision reinforcement **Internal perception of vision** - Late strategy misalignment - Benefit-oriented development process

Factor:	Knowledge Transfer	Technology and use-case	Security	Funding and Economic Considerations	Organizational	Vision
	- Diverse opinions - Informing legal staff that sovereign data resides off-chain **Problem identification** - Problem definition - Knowledge integration of problem definition - Fear of being open	**Use-case identification** - Use-case stagnation - Problem definition			- Consortium terms boundary	

6.3.2 Assessing potential benefits

With the chosen definition of a potential benefit as: *The positive outcome of the task or element is established, and it has a low level of uncertainty regarding the outcome*, exploration and discussion of the potential benefits encountered can be done with the data provided by the four blockchain consortia cases. Table 5 shows the codes of potential benefits placed within groups and factors. Throughout the remainder of this section, the potential advantages consistently correspond to the codes and categorizations delineated in Table 5, across all four cases.

6.3.2.1 Future Mobility Data Marketplace

For the Future Mobility Data Marketplace, potential benefits are highlighted in each of the six factors. Collaboration between industry and universities is fostered by Rijkswaterstaat, the main stakeholder in FMDM. Rijkswaterstaat initiates 'Challenge' programmes at universities to stimulate knowledge creation and gather this knowledge for generating additional use-cases within FMDM. This potential benefit code is identified to be in the learning facilitation group, due to the facilitated way of learning and developing new innovations by Rijkswaterstaat. Related to this, is the potential benefit of the *learning strategy* involved in this approach (pertaining to the vision factor), as collaboration is leveraged in order to openly innovate. In the technology and use-case factor, the synthesisation of multiple use-cases enabled by blockchain was grouped. It was stated that the blockchain infrastructure allowed for *auditability datasets and algorithms*, combined with a cryptographic signature and label of the party that did the audit. In addition to this, being able to set specific conditions on each dataset and algorithm such as pricing, synthesized with the aforementioned auditability use-case. Furthermore, this *automatic payment processing* can receive automatic payment from the transactions and monetize the datasets and algorithms. The compelling gain in efficiency while maintaining privacy is a key aspect of the compute-to-data concepts used within FMDM. Rijkswaterstaat controls high amounts of video data which is restricted due to the sensitive nature of the data. Expensive and long legal procedures are the standard practice for enabling the sharing of restricted data to external parties and the current FMDM application reduces costs and time in this regard. The *return on investment* (ROI) metric pertains to qualitative returns that the consortium and/or society gains. The potential benefits in this group come from the fact that public goods and services are created from income that Rijkswaterstaat receives. The *workflow transformation* belongs to the process optimization group, as the code signifies the change in ways of working for the consortium partners in pivoting towards the platform for sharing data rather than through lengthened legal contracts between parties. Finally, a potential benefit in *strategic early branding* as a key strategy was identified, as mobility and data sharing was combined on a very limited marketing budget.

6.3.2.2 Hyfen

In the project leading to the Hyfen spinoff, which enables pension rights transfer between pension providers, potential benefits were identified in all six overarching factors. The collaborative experimentation showed that the *business knowledge* was synthesized between the two pension providers involved, and was essential for establishing a joint economic model based on the data owned by of each pension providers. In section 6.4, *imbalances in legal and software expertise* between APG and PFZW is described as a challenge, however from the same data point it is gathered that this also drove motivation for PFZW to improve their knowledge and practices in legal and software expertise, constituting a potential benefit and coded within the learning facilitation group. An example of a potential benefit within the technology and use-case factor is the *customer-oriented* nature of the pension transfer use-case, as digitalization of the previously paper-based process means that Hyfen can transfer the pension rights in a matter of 10 days, compared to the 9 month average time period of the paper-based process. In the security factor, a key advantage for commitment from partners was the *early priority given to risk and compliance models*, as a priori to the innovation. Later on in decision-making processes, this allowed for the focus to shift to the innovative technologies involved in the project without jeopardizing risk and compliance of the innovation. This was inductively placed as ecosystem trust, as this approach allowed for gaining partner confidence in further commitments in later stages of the project. Within the financial structure group, the equitable funding structure between the involved partners was stated to not be a cause of the successful failure aspect of the project, as it was balanced in the capital committed by each partner, facilitated by the fact that all parties involved are LEs. A participant describes the information flow as "very open, with highly interjoined processes, information architecture and clear work instructions. The amount of fluidness on information between organization was very high, which led to good collaboration." This example of a successful *cross enterprise optimization process* was gathered within the process optimization group, as it clearly shows the benefits of optimizing processes by highly interjoining the way of working for consortium partners.

Sustained belief in decentralized collaboration, describes the collaboration strategy which still resides in the consortium despite the phasing out of the underlying decentralized blockchain infrastructure, and is classified accordingly. It follows that Hyfen still firmly believes that working together in the pension industry is better than working individually on own solutions, and the scope of solutions that can be developed via collaboration is expanding.

6.3.2.3 uNLock

In the factors knowledge transfer, funding and economic considerations, organization and vision, the uNLock initiative presented significant potential benefits. Certain knowledge transfer occurred between uNLock and the Corona-app when it was eventually rolled out by the Dutch Ministry of Health, labelled as *cross-project design influencing*. This is because to some extent, certain lessons learned in uNLock had been observed by the Dutch Ministry of Health, which is a tacit knowledge transfer aspect. A key potential benefits that resides within the economic value group is the *spillover of economic benefits in parallel projects,* which is highly attributable in uNLock. It was highlighted that all partners had economic benefits resulting from their involvement in the uNLock consortium, albeit to different degrees. Deloitte, CMS and Rabobank received addition work from the Dutch Ministry of Health for other projects in the same field, as a result of uNLock. Consequently, this beneficial aspect was placed within the economic value group. Resources were more efficiently mobilized by *authority augmentation* within TNO. This was highly situational, as an internal programme named 'Brains against Corona' allowed for increased authority of the consortium manager for mobilizing resources in favour of a project pertaining to circumventing the health safety and social problems due to the COVID pandemic. This was inductively placed as pertaining to the project management, as it directly describes how the project can be planned and executed under a modified structure of authority. In the vision factor, the *problem urgency* within the social strategy group was key towards driving a collaborative mindset. By catering to the nationally and internationally high-urgency problem of health safety and social implications caused by the COVID pandemic, each individual within each consortium partner could personally identify themselves with the problem at hand. This feeling the cruciality of the problem in their day-to-day lives, fostered motivation towards collaboration.

6.3.2.4 JuicyChain

The predominant potential benefits highlighted in the JuicyChain project are found throughout all factors of Table 5. *Iteration of partner requirements* is identified as collaborative experimentation in the knowledge transfer factor. This beneficial approach embraces the doubts or questions that new prospective JC partners and clients have about the system characteristics. In addition, it is related to the situational assessment as highlighted in the Consortium Capabilities framework, as the iteration of *partner requirements* analyses whether "characteristics been structured unknowingly in a way that is conducive to some partners, but not to other partners", also followed up by the mentioning of consortium diversification by the interviewee. A potential benefit results from the design of a *seamless client onboarding experience through APIs*, which enables integration into day-to-day activities of supply chain partners rather than disrupting internal workflows. Therefore, this positive attribute is allocated as a customer focus aspect in the factor of technology and use-case. The benefit of *parallel project trust spillover* (placed within the ecosystem trust group) is an example of a code which is very difficult to induce into a group, as it can be attributed to multiple groups on a higher level. While the code demonstrates a transfer of trust in an ecosystem, from one project to another, this can also be attributed to the tacit knowledge group within the knowledge transfer factor. This is because trust is difficult to formalize or explicitly document, as it is based on personal relationships and shared experiences.

Table 5: Codes of potential benefits for blockchain-based consortia.

