Breaking Through Data Silos in Multinational Engineering Companies

MSc thesis by D. P. Berck

TU Delft Delft University of Technology

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Master Thesis

Breaking Through Data Silos in Multinational Engineering Companies

A study on how to enhance intra-organizational data sharing by understanding social networks

by

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PREFACE

Here it is, the final piece of work that completes my studies in Delft. I can definitely say that it has been an incredible ride that challenged me, taught me many lessons, and was a revelation. I did not expect that conducting a research would be so joyful to me. And looking back, this was mainly due to the great people surrounding me over the last eight months.

It might be a bit cheesy, but this quote of Aristotle sums up my thesis time altogether: *"The Whole is Greater than the Sum of its Parts"*. First, we are currently in the middle of a surreal reality. Despite all the chaos, people seek each other to grow impact in these uncertain times. I hope this will also result in a wakeup call where we understand how vulnerable we are when standing alone and how much we can achieve together. Secondly, it reflects on my research findings in which I found that optimal data sharing between people and teams can only be established with mutual effort and collaboration. The power of data will offer us more than we can imagine, but only if we manage to create disruptive change together. I hope this research contributes to that cause and further fuels scientific and practical knowledge. And finally, this quote is perfectly in line with how I experienced working with my committee. We definitely were a team, with constructive meetings and discussions. I could always rely on and look forward to practical feedback, critical questions, and encouragement to lift my research to the next level. Therefore, I genuinely want to thank them.

Afshin, we have been working together for more than a year now. First, on my internship and afterward on my master thesis. I am still very grateful that I decided to slightly change my topic so you could be my first supervisor. You always took the time to help me rearrange my thoughts and pushed me to go the extra mile. Because of your enthusiasm, I stayed motivated and eager to improve my work. Aksel, your contribution as second supervisor was very valuable to me. You always asked to the point and out of the box questions, and truly let me think through how to deal with them in my research. Your brainstorming style was really useful and inspired me to apply it too. Marcel, thank you for your time, your wise and critical feedback during our meetings, and most of all being so positive. You always asked me: 'And are you still enjoying it all?', which made me realize how much I did. And of course, Ivar, who created such a welcoming environment for me at Royal HaskoningDHV. Your mix of scientific and practical knowledge has been so interesting. Thank you for always making sure I spoke to the right person at the office and for our discussions about my topic. I also want to thank all the colleagues at RHDHV, in The Netherlands and in Vietnam, who took the time to talk to me and gave me all the relevant input to conduct this research. Without you, my graduation would not have been possible.

Lastly, thank you to all the other people around me. My parents and brother, who have always been there for eternal support, encouragement, fun and feedback. They always make me feel proud of what I have accomplished. Luuk, you always listen and cheer me up when my mind is in chaos. Planning our next adventures together makes me the happiest person alive. And my friends, roommates, who make me laugh and give me places of comfort. It has been a crazy and interesting experience! The only thing left to say is: Enjoy reading my master thesis and let's connect for further discussions on the topic.

Dominique Berck,
March 2020

SUMMARY

Data is everywhere and growing in volume. The smart utilization of these quantitative and qualitative sets of (un)structured numbers, facts, statistics, and documents has become the ultimate source of effective decision-making. The uniqueness of enterprise data offers valuable competitive advantage (Larrú, 2018), which is essential in the current global market with more international opportunities but also stronger competition (Abbasi & Baldry, 2004). Worldwide, construction companies are one of the least advanced sectors in adopting digital solutions (Gandhi, Khanna, & Ramaswamy, 2016). Typical characteristics of the industry make it harder to break through data silos and organize data sharing (Martínez-Rojas et al., 2016), while data adoption can reduce time delays and budget overruns and increase quality and project success (McAfee & Brynjolfsson, 2012). Scientific studies mostly focused on knowledge sharing between external parties, but more research is needed about how intra-organizational data sharing can be enhanced in multinational engineering companies. This research investigates data sharing in a multinational project portfolio, supported by the following research question. ***How can intra-organizational data sharing be enhanced in multinational engineering companies?***

Methodology

This research is conducted in three phases. First, a literature review is performed to understand the field of data sharing in the construction industry and retrieve intra-organizational data sharing factors from theory. Secondly, three brewery projects from one multinational portfolio are analyzed in the case study. A mixed research approach is applied, consisting of quantitative social network analysis (SNA) and a qualitative root cause analysis (RCA). Using a survey, the SNA exposed structures and patterns in the networks of the case projects and in the total portfolio network. It is identified who are the most connected team members in the networks. After that, in the RCA, ten in-depth interviews gave insights into why certain structures occurred and what factors explained their data sharing behavior. In the third synthesis phase, the discussion and conclusions combine all the results and analysis findings of this research. The recommendations present measures how data sharing in multinational engineering companies can be enhanced on project, portfolio, and organization level and what further research is proposed.