Factor:	Knowledge Transfer	Technology and use-case	Security	Funding and Economic Considerations	Organizational	Vision
Potential benefits	**Collaborative experimentation** - Partner requirements iterating - Use-case communication - Business knowledge synthesisation **Learning facilitation** - Motivated by knowledge transfer process - Learning development - Industry-Education collaboration - Non-technical partner learning facilitation - Educational blockchain outreach **Tacit knowledge** - Awareness enrichment process - Decentralized and collaborative concept retention - Cross-project design influencing	**Customer focus** - Customer-oriented use-case - Pension Transfer speed optimization - Seamless client onboarding experience (API) **Functionality** - Collaboration facilitation technology - Collaboration transformation process, blockchain definition **Readability use-case** - Development of transparency design - Agricultural traceability importance - Open readability requirement - Data abundance of driving sensors - Interoperability - Audit trail development **Use-case synthesization** - Companies adopting to benefit from multiple use-cases - High market reach servicing, use-case exploration	**Privacy** - Privacy integration - Decentralized preference for sensitive data handling - Restricted data sharing **Ecosystem trust** - Parallel project trust spillover - Security-centric process - Risk and compliance priority	**Financial structure** - Early funding arrangements process - Investment based on demonstrated commitment - Equitable funding structure **Economic value** - Efficient data commercializing - Value realization - Spillover economic benefits parallel projects **ROI** - Value realization - Financial benefit for consultants	**Collaboration dynamics** - Triple helix ambition - Decentralized supply-demand integration - Domain-expertise exploitation - Leveraging diverse consortium for enhanced decision-making **Governance model** - Equitable decision-making - Pivotal LE governance model - User data governance - Initial free-format decision-making success **Process optimization** - Situational internal process development - Onboarding and situational assessment synthezising - Workflow transformation, process innovation - Successful cross enterprise optimization process **Project management** - Agile business development - Screening by main stakeholder - Stage gate use-case evaluation process - Project constraint minimization (Greenfield design)	**Collaboration strategy** - Transformative collaboration desire - LE network reach benefit - Leveraging relations strategy - Partner diversifying for covering many problems that they face - Partner showcasing - International domain use-case replication - Senior sponsorship importance - Collaboration benefits from stable strategic goals - Sustained belief in decentralized collaboration - Domain-expertise exploitation - Reputation influence exploitation - Bottom-up collaboration shaped by ecosystem-thinking **Key initial strategy** - Business process priotitizing - Situational driving-force - Strategic early branding **Learning strategy** - Domain-expertise exploitation - University exploitation for use-case generating **Product strategy** - Gradual buildup of use-case - Decisions for demonstrating working solution early **Social strategy** - Customer focus

Factor:	Knowledge Transfer	Technology and use-case	Security	Funding and Economic Considerations	Organizational	Vision
		- Automatic auditing and data and algorithm sharing in single system - Monetization with automatic payment processing			- Resource mobilization by authority augmentation - Multi criteria analysis for decision-making used	- Problem urgency - Societal and economical motivational benefit **Value-centric strategy** - Presenting value in use-case - Efficiency-centric decision-making process - Client attraction by showcasing use-case

6.3.3 Risks during development

Using the definition of risk as presented in section 6.1 (*Risk*: *This category marks a high uncertainty concerning occurrence, is undefined in task difficulty, and can have an undecided positive or negative effect*), this section explores and discusses the diverse risks encountered within the decision making process of the four blockchain consortia cases. Table 6 shows the codes of risks that blockchain-based consortia face, framed by groups and factors. Throughout section 6.3.3, the risks refer to the codes and categorizations specified in Table 6.

6.3.3.1 Future Mobility Data Marketplace

By increasing *blockchain literacy* (explicit learning group) in other partners of the consortium, autonomy ensues for each partner in the technical domain. However, this presents a risk, as a carefully balanced trade-off is necessary. The trade-off is between increasing technical autonomy, and the benefit of development in rapid leveraging the domain-capabilities of each partner to synergize as a whole. The ecosystem recognition of a blockchain project is part of a situational assessment carried out by internal managers or external senior managers for progressing the project to the next stage. It is examined whether the "success of a project is recognized in the ecosystem in order to decide on the next scaling-up step", as mentioned by an interviewee. This presents a funding and economic risk, as projects must focus on being recognized in the ecosystem. The outcome can be both negative and positive, as shifting internal resources from developing the use-case to aspects like branding and marketing can influence the internal assessments and suggest that the project is not ready for the next stage.

6.3.3.2 Hyfen

An interviewee highlighted that "collaboration within innovative technologies gives a double risk factor." The pension industry had not experienced the intensity of collaboration before 2021, and this highlights the need for a *collaboration precedent,* before engaging in collaborating on innovative technologies together. Another risk factor is the *job displacement* risk within the vulnerability group.

Partners in the pension industry were hesitant to go forward with this kind of initiative, as the overhaul of the industry practices meant a reduction in jobs.

6.3.3.3 uNLock

While the Hyfen case had an equalized *risk disparity* (financial equitability group) in the consortium, due to the LE-nature of each partner, the uNLock case had a mix of SMEs and LEs, which increased the risk in collaboration for the SMEs. The blockchain-developer SME committed a lot more *resources on a net percentage basis*. This can be a cause for SMEs to abandon the consortium, in order to guarantee the survival of the company if the consortium initiative does not turn out to be a success. In the project management group of the organizational factor, the '*lack of situational awareness risk'* is highlighted as an important factor. Due to the voluntary nature of the uNLock consortium, no real (periodic) situational awareness was carried out by the partners, as the project is described as "living week-by-week". This can lead to systemic problems being entrenched and uncovered, with late discovery of these problems being detrimental to success.

6.3.3.4 JuicyChain

This case demonstrates the importance of external unforeseen regulatory risks (external factors group). The OFC, which is the technological partner behind the JuicyChain application, also founded the CacaoChain. Regulation around sustainable cacao farming has created incentives for organizations to create traceability solutions in order to comply and innovate with regulations, showing *external unforeseen regulatory benefits.* While such an effect has not happened for the JuicyChain application, it emphasizes the external regulatory risk that blockchain consortia run, which can have both a desired and undesired effect.

Table 6: Codes of risks for blockchain-based consortia.

Factor:	Knowledge Transfer	Technology and use-case	Security	Funding and Economic Considerations	Organizational	Vision
Risks	**Explicit learning** - Leapfrogging risk - Innovation desire involvement - Increasing partner blockchain literacy for risk mitigation **Tacit learning**	**Customer focus** - External unforeseen regulatory benefits - Not hindering work routine of low digital literacy persons - Focussing on use-case benefits, rather than technology push	**Privacy** - Formulation for an alternative for data sharing of identifier variable - Streamlining agreements for sensitive data handling **Trust** - Interorganizational trust precedent	**Ecosystem recognition** - Assessment of how the project is recognized within ecosystem - Performance-based decision-making - Funding vs open-source paradox **External (economic) factors** - Macroeconomic risk	**Collaboration dynamics** - Lack of historical collaboration precedent - Work culture differences - Risk of power imbalance in technology partnership - Unprioritized consortium format - Consortium priorities divergence - Project attention divergence due to side-initiatives - Governance and decision-making divergence	**External Vision communication** - Data sharing value awareness - Delayed shared vision formulation - Shared vision collaboration with other consortia **Image strategy** - Crisis responsibility image - Brand image exploitation

Factor:	Knowledge Transfer	Technology and use-case	Security	Funding and Economic Considerations	Organizational	Vision
	- Data sharing decision understanding (why voluntary sharing is important) - Informal networking for organizing collaboration - Low available knowledge on blockchain consortia mechanisms	**Functionality** - Use-case exploring - Technology maintenance stagnation - Mobility data-sharing interoperability demand - Main stakeholder internal use-case negotiation	before initiating innovation - Scale dependence in absence of collaboration precedent - Strategic trust buildup - Digital collaboration progression - Partner confidence dynamics evolution, from high confidence to less confidence, based on partner size **Vulnerability** - Collaboration and innovation risk synergy - Job displacement risk - Unintended societal marginalization due to blockchain surveillance	- Economic distress decaying innovation interest - External legislation and macroeconomic effects **Financial equitability** - Distributing funding responsibility - Unequal net percentage-based resource allocation - Risk disparity in LSE vs SME - Company politics impact on funding commitments - Investment risk for SME's - Equitable funding distribution - Commercialization differences leading to resource dynamics regression **Financial structure** - High cost blockchain - Legal expense minimization **Funding timing** - Cost-benefit analysis - Funding should have been established sooner, led to diversion of goals	- Collaboration divergence, focusing on individual goals - Technology: Enthusiasm vs misalignment tradeoff **Project management** - Iterating previous decisions from a central point of control - Senior assessment - Project monitoring - Lack of situational awareness risk - Initial goals failure - Coupling governance with scaling - Authority management (BaC) **Structural factors** - Evolution of partner roles - Foundation architecture complexities - Consortium vs startup trade-off - Consideration of startup model for decision-making efficiency - Partner domain-expertise and timing - Blockchain infrastructure decision-making (RWS node)	- Image strategy and consortium size discrepancy, as it led to slower decisions - Key partner capabilities (image) evolution of value **Innovation strategy** - Technology choice deprioritizing - Internal process improvement via innovating - Low-complexity prioritization - Open-source showcasing - Template-based opportunity exploration **Strategic alignment** - Innovation-speed vision misalignment - Vision vs vision implementation strategy discrepancy - Regulator misalignment - Balancing speed and formality in consortium initiation - Consortium risk in not reinforcing and reiterating strategy

6.3.4 Blockchain consortia decision-making factors

The decision-making factors are the factors presented in Figure 12. The data collected and processed from interviews has demonstrated that observing and managing these factors in blockchain consortia is significant for addressing challenges, assessing potential benefits and managing risks. It is important to note the similarities and differences between the results of the framework from thematic analysis (Figure 12) and the Consortium Capabilities analytical framework (Figure 9). Firstly, the importance of use-case emerges from the fact that it is an overarching component in both frameworks, although Figure 12 frames this together with technology. Technology is framed independently from use-case in Figure 9, but the empirical evidence in this research has shown that the high degree of interconnection between these two elements called for a combined overarching factor. Vision is another similarity, although Figure 12 takes a more holistic view compared to Figure 9, with subset strategic factors, because strategies are defined as implemented approaches to execute the vision of a consortium. While Security is another similarity between the two figures, it is placed at a significantly higher level in Figure 12.

The difference follows from the discovery of the importance placed on the groups within the Security factor in the studied cases. In Figure 9, Security presents itself as an outcome within Partner Operations, however in Figure 12 the specific Security elements are detailed on the group level as being privacy, vulnerability, trust, and ecosystem trust, and do not pertain to an outcome of the decision-making process, rather as contributing elements throughout the decision-making process.

Numerous other factors and groups are added and thus differ to the Consortium Capabilities framework, namely Knowledge Transfer, Funding and Economic Considerations, and Organizational, on the factor level. The factor Knowledge Transfer, nor similar concepts are mentioned in the Consortium Capabilities framework, which is not in agreement with empirical findings. In order to provide a collaborative advantage as dictated by the adapted RBV framework, transfers of knowledge take place between partners, to synergize the domain expertise of each organization. Funding and Economic Considerations are mentioned as an overarching factor in Figure 12, while the Consortium Capabilities framework includes related components of this such as 'Economic analysis' and 'Direct economic benefits', but not under an overarching Economics category, rather separated by Conditions for success and Outcomes. The Organizational factor is introduced in Figure 12, marking a significant difference to Figure 9. This is because organizational elements are present in Figure 9 on the component level (Situational assessment and Governance) and for certain subcomponents (Cross enterprise workflows and Process improvements). With these similarities and differences in mind, the resulting factors and groups shown in Figure 12 set the stage as building blocks of the guidelines in Chapter 7.

6.4 Conclusion

The sub-question tackled in this chapter was: *What factors emerge from challenges, potential benefits and risks in development of blockchain-based applications managed in the decision-making process?* Chapter 6 has presented and discussed the data processing and analysis methods, statistical insights and the coding results. The statistical insights were used for the pragmatic identification of simple data trends and possible outliers. To conclude, case-specific challenges, potential benefits and risks were triangulated in order to inductively construct groups, followed by the inductive exploration of the overarching factors. To answer the sub-question, the factors that arise from the challenges, potential benefits and risks, that affect blockchain consortia are: *Knowledge Transfer, Technology and use-case, Security, Funding and Economic Considerations, Organization* and *Vision*. This finding is important in order to realize the foundation on which guidelines are built for answering the main research question. The next chapter presents the guidelines based on the factors found, as presented in figure 13.

7 Guidelines for decision-making

The relevant research sub-question to this chapter is:

Which guidelines can be designed for managers in consortia to aid in decision-making of development of blockchain-based applications?

Firstly, this chapter presents the guidelines constructed, developed on the group-level, within the factors shown in Figure 12 in section 7.1. The guidelines are inherently built on how these factors played a role in decision-making in the cases, based on challenges, potential benefits and risks. An initial version of the guidelines was validated by consortium managers of two other cases: EnergySHR and Ondernemingspaspoort (Company Passport). Then, in section 7.3 the guidelines are adapted to contain any critiques given by the interviewees. The validated guidelines present the final deliverable of this thesis.

7.1 Guidelines for decision-making

The guidelines for decision-making are presented in Table 7. These guidelines follow directly from combining the challenges, potential benefits and risks that consortia face within each of the established groups in the factors. For some groups, such as the collaboration dynamics group within the organizational factor, the group can be identified across all challenges, potential benefits and risks sections. This allows for the comprehensive combination of codes within the common group across the different sections or within the section if the group is associated exclusively to challenges, as further discussed in the latter half of this paragraph for the example provided. Furthermore, the advice pertained in the guidelines was constructed by generalizing the information provided within the group. For example, the manner in which Guideline 1 was created follows from the challenges identified in the cases, derived from Table 4. JuicyChain's challenge in raising *awareness around transparency benefits* shows challenges in the appropriate decision-making for achieving this, which is similar to the Hyfen case in the convincing of partners of the valuable differences (*persuading of benefits*) in changing to a blockchain-based system for the sharing data in a pension-rights transfer. Also in the FMDM case, an *orientation around awareness* had to be developed for legal staff to learn how and what data is stored on-chain. Enabled by this common role of unawareness of benefits in the cases, these codes (as shown in italics) create the guideline "It is necessary to develop rigid **Communication of benefits**, as less informed partners need to be made aware of the benefits of blockchain based-applications" as shown in Table 7. The same approach was used for all guidelines constructed in Table 7.

Table 7: Blockchain Consortia Guidelines.

Category	Guide-line number	Guidelines
Knowledge Transfer	1	It is necessary to develop rigid **Communication of benefits**, as less informed partners need to be made aware of the benefits of blockchain based-applications.
	2	**Explicit learning** needs structured transfer of hard skills between partners within the consortium in order to improve overall blockchain innovation literacy.
	3	**Tacit knowledge** and **Tacit learning** are crucial and should be stimulated in order to capture informal knowledge transfer and develop synergies between projects in an ecosystem.
	4	The **Inter-organizational knowledge process** needs structured mechanisms to ensure the capture, organization, maintenance and storage of knowledge. Integral to this, is **Problem identification**, whereby the problem must be defined with specific boundary conditions**.**
	5	**Collaborative experimentation** is essential in order to communicate and iterate critical partner and customer requirements for the minimum viable product.
	6	Create **Learning facilitation** environments, as it is essential for gaining knowledge from knowledge institutions such as universities, and for capitalizing on motivated partners.
Technology and use-case	7	Prioritize recognition of the **Maturity** of the components of the technology, by innovation stage assessment.
	8	Define and iterate the **Technology architecture**. While templates can offer the fastest delivery of a minimum viable product, a bottom up approach offers the highest degree of customization.
	9	Maintain a **Customer focus**, whereby decision-making evolves around how use-case(s) can improve the experience of a client. Develop seamless onboarding mechanisms with an API.
	10	**Readability as a use-case** of blockchain has been shown as a core use-case whether for audit trail purposes, social transparency, or interoperability. Emphasize the importance of readability to consortium partners and create a supportive community around this.
	11	Employ a significant amount of time towards **Use-case identification** and **synthesisation,** as building multiple **Functionalities** into one design creates higher added value for customers and increases customer reach.
Security	12	The sole creation of a **Privacy** compliance model is insufficient for blockchain consortia. As **privacy** presents itself as a pressing issue in blockchain consortia, a privacy strategy and privacy business process management must be developed in the initial stage of the project.
	13	Societal, corporate and operational threats create **Vulnerability** to the success of the initiative. Awareness of these vulnerabilities and possible mitigation measures must form the core of ethical defence mechanisms of the consortia.
	14	Prioritize initiatives with a collaboration precedent, as success of an initiative shows dependence on **Trust** established in previous or parallel projects. **Trust** should be monitored across consortium members, and a significant difference in scale for sequential projects is not desirable for solidifying trust, rather a gradual scale should be established.
	15	**Ecosystem trust** is enabled by spillover trust from other parties and initiatives in the ecosystem during previous or parallel projects.
Funding and Economic Considerati ons	16	**Resource deployment** should focus on the resource mobilization process for achieving the vision of the consortium, while being conscious of funding allocation processes within partner allocations, as to create an equitable **funding structure** before initiating a consortium for collaboration on a project.
	17	**Funding** for the project should encourage the allocation of resources as soon as possible in the decision-making process, as lacking or delayed commitment in this can cause a diversion of goals as partners lengthen their exploration process.
	18	Create a **Financial structure** based on commitment demonstrated by consortium initiators, with tracking of the costs of the blockchain system**.** Paradoxically, open-source structuring can moderate the importance of the financial structure as a community driven initiative can show significant participation and worthiness.