Results and findings

The literature review resulted in the identification of factors that have an impact on data sharing in multinational engineering companies. A qualitative factor analysis categorized the factors using a grid with axes in 'people-technology' and 'individual-collective'. It was found that intra-organizational data sharing is mostly people and collectively focused. This emphasizes that data sharing takes place in social networks of people, which supports the choice to apply social network analysis to further explore data sharing in multinational engineering companies. The main themes that were derived from the qualitative factor analysis are presented below. These will be used during the in-depth interview to declare data sharing behavior or employees.

Quantitative social network analysis

In the social network analysis, the data streams, connections of employees, and network layout are investigated. All three case projects consist of very different network structures and patterns, but they have in common that in each network, the project manager is one of the most connected nodes. Project A shows high density and decentralization. Project B shows high hierarchical centrality around the project manager. Project C shows multiple fragmented data sharing hubs and stronger cohesion within disciplines. The networks imply that there is not a uniform data sharing strategy but also does not show explicit data silos because all team members are connected through one network. However, weaker links are observed between geographically dispersed teams, while multicultural teams need higher density networks to be successful. In all three projects, the most used and preferred tool for data sharing is email, followed by face-to-face meetings.

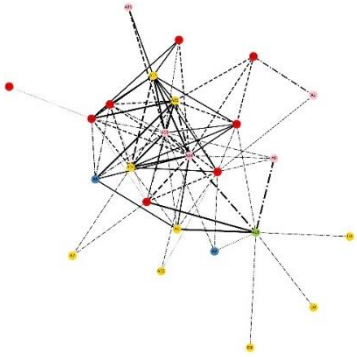


Figure 1: Project A Haiti brewery

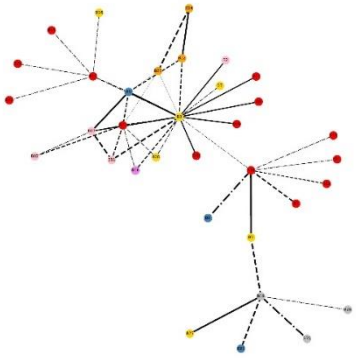


Figure 2: Project B Ethiopia brewery

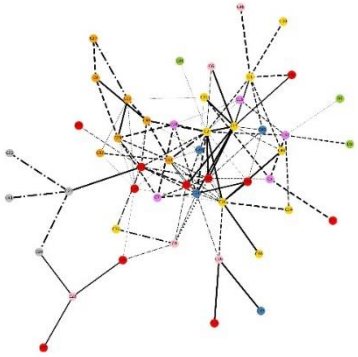


Figure 3: Project C Vietnam brewery

The portfolio network identifies which employees are the linking nodes between the project networks. From the 224 data streams in the total portfolio network, 15,6% of them are data streams connecting the projects. A small group of project managers and engineering connects geographically dispersed offices in the portfolio network. The most external project connections made by an employee in the portfolio is six, which is not high and implies that data silos exist in the portfolio. Employees within the same discipline but working on different projects often show data silos and fragmentation in their networks. If people of the same role are not sharing data and experiences with each other, organizational learning is limited. The social network analysis is followed by the qualitative research that explains the reasons why the patterns and structures of the networks are observed.