Category	Guide-line number	Guidelines
	19	Account for **Ecosystem recognition** for the project, as interconnected nature of business ecosystems plays a prevalent role in assessing performance, and therefore the priority given by senior managers.
	20	Develop methods to quantify the **Economic value** created by data commercialization on a blockchain system, including threats and opportunities presented by **External economic factors** such as the sensitivity of innovation towards the macroeconomic landscape and legislative changes.
	21	Individual and systemic **ROI** metrics establishment is necessary in order to track the creation of added value. Funding responsibility should not be exclusive to a single partner, therefore the **Financial equitability** principle states that distribution of this is necessary on a net percentage basis, taking into account the reduced funding capability of SME partners.
Organizational	22	Foster promotion and awareness of implicit **Collaboration dynamics** to enable coordination of use-case development and implementation. Partners should assess ahead of initiation whether work platforms are compatible and the extent to which workflows can be integrated, recognizing that large enterprises (LEs) tend to be less flexible in this. Productivity is enhanced when partners exploit their expertise centre, and frameworks should be developed for work distribution. When organizations do not have a historical collaboration precedent, smaller collaborative projects should be prioritized to accustom oneself to each other and highlight differences in work culture.
	23	The voluntary nature of consortia with insufficient organisational rigidity and clear consortium boundary terms are crucial **Structural factors** that must be designed and evaluated before initiating the consortium, due to the disruptive nature of blockchain as an organizational data foundation.
	24	While the aforementioned **Structural factors** refer to foundational elements of a project undertaken by consortia, **Project management** entails the planning, oversight and control aspects of the initiative. Embrace agile development while utilizing periodic senior monitoring, screening and assessment as a stage-gate oversight tool.
	25	Couple governance with scaling, making sure to assess whether the governance model is optimal as more partners join the consortium. Ensure each partner has equitable authority in the **Governance model.** When LE's form the foundation of the consortium governance, it allows the largest market concerns to be addressed and the development of a high impact use-case.
	26	Develop a specified **Recruitment management** strategy for talented blockchain developer acquisition, that fulfils the necessary capacity for achieving consortium goals.
	27	Evaluate desired **Process optimization** approaches, and track the differences with business process management tools.
Vision	28	The initiation of a consortium should start with the formation of a shared vision. Establish how the **vision is perceived externally**, and reinforce this vision throughout the lifecycle of the consortium with **External vision communication** channels. Ensure that the **Internal perception of the vision** is in alignment since the consortium initiation stage.
	29	Exploitation of the brand image of a LE to gather awareness for a use-case and overall project is a popular **Image strategy**, which helps in adding perceived legitimacy and bring attention to the project.
	30	Integrate a **Societal strategy** that has a customer focus and academically advocates the problem urgency that the use-case is addressing.
	31	A **Collaboration-centric strategy** must be followed in order to leverage and expand network reach for attracting new consortium partners. Follow a strategy of monitoring and communicating with external actors that exert influence on the undertaken initiative. Seek senior sponsorship and showcasing to partners as strategies for accelerating the decision-making process.
	32	Identify the **Key initial strategy** with minimal pivoting, without continuous strategy shifting, in order to retain partners.
	33	The **Learning strategy** should evolve around leveraging the core competencies of each partner and appealing to knowledge institutions, while the **Value-centric strategy** should focus on how to present the value proposition towards prospective new parties.

Category	Guide-line number	Guidelines
	34	Establishing the **Product** and **Innovation strategy** can involve approaches such as demonstrating an early working solution, deprioritizing the blockchain theme, and prioritizing a low-complexity solution.
	35	Foster **Strategic alignment** between consortium partners by clearly defining the objectives, periodically reiterating the selected strategies, and identifying vision implementation discrepancies.

7.2 Cases used for guidelines validation

The factors, groups and guidelines in Table 7 were validated using two blockchain projects taking place in a consortium format. The factors were fully recognized by all managers. The following two subsections describe each of these projects. In order to perform a scientific validation it is necessary to remain in line with the same case selection approach of section 5.1, for selecting validation cases. On this basis, it followed that cases had to be most-different as much as possible from each other, but also from the four cases that were selected for building the guidelines.

7.2.1 EnergySHR

EnergySHR is a platform on which researchers can share datasets and AI algorithms to facilitate the energy transition from fossil fuels to renewable energy. TU Delft, Erasmus University Rotterdam, DBC, deltaDAO and Sphereon are the consortium partners. The platform uses the compute-to-data approach and the European Gaia-x framework to maintain digital sovereignty of data and benefit from data that is otherwise difficult to share. Currently, researchers using EnergySHR have their own login credentials but have a 'hosted' walled. This means that they have no access to the cryptographic keys of their individual wallet, which are instead controlled by an identifiable third party.

7.2.2 Ondernemingspaspoort

The 'Ondernemingspaspoort' (English: Company passport), is a joint project between KNB, KVK (Dutch Chamber of Commerce), ABN AMRO, the Netherlands Tax Administration and the DBC. The project entailed designing a trust framework so that new private-limited companies can be fully arranged online by individuals. The Ondernemingspaspoort complies with the electronic Identification and Trust Services (eIDAS) 2.0 framework. The significance of eIDAS (European Commission, 2023) is the regulation of digital identity and personal data storage on European Identity Wallets. The practical implementation of Ondernemingspaspoort is set to provide technical, functional, juridical and organizational agreements to enable secure and interoperable exchange of data. Blockchain was explored as a technology for verifying credentials (digital proofs) as part of the system architecture for the digital founding process of a new private-limited company.

7.3 Guidelines validation

In order to validate the guidelines, the interviewees, who are consortium managers in either the EnergySHR or Ondernemingspaspoort project, were requested to read each of the independent listed guidelines in Table 7, in a one-on-one interview. In essence, the act of validating these guidelines with two cases is also a way of accounting and correcting subjectivity bias present in the guidelines. Bias in subjectivity is reduced with validation interviews, as these interviews help mitigate subjectivity by providing an opportunity for participants to confirm or challenge the researcher's interpretations, which results in the enhancement of the validity of the findings.

The available answer options for the three interviewees were to either recognize, partly recognize, or not recognize the guideline at all (in the context of their project), and to provide additional comments, summarized in the same cell. For the detailed comments of each interviewee, see Table 12 in appendix B, which shows the response for each of the managers in the two cases. Notably, Manager 1 refrained from observing and commenting on the technology and use-case guidelines, while Manager 2 refrained from observing and commenting on most of the organizational guidelines, due to the focus of their respective expertise and job roles within the project. All three managers recognized the factors *knowledge transfer, technology and use-case, security, funding and economic considerations, organizational* and *vision* in their projects to be the top level factors. Comparing the recognition of all guidelines in every factor, the 35 guidelines are mostly labelled as recognized, with 17 guidelines benefitting of correction, of which 14 needed minimal adaptation as they were partly recognized. The rest of section 7.4 compares the validity of the guidelines, focusing on responses labelled as 'partly recognized' and 'not recognized' by the two validation cases.

Comparing the recognitions given within the Knowledge Transfer factor, Guideline 2 is fully recognised in the EnergySHR case, while partly recognized in the Ondernemingspaspoort case. This means an additional condition was necessary for the guideline, namely the trade-off between faster development and explicit learning of other partners. Furthermore, Guideline 6 is partly recognized in the EnergySHR case and fully recognized in the Ondernemingspaspoort case. The EnergySHR manager commented that knowledge institutions are not necessary in order to facilitate learning. In addition, it was mentioned that this guideline was too generalized. In the technology and use-case factor, the Guideline 7 is partly recognized in both cases. Not only the maturity of the components but also the operational and architectural maturity is necessary as a vital aspect mentioned as a comment. Furthermore, attention is brought to release management, which was stated to being a key hurdle in EnergySHR. Guideline 10 was not recognized within the EnergySHR case, while recognized within the Onderneminspaspoort case. This is due to EnergySHR not building a use-case on audit trailing, nor transparency. Combining this feedback means that this guideline was too specific, leading to the coincidental alignment to the Ondernemingspaspoort case but being irrelevant to EnergySHR. This has implications for the external validity of this guideline, as it is diminished by not being appropriate to EnergySHR.

Guideline 13 is partly recognized by both cases. This was because societal, corporate and operational threats occurred to different or no extent in the two cases. In the funding and economic considerations factor, Guideline 17 is recognized to different levels by all participants. This pertains to the possibility that this guideline was insufficiently generalized. Guideline 18 is partly recognized in Ondernemingspaspoort. This conflicting guideline did not take into account that LEs have slower mobilization and longer formal approval processes. Also, the Guideline 21 is partly recognized by both cases, as they state that it is difficult to measure social ROI, while the guideline still acknowledges the presence of social ROI through the describing ROI as systemic.

In the organizational factor, the guideline on governance (Guideline 25) is partly recognized by Ondernemingspaspoort. In addition, recruitment management (Guideline 26) is partly recognized in both cases, highlighting insufficient generalization, as blockchain architects should also be within the scope of the guideline. In the vision factor, Guideline 28 was partly recognized by the Ondernemingspaspoort case. While the guideline captures the difference and importance between external and internal perception of the vision, additional advice is needed on the adjustment of these in response to knowledge dynamics. Similarly, the key initial strategy was partly recognized by the Ondernemingspaspoort case, with the same reasoning. Lastly, the image exploitation strategy (Guideline 29) was only partly recognized by the EnergySHR case, signalling that this guideline was insufficiently generalized.

Four responses are labelled as ‘not recognized’. It was critical predicament for guideline 27, as seen in Table 12 in Appendix B, where two of the four non-recognitions reside, of which both are for the EnergySHR case, presenting a limitation of the guidelines if not adapted. Following the assessment of the guidelines by the validation interviews, the guidelines with partial recognitions and non-recognition are adapted in order to incorporate the critique given, as shown in Table 8. For example, the critical guideline 27 was adapted using feedback given in the validation interviews of EnergySHR. As EnergySHR did not have a comparable working system to compare the blockchain-based application to, the process optimization approaches advice is specified to consortia which do have working solutions, such as Hyfen, which had an entirely paper-based system before their current digitalized solution.

Table 8: (Validated) blockchain Consortia Guidelines

Note on symbols: NA = not applicable, √ = Yes (with guideline modification in following column in italics)

Factor	Guide-line number	Adaptation	(Adapted) guidelines
Knowledge Transfer	1	√	It is necessary to develop *clear* **Communication of benefits**, as less informed partners need to be made aware of the benefits of blockchain based-applications.
	2	√	**Explicit learning** needs structured transfer of hard skills between partners within the consortium in order to improve overall blockchain innovation literacy. *In order to gain initial development traction, trust in other partners with domain expertise is necessary.*
	3	NA	**Tacit knowledge** and **Tacit learning** are crucial and should be stimulated in order to capture informal knowledge transfer and develop synergies between projects in an ecosystem.
	4	NA	The **Inter-organizational knowledge process** needs structured mechanisms to ensure the capture, organization, maintenance and storage of knowledge. Integral to this, is **Problem identification**, whereby the problem must be defined with specific boundary conditions**.**
	5	NA	**Collaborative experimentation** is essential in order to communicate and iterate critical partner and customer requirements for the minimum viable product.
	6	√	Create **Learning facilitation** environments, as it is essential for gaining knowledge from (*knowledge*) institutions such as universities, and for capitalizing on motivated partners.
Technology and use-case	7	√	Prioritize recognition of the **Maturity** of the technology components *and architecture*, by innovation stage assessment.
	8	NA	Define and iterate the **Technology architecture**. While templates can offer the fastest delivery of a minimum viable product, a bottom up approach offers the highest degree of customization.
	9	NA	Maintain a **Customer focus**, whereby decision-making evolves around how use-case(s) can improve the experience of a client. Develop seamless onboarding mechanisms with an API.
	10	√	*When* **readability** as a use-case of blockchain has been *identified for the project* (whether for audit trail purposes, social transparency, or interoperability), emphasize the importance of *openness* to consortium partners and create a supportive community around this.
	11	NA	Employ a significant amount of time towards **Use-case identification** and **synthesisation,** as building multiple **Functionalities** into one design creates higher added value for customers and increases customer reach.
Security	12	NA	The sole creation of a **Privacy** compliance model is insufficient for blockchain consortia. As **privacy** presents itself as a pressing issue in blockchain consortia, a privacy strategy and privacy business process management must be developed in the initial stage of the project.
	13	√	Societal, corporate and operational threats *can* create **Vulnerability** to the success of the initiative. *If program management is present at a higher level of authority, appropriate guarantees can negate this*. Awareness of these vulnerabilities and possible mitigation measures must form the core of ethical defence mechanisms of the consortia.
	14	√	Prioritize initiatives with a collaboration precedent, as success of an initiative shows dependence on **Trust** established in previous or parallel projects. *Internal and external* **Trust** *levels* should be monitored across consortium members, and a significant difference in scale for sequential projects is not desirable for solidifying trust, rather a gradual scale should be established.
	15	NA	**Ecosystem trust** is enabled by trust spillover from other parties and initiatives in the ecosystem during previous or parallel projects.
Funding and Economic Considerations	16	NA	**Resource deployment** should focus on the resource mobilization process for achieving the vision of the consortium, while being conscious of funding allocation processes within partner organizations, as to create an equitable **funding structure** before initiating a consortium for collaboration on a project.

Factor	Guide-line number	Adaptation	(Adapted) guidelines
	17	√	**Funding** for the project should encourage the allocation of resources as soon as possible in the decision-making process, as lacking or delayed commitment in this can cause a diversion of goals as partners lengthen their exploration process. *This is not relevant for projects that prioritize innovation for the sake of creating a new solution without any financial objective, and are only have a focus on creativity and experimentation.*
	18	√	Create a **Financial structure** based on commitment demonstrated by consortium initiators, with tracking of the costs of the blockchain system**.** *Diverse organizational paces and formal approval processes need to be acknowledged, mainly affecting large organizations.* Paradoxically, open-source structuring can moderate the importance of the financial structure as a community driven initiative can show significant participation and worthiness.
	19	NA	Account for **Ecosystem recognition** for the project, as interconnected nature of business ecosystems plays a prevalent role in assessing performance, and therefore the priority given by senior managers.
	20	√	Develop methods to quantify the **Economic value** created by data commercialization on a blockchain system, including threats and opportunities presented by **External economic factors** such as *increased efficiency*, the sensitivity of innovation towards the macroeconomic landscape, and legislative changes.
	21	√	Individual and systemic **ROI** metrics establishment is necessary in order to track the creation of added value. *Financial ROI may be easier to metricize and measure compared to social and environmental ROI.* Funding responsibility should not be exclusive to a single partner, therefore the **Financial equitability** principle states that distribution of this is necessary on a net percentage basis, taking into account the reduced funding capability of SME partners.
Organizational	22	NA	Foster promotion and awareness of implicit **Collaboration dynamics** to enable coordination of use-case development and implementation. Partners should assess ahead of initiation whether work platforms are compatible and the extent to which workflows can be integrated, recognizing that large enterprises (LEs) tend to be less flexible in this. Productivity is enhanced when partners exploit their expertise centre, and frameworks should be developed for work distribution. When organizations do not have a historical collaboration precedent, smaller collaborative projects should be prioritized to accustom oneself to each other and highlight differences in work culture.
	23	NA	The voluntary nature of consortia with insufficient organisational rigidity and clear consortium boundary terms are crucial **Structural factors** that must be designed and evaluated before initiating the consortium, due to the disruptive nature of blockchain as an organizational data system foundation.
	24	NA	While the aforementioned **Structural factors** refer to foundational elements of a project undertaken by consortia, **Project management** entails the planning, oversight and control aspects of the initiative. Embrace agile development while utilizing periodic senior monitoring, screening and assessment as a stage-gate oversight tool.
	25	√	Couple governance with scaling *and partners' financial contribution*, making sure to assess whether the governance model is optimal as more partners join the consortium. Ensure each partner has equitable authority in the **Governance model.** When LE's form the foundation of the consortium governance, it allows the largest market concerns to be addressed and the development of a high impact use-case.
	26	√	Develop a specified **Recruitment management** strategy for talented blockchain developers *and blockchain architects* acquisition, that fulfils the necessary capacity for achieving consortium goals.
	27	√	*For projects with a comparable current system*, evaluate desired **Process optimization** approaches, and track the differences with business process management tools.
Vision	28	√	The initiation of a consortium should start with the formation of a shared vision. Establish how the **vision is perceived externally**, and reinforce this vision throughout the lifecycle of the consortium with **External vision communication** channels. Ensure that the **Internal perception of the vision** is in alignment since the consortium initiation stage, *reacting timely to changes in knowledge dynamics by adjusting the vision if necessary*