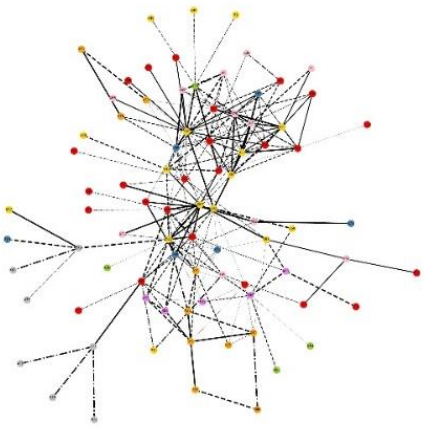


Figure 4: Multinational portfolio network

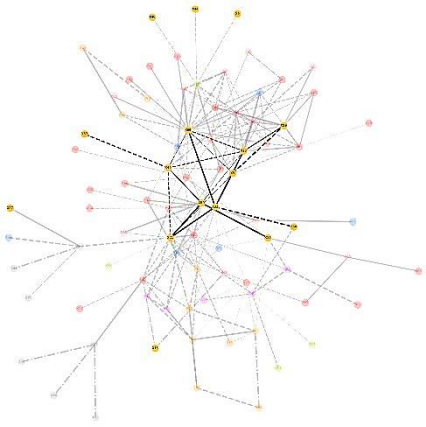


Figure 5: Role specific network

Qualitative root cause analysis

In the qualitative root cause analysis, ten in-depth interviews have been conducted with team members to understand their data sharing behavior in the networks. This indicated the reasons why certain patterns and structures are formed and identified what enables and limits data sharing in practice. The most addressed enabling root causes are practicing simplicity in communication and having a central point of contact for data sharing. Data sharing tools and systems should be made understandable and reduced to a limited number of optional systems, and implementation should be done in manageable steps. Other determining root causes refer to soft factors in data management. Being in the physical of colleagues, having the eagerness to learn new digital ways of working, and feeling responsible contribute to better data sharing is essential to employees in applying effective data sharing.

The most prominent limiting root cause is the missing drive to change. The urge to adopt new digital ways of working is important to enhance data sharing. If people are not encouraged to change their ways of working, they stick to their conventional methods. The following main limiting root causes show overlapping themes. Information overload and lack of coordination conclude that employees need guidance and control. Pushing deadlines and changes happening too fast refers to the lack of time perceived to adopt data sharing. This does not create adaptive environments but instead results in redundancy.

Main root causes of enabling factors

- Simplicity in communication
- Central point of contact
- Eager to learn
- Feeling responsible
- Physical presence

Main root causes of limiting factors

- Missing drive to change
- Information overload
- Lack of coordination
- Pushing deadlines
- Too fast changes

In the RCA, it becomes clear that the project managers have a strong influence in determining the way that data is being shared. The project teams depend on their effort in implementing digital ways of working, while often, project managers do not always have all the necessary skills or resources available to establish that. It was also found that all projects and the overall portfolio consisted of a high level of disconnected figures and a small number of central figures. Decentralized, composed of loosely coupled teams are best for effective data sharing and to stimulate the adoption of novel ideas and initiatives. Project leaders should facilitate linkages between individuals and teams to create balanced networks.

Discussion and conclusions

In the discussion, the root causes identified in practice and the data sharing factors derived from theory are compared. This enabled to assess what data sharing factors have the highest impact on data sharing and found out what factors do not have a high impact on data sharing in practice.

Factors with the highest impact on data sharing

- Perception of control and overview of data streams
- Use of change management and data governance
- Extrinsic motivation by external rewarding or incentives
- Operation ability of information infrastructure accessibility
- Intra-organizational relationships between employees

Being in control and having an overview of data streams by applying simple communication and having a central point of contact is found to offer high benefits for effective data sharing. This research found that many problems occurred in using change management and data governance. Companies need to resolve the lack of coordination, the wrong timing of initiating change, and taking manageable steps. Extrinsic motivation to adopt digital ways of working was often found missing. Research says that initiatives are better adopted using a bottom-up approach. But this research concludes that employees still need the encouragement of higher management to start bottom-up initiatives in data sharing. The accessibility of data and information systems enhances effective data sharing. Accessibility is mostly caused by the convenience level of procedures and work methods perceived by employees, which people incline to place before the quality of these procedures and work methods. Lastly, the level of trust and relationship between employees turned out to be an effective factor to enhance data sharing, which often comes naturally within project-based organizations but can be further pursued by maintaining an open and transparent environment in which people spend more time in each other physical presence.

Concluding, measures should be taken to either stimulate the most enabling factors and prevent the most limiting factors. Enhancing data sharing on a global scale and engage all layers of the organization should be done by reshaping the way to approach data sharing in projects, the portfolio, and in the organization.

Recommendations

This research provides practical recommendations in the form of measures to solve or stimulate the most occurring root causes and data sharing factors. Quick wins on project level can be achieved by agreeing at project kick-off how, when, and who to share data with and assign a central point of contact for document control. Also, the client should be involved in digital development for support and time and in the project. Long term strategy at portfolio level is advised to focus on developing uniform data management plans and make more people responsible for controlling the data sharing strategies. Also, there should be global templates that only allow small adjustments for flexibility, and more mandatory training should be organized for employees varying between individual, team, and portfolio focused needs. Lastly, to reach a data-driven mindset on organization level, it is advised to cultivate a global and tangible vision and mission for digital transformation. This should be done by evoking bottom-up initiatives by top-down encouragement. Employees should be convinced that data sharing benefits them by explaining in terms of their interest. Lastly, reserve time for all employees to spend on personal development and training to ensure the growth of digital skills for all employees and enables to monitor the pace of organizational learning.