Factor	Guide-line number	Adaptation	(Adapted) guidelines
	29	√	Exploitation of the brand image of *(the) large organization(s) in the consortium* to gather awareness for a use-case and overall project is a popular **Image strategy**, which helps in adding perceived legitimacy, and bring attention to the project.
	30	NA	Integrate a **Societal strategy** that has a customer focus and academically advocates the problem urgency that the use-case is addressing.
	31	NA	A **Collaboration-centric strategy** must be followed in order to leverage and expand network reach for attracting new consortium partners. Follow a strategy of monitoring and communicating with external actors that exert influence on the undertaken initiative. Seek senior sponsorship and 'showcasing to partners' as strategies for accelerating the decision-making process.
	32	√	Identify the **Key initial strategy** with minimal strategy pivoting, in order to retain partners. *Critically assess whether modifying the existing strategy due to changes in the environment and/or partners is necessary, and how the change is perceived by the consortium.*
	33	NA	The **Learning strategy** should evolve around leveraging the core competencies of each partner and appealing to knowledge institutions, while the **Value-centric strategy** should focus on how to present the value proposition towards prospective new parties.
	34	NA	Establishing the **Product** and **Innovation strategy** can involve approaches such as demonstrating an early working solution, deprioritizing the blockchain theme, and prioritizing a low-complexity solution.
	35	NA	Foster **Strategic alignment** between consortium partners by clearly defining the objectives, periodically reiterating the selected strategies, and identifying vision implementation discrepancies.

7.4 Conclusion

The sub-question in this chapter was: *Which guidelines can be designed for managers in consortia to aid in decision-making of development of blockchain-based applications?* To conclude, 35 guidelines were designed for managers to consider and use in decision making, which answers this sub-question. These guidelines each pertain to an overarching factor. Two cases were introduced, EnergySHR and Ondernemingspaspoort, which were used as a basis for internal and external validity of the guidelines. Managers of both cases fully recognized the overarching factors and groups of the framework in their blockchain consortium, however certain advice or scope in the guidelines was only partially recognized, and few were not recognized at all. 17 guidelines had elements which were too specific or insufficiently general to varying degrees, which affected the external validity of the guideline. Therefore, they were re-evaluated and adapted according to the content of the validation cases in order to increase the external validity. The final version of the guidelines is presented in table 8.

8 Conclusion

In this chapter, the research is summarized by answering reiterating the importance of the research and answering the main research question. Following this, the scientific and societal relevance are discussed. Then, limitations of this research are highlighted. Subsequently, future research options are presented, a number of which are directly based on the overcoming the limitations of this study. Finally, the connection to the MOT program is made by highlighting the knowledge provided by certain courses which proved invaluable for completing this thesis.

8.1 Key findings

The main goal of this investigation was to provide managers in consortia with guidelines to make decisions towards development of blockchain-based applications, by generalizing findings from case studies. After selecting appropriate conceptual and analytical frameworks, blockchain consortium managers were approached for gathering qualitative data via interviews. The main research question was formulated as:

Which guidelines can aid consortium managers in their decision-making process of developing blockchain-based applications?

To aid in answering the main research question, sub-research questions were formulated:

1. *What decision-criteria for choosing blockchain and potential technological alternatives are available to consortia?*

To answer this sub-question, chapter 3 identified a multidisciplinary decision-criteria scheme to the consortium context of this thesis, based on motives, with distinction being made between the exploration phase and the prototyping. The six motives that consortia must align itself to are: *technology innovation, political positioning, business goal, information tokenization, technology enabling* and *governance necessity*. A consortium must exhibit at least one of the components within the motive as a key driver, for all of the motives, to initiate blockchain exploration. Regarding alternatives technologies to blockchain, cloud services, data spaces, federated architectures, centralized databases, or distributed databases (DLT's but non-blockchain systems) are presented. This is was an important initial chapter to this study, as alignment in the form of having chosen blockchain is a precondition for receiving guidelines tailored to blockchain consortia.

2. *What analytical frameworks are available to consortia in order to manage decision making for development of blockchain-based applications?*

This sub-question explored various strategic management frameworks, and two analytical frameworks were combined (the RBV and Consortium Capabilities frameworks) due to the strong and complementary similarities observed between them. The RBV framework was adapted to consortia by changing the outcome from a ‘competitive advantage’ to a ‘collaborative advantage’, reflecting the key value proposition of consortia, which is collaboration. This chapter was key useful for the retrieval of empirical data for case studies.

3. *What case study design can be employed to uncover factors in decision-making of blockchain-application development?*

For this sub-question, the case selection approach utilized a most-different cases strategy, selected by identification and variation on three dimensions: the outcome type, application type and complexity of the consortium. The four selected cases (FMDM, Hyfen, uNLock and JuicyChain) are presented as the selected cases and the data collection procedures are described in the interview protocol section. This chapter was vital for the organization for the methodical approach for sub question 4, for finding challenges, potential benefits, risks, and the factors that can be generalized from these.

4. *What factors emerge from challenges, potential benefits and risks in development of blockchain-based applications managed in the decision-making process?*

Sub question 4 was an exploratory question for finding case-specific challenges, potential benefits and risks, that were then triangulated in order to inductively construct groups. Subsequently, the exploration of overarching factors followed in an inductive manner. The factors affecting blockchain consortia, that arise from the challenges, potential benefits and risks, are: Knowledge Transfer, Technology and use-case, Security, Funding and Economic Considerations, Organization and Vision. The initial framework (combined analytical framework) did not suffice due to the emergence of additional factors which played pivotal roles in the four case studies performed. In addition, a process-based decision-making framework could not be reconstructed due to the highly non-linear and iterative nature of blockchain consortia. Instead, this called for the construction of specific guidelines to be constructed based on the proceedings in the cases.

5. *Which guidelines can be designed for managers in consortia to aid in decision-making of development of blockchain-based applications?*

In conclusion, 35 guidelines, divided into the factors found in sub question 4 were designed for managers to consider before and during decision making (see Table 8). Two validation cases were used, EnergySHR and Ondernemingspaspoort. Managers of both cases fully recognized the overarching factors and groups of the framework in their blockchain consortium, however 17 guidelines needed to be re-evaluated and adapted accordingly to various degrees, based on the reflective feedback of the validation cases, in order to increase the internal and external validity of the guidelines. The final version of the guidelines can be found in table x as an answer to the main research question.

8.2 Contribution

In this subsection, the scientific and societal relevance of this study is highlighted.

8.2.1 Scientific relevance

The development and subsequent implementation of blockchain applications is a highly researched topic as demonstrated by Scopus. When searching for the term “blockchain application”, 2,071 papers are found to have been published between 2016 and 2024. However, the niche aspect pertaining to the topic of this study is in combining the collaboration-driven environment of consortia with blockchain innovation on the application level. Combining these terms into Scopus (“blockchain application” AND (“consortia” OR “consortium”) yields an average of 10 documents published per year in the last five years, showing rising interest. The interviewing data collection method in this niche is further underrepresented, only pertaining to one other article, using this data collection method. This single article is by Proskurovska (2023) and exclusively focusses on housing finance as an application.

This study has contributed in providing top-level factors, the corresponding groups on the middle level, and guidelines on the bottom-level in the context of decision-making for blockchain consortia. The resulting factors and groups (shown in Figure 12) were compared to the Consortium Capabilities framework (Figure 9) in section 6.3.4, and is reiterated here to highlight the contribution of this study when analysed in relation to the existing literature. The contribution entails the numerous additional factors and groups added, differing significantly to the Consortium Capabilities framework, namely *Knowledge Transfer, Funding and Economic Considerations,* and *Organizational*, on the factor level. The other factors not stated here (*Security, Technology and use-case, Vision)* are present to some extent in the Consortium Capabilities framework, but rather on a bottom-level, while the empirical findings of this research have demonstrated that they should be present on a higher level. This study has also contributed in providing contextual guidelines for blockchain consortium managers in a holistic way, through a hybrid coding approach, which uses both deductive and inductive coding. Based on the search procedure detailed above, it is recognized that this study presents an alternative research approach in a niche with rising interest.

8.2.2 Societal relevance

As a result of this study, not only have there been scientifically relevant results, but also beneficial aspects for societal problems. From this study, the guidelines that were developed can be used by the DBC and other coalitions of consortia in order to make informed decisions based on the six overarching factors which emerged. Coalition managers can use the guidelines either during the development process of projects involving blockchain-based applications or before initiating such a project. This is beneficial because overlooking a factor can be detrimental to the success of a project, and while success is never guaranteed, the guidelines that have been designed in this thesis can help in steering blockchain exploration and prototyping into a successful project outcome.

8.3 Limitations

The interview data led to inability of constructing a (blockchain consortia-oriented) process-based framework as a final deliverable due to insufficient relationships between decision-making and factors in the combined analytical framework, as presented by the contents of the interview data. In order to arrive at a general process-based framework, a theory-driven approach may be pursued, by integrating the theory building blocks within decision-making, blockchain and consortium structure. Another limitation is skewness in the empirical data was present towards potential benefits by managers, as presented in section 6.2. This can be due to the genuine presence of more potential benefits when compared to challenges and risks, or due to the presence of bias. This can either be self-serving bias, social-desirability bias, or a combination of these two biases. Due to the nature of thesis research, a single researcher carries out the coding for case studies, which means that intercoder reliability is lower than if multiple researchers had carried out the coding. In addition, experimenter bias is always present to some degree in research. By rigorously adhering to the selected methods, this was limited, but it can never be entirely eliminated. Experimenter bias is especially present in qualitative coding, as there are many options in code interpretation, differences in coming up with concepts, code names, group and factor names, and the classification of these. Only one manager could be reached and subsequently interviewed for the JuicyChain case. This means that the answers to the interview questions could only be compared to previously available documentation, but not to the interview of another JuicyChain manager. Similarly, for the validation cases only one Ondernemingspaspoort manager was interviewed giving the same limitation as for JuicyChain.

8.4 Future research

This section suggests follow-up research directions and stimulates ideas for future research. Intuitively, addressing the limitations mentioned in section 8.3 would be a valuable undertaking for future research. One of the most simple sequential steps is to perform additional validation cases to the guidelines in Table 8. The significance of this is to build additional depth to the analyses in this study and further improve on the external validity of non-recognized parts in the validation of guidelines. A possible future quantitative study could be an analysis on survey data, gathered from a large sample size in terms of the number of blockchain consortium managers. This proposed study would aid in recognition of the guidelines framework in this report in order to validate the factors, groups and individual guidelines. A specific type of quantitative study for future consideration is a study utilizing the Best-Worst method to further analyse the key factors within each factor of the guidelines framework and rank them for importance. Another future research direction is to combine other analytical frameworks than used in this research, while maintaining the same case study design, data processing and data analysis methods. Such a combined framework could be the 'Dynamic Capabilities' framework together with the RVB framework, or alternatively a singular framework purely based on external forces to a consortium.

8.5 Relevant MOT program courses

This study has used knowledge from several courses taught within the MOT program. The course "Emerging and Breakthrough Technologies" provided valuable background in demonstrating that technological dominance is not enough for a successful innovative project, the appropriate organizational and environmental elements are necessary as well, which is explored in this research by the consortium dynamics. In the course "Technology, Strategy and Entrepreneurship", highly valuable knowledge on strategic management frameworks was provided, aiding in the expertise needed for this research study. The course "Research Methods" provided great depth in the steps needed to design and execute scientific research. Finally, the course "Preparation for the Master Thesis" gave the necessary theory and practical exposure to the process of scoping a research project and executing a literature review.

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Appendix A - Statistics

Table 9: Number of challenges, potential benefits and risks grouped by section in analytical framework.

Section	Challenges	Potential benefits	Risks
0: Questions on resources and capabilities from RBV framework	11 (21%)	24 (29%)	19 (29%)
1: Questions on 'Conditions for success' within Consortium Capabilities framework	20 (38%)	26 (32%)	14 (21%)
2: Questions on 'Consortium Capabilities' within Consortium Capabilities framework	10 (19%)	17 (21%)	23 (35%)
3: Questions on 'Outcomes' within Consortium Capabilities framework	11 (21%)	15 (18%)	10 (15%)
Total	52	82	66

Table 10: Number of challenges, potential benefits and risks grouped by interview question.

Question Number	Challenges	Potential benefits	Risks
1	0 (0%)	1 (1%)	4 (6%)
2	0 (0%)	5 (6%)	1 (2%)
3	2 (4%)	4 (5%)	4 (6%)
4	4 (8%)	1 (1%)	5 (8%)
5	2 (4%)	5 (6%)	1 (2%)
6	2 (4%)	2 (2%)	0 (0%)
7	0 (0%)	2 (2%)	2 (3%)
8	7 (13%)	8 (10%)	4 (6%)
9	5 (10%)	8 (10%)	6 (9%)
10	8 (15%)	10 (12%)	4 (6%)
11	4 (8%)	6 (7%)	7 (11%)
12	1 (2%)	6 (7%)	4 (6%)
13	3 (6%)	3 (4%)	3 (5%)
14	2 (4%)	2 (2%)	9 (14%)
15	10 (19%)	4 (5%)	3 (5%)
16	0 (0%)	5 (6%)	6 (9%)
17	1 (2%)	9 (11%)	1 (2%)
18	1 (2%)	0 (0%)	1 (2%)
19	0 (0%)	1 (1%)	1 (2%)
Total	52	82	66

Note: Percentages are based on the total number of responses.

Table 11: Number of challenges, potential benefits and risks grouped by case.

Case Number	Challenges	Potential benefits	Risks
Hyfen	13 (25%)	21 (26%)	13 (20%)
FMDM	11 (21%)	24 (29%)	17 (26%)
JuicyChain	8 (15%)	17 (21%)	6 (9%)
uNLock	20 (38%)	20 (24%)	30 (45%)
Total	52	82	66

Appendix B - Validation of guidelines

Table 12: Validation of Blockchain Consortia Guidelines.

Factor	Guide-line number	Manager 1 validation (EnergySHR)	Manager 2 validation (EnergySHR)	Manager 3 validation (Ondernemings-paspoort)
Knowledge Transfer	1	Recognized. 'Clear' instead of 'rigid'.	Recognized.	Recognized. Also called "Value case".
	2	Recognized. Needed to a high degree in EnergySHR.	Recognized, needed mainly for clients.	Partly recognized. Trust on other partners with domain expertise necessary for faster development.
	3	Partly recognized.	Recognized, the future of this application in envisioned, but hard to communicate	Recognized.
	4	Recognized. Knowledge storage is vital and better release management is necessary for EnergySHR.	Recognized, storage is vital but challenging	Recognized. Tackled in design sprints for Onderneminspaspoort.
	5	Recognized. This was an underestimated factor in EnergySHR.	Recognized.	Recognized. Demo creation for customer interaction.
	6	Partly recognized. Motivated partners: Yes. Knowledge institutions: not necessarily.	Partly recognized. Components of platform should reach a self-explanatory stage	Partly recognized. However, this advice is too generalized. Expert-pool facilitation used for learning partners in Ondernemingspaspoort.
Technology and use-case	7		Partly recognized, also a focus on release management is needed for this guideline.	Partly recognized. Maturity not only in technology observed, also in operational and architectural maturity. Conscious 'no-regret' decision making with respect to maturity
	8		Recognized. EnergySHR has struggled with the latency of iterations.	Recognized.
	9		Recognized.	Recognized. Underestimated by some managers
	10		Not recognized. Compute-to-data does not pertain readability as described in this guideline.	Recognized.
	11		Recognized.	Recognized. Application architecture should be compatible with adding use-cases in the future.