Regarding further research, multiple suggestions are made for researchers and graduate students that wish to proceed with a study in a comparable field. Within the social network analysis, there is room for an extension to a longitudinal research design that measures data streams dynamics over time. It is also interesting to develop a tool that can track those dynamics. In the root cause analysis, it would be interesting to see the actual impact of data sharing on project success by incorporating the evaluation collaboration or project success factors. Lastly, researchers or students could also put more emphasis on the multinational context by assessing the effect of cultural dimensions of project teams on data sharing.

SAMENVATTING

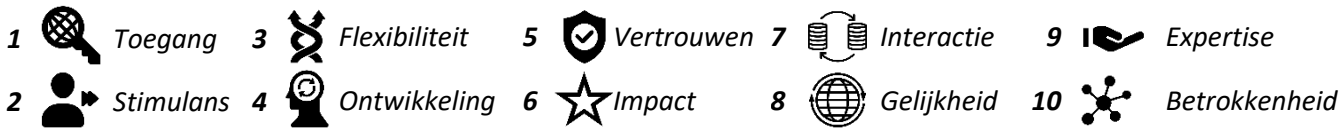
Data is overal en groeit in volume. Het slim benutten van deze kwantitatieve en kwalitatieve reeksen van (on)gestructureerde cijfers, feiten, statistieken en documenten is de ultieme bron van effectieve besluitvorming geworden. Het unieke karakter van data binnen bedrijven biedt een waardevol concurrentievoordeel (Larrú, 2018). Dit is essentieel in de huidige wereldmarkt, met meer internationale kansen maar ook met sterkere concurrentie (Abbasi & Baldry, 2004). De bouw is wereldwijd een van de minst vooruitstrevende sectoren in het adopteren van digitale oplossingen (Gandhi et al., 2016).Typische kenmerken van de sector maken het moeilijker om datasilo's te doorbreken en het delen van data te organiseren (Martínez-Rojas et al., 2016), terwijl datagebruik vertragingen en budgetoverschrijdingen kan verminderen en de kwaliteit en het projectsucces kan verhogen (McAfee & Brynjolfsson, 2012). Wetenschappelijke studies zijn nu vooral gericht op het delen van kennis tussen externe partijen, maar er is meer onderzoek nodig naar hoe het delen van data binnen de organisatie kan worden verbeterd in multinationale engineeringbedrijven. Dit rapport onderzoekt het delen van data in een multinationaal projectportfolio, ondersteund door de volgende onderzoeksvraag. **Hoe kan het delen van data binnen de organisatie worden verbeterd in multinationale ingenieursbureaus?**

Methodologie

Dit onderzoek verloopt in drie fasen. Eerst is een literatuuronderzoek uitgevoerd om het delen van data in de bouwsector te begrijpen en om factoren uit de theorie te halen die het delen van data bepalen binnen de organisatie. Ten tweede zijn in de casestudie drie brouwerijprojecten uit één multinationaal portfolio geanalyseerd. Er is een gemengde onderzoeksmethode toegepast, bestaande uit een kwantitatieve sociale netwerkanalyse (SNA) en een kwalitatieve root cause analyse (RCA). Met behulp van een enquête, zijn met de SNA structuren en patronen gevonden in de netwerken van de projecten en in het totale portfolionetwerk. Er is ook aangetoond wie de meest verbonden teamleden in de netwerken zijn. Met behulp van de RCA, gaven tien diepte-interviews met werknemers inzicht in waarom bepaalde structuren optraden en welke factoren bepalend waren voor hun gedrag bij het delen van data. In de derde fase combineren de discussie en conclusies alle resultaten en bevindingen van dit onderzoek. De aanbevelingen geven aan hoe het delen van data in multinationale ingenieursbureaus kan worden verbeterd op project-, portfolio- en organisatieniveau en welk vervolgonderzoek wordt voorgesteld.