Factor	Guide-line number	Manager 1 validation (EnergySHR)	Manager 2 validation (EnergySHR)	Manager 3 validation (Ondernemings-paspoort)
Security	12	Recognized. Compute-to-data. EnergySHR struggles with the formalization of this.	Recognized. Privacy-by-design within the compute-to data model means that it can be challenging to align the legal team for privacy and the software team for privacy.	Recognized. Privacy-by-design. Embedded in law for Ondernemingspaspoort. Occasionally customers make a tradeoff between consented convenience and privacy.
	13	Partly recognized.	Partly recognized. The vulnerabilities do not apply due to the project being within a program and managed at a higher level as well.	Partly recognized.
	14	Recognized.	Recognized. While it is a good guideline, a distinction should be made with internal vs external trust.	Recognized.
	15	Recognized. Previous innovation projects with Erasmus University as a partner.	Recognized,	Recognized. In an increasingly connected (online) businesses world this is key.
Funding and Economic Considerati ons	16	Recognized. Near impossible to join for non-funding partners.	Recognized. Intense time contribution needed if partner doesn't provide funding (e.g. Sphereon)	Recognized.
	17	Partly recognized. This is less of a case for the innovation project, as it is highly dependent on the financial structure.	Not recognized, as it is an innovative project.	Recognized. Working with HR on foundations before final signatures
	18	Recognized. Strong mutual interest must be followed by joint funding.	Recognized**.**	Partly recognized. Reality is that all organizations work at a different pace. LE's cannot demonstrate commitment quickly due to long formal approvement processes
	19	Recognized**.**	Recognized.	Recognized. Key proposition of blockchain is connecting ecosystems.
	20	Recognized. Consortia projects are more financially sensitive to external economic factors than projects in a company	Partly recognized, as more emphasis should be on the opportunities it provides in increased efficiency.	Recognized.

Factor	Guide-line number	Manager 1 validation (EnergySHR)	Manager 2 validation (EnergySHR)	Manager 3 validation (Ondernemings-paspoort)
	21	Recognized.	Partly recognized. ROI can be difficult to measure for social benefits that the MVP provides.	Partly recognized. ROI implies a measurement, but added social value and provided by Onderneminspaspoort is difficult to quantify.
Organizational	22	Recognized. Difficult to give consortium partners (durable) access to MS Teams environment and files. Not key for collaboration, but facilitates it.		Recognized.
	23	Recognized. Bigger structure and aligned with other projects. Structured with AI&energy project		Recognized.
	24	Recognized.		Recognized. Sound approach, as innovation results are very unclear beforehand.
	25	Recognized.		Partly recognized. Governance power must be correlated to the contribution in the financial structure.
	26	Recognized. For all innovative solutions there is a general lack. Also these workers are often more attracted by high-paying companies.	Partly recognized. ICT architects are more challenging to find and employ than ICT developers.	Partly recognized. Blockchain architects are even harder to find than blockchain developers
	27	Not recognized. Not applicable	Not recognized.	Recognized.
Vision	28	Recognized.	Recognized.	Partly recognized. In innovation, knowledge dynamics are very high and the vision might adjust to this.
	29	Partly recognized.	Partly recognized. LE company not applicable to university environment.	Recognized.
	30	Recognized. Sufficient publishers and sufficient users needed.	Recognized. Done via a presentation at Energy conference	Recognized.
	31	Recognized. Community must be built in parallel	Recognized.	Recognized. CRM tools are used for this.

Factor	Guide-line number	Manager 1 validation (EnergySHR)	Manager 2 validation (EnergySHR)	Manager 3 validation (Ondernemings-paspoort)
		to application and platform building		
	32	Recognized. Situational only: If situation changes too much, pivoting is better.	Recognized. Strategy shifts can discourage partners.	Partly recognized. Vision might need to change in an innovation environment.
	33	Recognized.	Recognized.	Recognized.
	34	Recognized.	Recognized. Early working solution and deprioritizing blockchain theme as most relevant to case.	Recognized.
	35	Recognized.	Recognized. EnergySHR highly struggled with this, and it was an underestimated factor.	Recognized. Semi-annually strategic calibration with partners.

Appendix C – Informed consent form

Informed Consent form

You are being invited to participate in a research study titled 'Decision-making of blockchain development in consortia'. This study is being done by Adrian Oderwald Blazquez from the TU Delft and the Dutch Blockchain Coalition (DBC), which provides the funding.

The purpose of this research study is to determine how and why managers in consortia make decisions towards implementing blockchain-based data sharing solutions. The (face-to-face or online) interview will take approximately 60 minutes to complete. The data will be used for identifying challenges, benefits and risks of blockchain-based applications in consortia, to be used for a master thesis report for TU Delft and a whitepaper ('bevindingenrapport') for DBC. The whitepaper aims to aid industry professionals in managing the decision-making process of future developments of data sharing solutions in consortia. I will be asking you to answer interview-style questions regarding blockchain initiatives of your organisation. More specifically, the questions in the interview will evolve around the decision-making process of your organisation towards development of the blockchain-based data sharing solution in the consortium setting.

The extremely unlikely risk of a data breach (which will have minimal impact in this case) will be minimized by using the institutional OneDrive service provided by TU Delft to store any Personal Data collected (name, email address, audio recording and the coding system to be used to represent an interviewee's identity, e.g. 'Manager Z'). The only two people with access to this OneDrive will be the Corresponding researcher (Adrian Oderwald Blazquez) and the TU Delft Responsible researcher (my first supervisor, Dr. Jolien Ubacht), ensuring confidentiality. The Responsible researcher will only access the OneDrive to delete all Personal Data, in the event that the Corresponding researcher has to abandon the research due to unforeseen circumstances. Anonymization will be done by removing markers of Personal Data from the transcribed audio, followed by producing a summary of the transcription. You will then be sent the summary for you to request your approval before using it in the thesis report and the whitepaper.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. The Personal Data will be permanently destroyed within 1 month after the thesis defense date, which is expected to take place at the end of February 2024.

Contact details:

Corresponding researcher: Adrian Oderwald Blazquez

Responsible researcher: Dr. Jolien Ubacht

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [27/10/2023], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves: • An audio-recording of an interview, for transcription of the responses, to be studied after completion of the interview. • After transcribing, the audio will be deleted. • A summary of the transcription will be written • After the analysis phase of the study, the transcriptions will be deleted.	☐	☐
4. I understand that the study will end with the presentation of the Thesis defence in the first quarter of 2024.	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
5. I understand that taking part in the study involves the following risks: the possibility of accidentally exposing commercial data and data related to a competitive advantage. I understand that these will be mitigated by the simple fact that I should not communicate to the researcher more than what I already communicate to other consortium members concerning sensitive data related to competitive advantages, and further limiting information which needs a non-disclosure agreement (NDA). Another way this will be mitigated is by sending the produced summary of the interview back to me, to check for a leak of confidential information about a certain competitive advantage or sensitive commercial data. I agree to the summary being presented as an appendix to the thesis report.	☐	☐
6. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) and associated personally identifiable research data (PIRD) with the potential risk of my identity being revealed. The following items are collected: • Full name and email address (PII) • Employer and job title (PII) • Audio recording (PIRD) ➢ Reidentification may occur by local industry professionals in the same sector who are highly involved with similar projects as yourself.	☐	☐

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
7. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach: • Transcription of audio recording • Anonymisation in summary of transcription • Personal research data will be destroyed after the end of the research project • Only anonymised or aggregated data will be shared with others • Secure data storage on TU Delft institutional OneDrive with sole accessibility of the Corresponding researcher and Responsible researcher (the Responsible researcher can only access this in the case that the Corresponding researcher leaves TU Delft and the data needs to be checked for complete deletion)	☐	☐
8. I understand that personal information collected about me that can identify me, such as my full name, job position and employer will not be shared beyond the study team.	☐	☐
9. I understand that the (identifiable) personal data I provide will be destroyed within one month after the Thesis defence, projected to take place in the first quarter of 2024.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
10. I understand that after the research study the de-identified information (summary) I provide will be used for a master thesis report for TU Delft and a whitepaper ('bevindingenrapport') for DBC, to aid industry professionals.	☐	☐
11. I agree that my responses, views or other input can be quoted anonymously in research outputs.	☐	☐

Signatures

____________________________   ___________________________   ________

Name of participant   Signature   Date

I, as researcher, have sent or accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

<u>Adrian Oderwald Blazquez</u>

Researcher name   Signature   Date

Study contact details for further information: Adrian Oderwald Blazquez, ___________@student.tudelft.nl