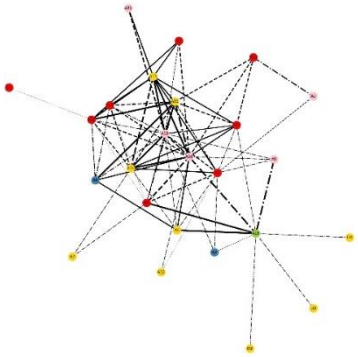
Resultaten en bevindingen

Het literatuuronderzoek resulteerde in de identificatie van factoren die van invloed zijn op het delen van data in multinationale ingenieursbureaus. Een kwalitatieve factoranalyse heeft de factoren gecategoriseerd aan de hand van een raster met assen langs ‘mensen-technologie’ en ‘individueel-collectief’. De meeste factoren staan in het mensen-collectief vlak. Dit benadrukt dat het delen van data plaatsvindt in sociale netwerken van mensen, wat de keuze ondersteunt om een sociale netwerkanalyse uit te voeren om het delen van data in multinationale ingenieursbureaus verder te verkennen. De hoofdthema's die zijn afgeleid van de kwalitatieve factoranalyse zijn hieronder weergegeven en worden gebruikt in de diepte-interviews.

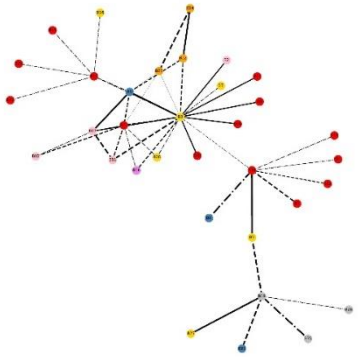


Kwalitatieve sociale netwerkanalyse

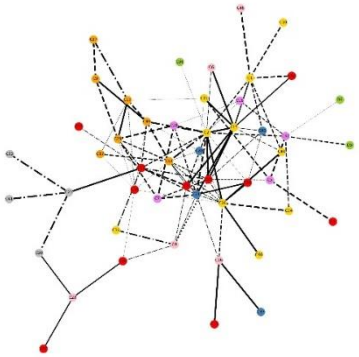
In de sociale netwerkanalyse worden de datastromen, verbindingen tussen medewerkers en de netwerkstructuur onderzocht. Alle drie de projecten laten zeer verschillende netwerkstructuren en -patronen zien, maar ze hebben gemeen dat in elk netwerk de projectmanager een van de meest verbonden knooppunten is. Project A toont hoge dichtheid en decentralisatie. Project B vertoont een hoge hiërarchische centraliteit rond de projectmanager. Project C toont meerdere gefragmenteerde data hubs en een wat sterkere samenhang in disciplines. De netwerken impliceren dat er geen uniforme strategie voor het delen van data bestaat, maar toont ook geen expliciete datasilo's aan omdat alle teamleden via één netwerk zijn verbonden. Er zijn echter wel zwakkere datastromen tussen de geografisch verspreide teams, terwijl multiculturele teams juist een hogere dichtheid datastromen nodig hebben om succesvol te zijn. In alle drie de projecten is e-mail de meest gebruikte en geprefereerde tool voor het delen van data, gevolgd door persoonlijke ontmoetingen.



Figuur 6: Project A Haïti brouwerij

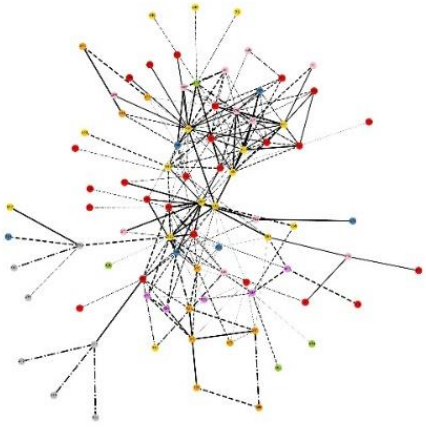


Figuur 7: Project B Ethiopië brouwerij

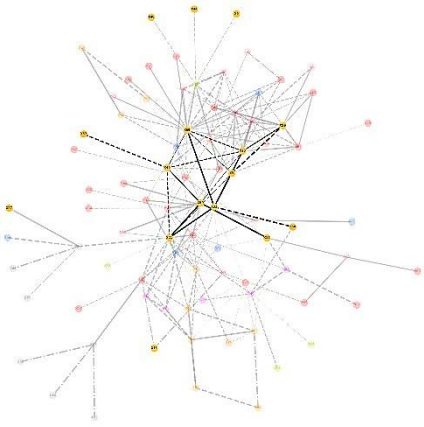


Figuur 8: Project C Vietnam brouwerij

Het portfolionetwerk identificeert welke medewerkers de knooppunten zijn tussen de projecten. Van de 224 datastromen in het totale portfolionetwerk zijn 15,6% daarvan datastromen die de projecten met elkaar verbinden. Een kleine groep projectmanagers en ingenieurs zijn de links tussen de geografisch verspreide kantoren in het portfolionetwerk. De hoogste aantal externe links wat door een medewerker in het portfolio is gemaakt zijn zes verbinding. Dit is niet hoog en impliceert dat er datasilo's in het portfolio bestaan. Medewerkers binnen dezelfde discipline, maar die aan verschillende projecten werken, vertonen fragmentatie en laten datasilo's in hun netwerken zien. Als mensen met dezelfde rol geen gegevens en ervaringen met elkaar delen, is organisatorisch leren beperkt. De sociale netwerkanalyse wordt gevolgd door een kwalitatieve onderzoeksmethode die de redenen geeft waarom de patronen en structuren plaatsvinden.



Figuur 9: Multinationaal portfolionetwerk



Figuur 10: Rol-specifiek netwerk

Kwalitatieve root cause analyse

In de kwalitatieve root cause analyse zijn tien diepte-interviews gehouden met teamleden om inzicht te krijgen in hun datagedrag. Dit heeft aangegeven wat de redenen zijn voor netwerk-patronen en -structuren en identificeerde wat het delen van data in de praktijk mogelijk maakt of juist beperkt. De meest bepalende hoofdoorzaken zijn eenvoud in communicatie en het hebben van een centraal contactpunt voor het delen van data. Instrumenten en systemen voor het delen van data moeten begrijpelijk worden gemaakt, het aantal systemen moet worden teruggedrongen en veranderingen moeten in beheersbare stappen worden uitgevoerd. Andere bepalende oorzaken verwijzen naar de 'softe' factoren in databeheer. In de buurt zijn van collega's, het willen leren van nieuwe digitale manieren van werken, en de verantwoordelijk voelen om bij te dragen aan verbeterede data uitwisseling zijn essentieel voor werknemers voor het effectiever maken van het delen van data.

De meest beperkende hoofdoorzaak voor data delen is de ontbrekende drive om te veranderen. De stimulans om nieuwe digitale werkwijzen in te voeren is belangrijk. Als mensen niet worden aangemoedigd om hun werkmethodes te veranderen, zullen ze hun conventionele methodes aanhouden. De volgende oorzaken tonen overlappende thema's. Ervaren informatie-overload en gebrek aan coördinatie, geven aan dat werknemers begeleiding en controle nodig hebben. Deadlines en te snelle veranderingen verwijzen naar tijdsgebrek om effectief data te delen.

Hoofdoorzaken van activerende factoren

- Eenvoud in communicatie
- Centraal punt van contact
- Wil om te leren
- Verantwoordelijk voelen
- Fysieke aanwezigheid

Hoofdoorzaken van beperkende factoren

- Ontbrekende drive om te veranderen
- Informatie overload
- Gebrek aan coördinatie
- Drukkende deadlines
- Te snelle veranderingen

In de RCA wordt duidelijk dat projectmanagers een sterke invloed hebben in de manier waarop data wordt gedeeld. De teams zijn nu afhankelijk van hun inspanningen in het implementeren van digitale werkwijzen, terwijl projectmanagers vaak niet over alle noodzakelijke vaardigheden of middelen beschikken. Er is ook vastgesteld dat in alle projecten en in het gehele portfolio veel slecht verbonden werknemers zijn en maar een paar centrale werknemers. Gedecentraliseerde netwerken, met losjes gekoppelde teams, is het beste voor effectieve data uitwisseling en om nieuwe ideeën en initiatieven te stimuleren. Projectleiders moeten zorgen voor links tussen individuen en teams om evenwichtige netwerken te creëren.

Discussie en conclusies

In de discussie worden de geïdentificeerde hoofdoorzaken uit de praktijk en de factoren uit de theorie vergeleken. Er is beoordeeld welke factoren de grootste impact hebben op het delen van data en welke factoren in de praktijk geen grote invloed hebben op het delen van gegevens.

Factoren met de hoogste impact op delen van data

- Perceptie van controle en overzicht van datastromen
- Gebruik van verandermanagement en data governance
- Extrinsieke motivatie door externe beloning of prikkels
- Operationeel vermogen van informatiesystemen toegankelijkheid
- Intra-organisatorische relaties tussen werknemers

Het blijkt een groot voordeel te zijn als er controle en overzicht is in datastromen. Dit kan door eenvoudige communicatie toe te passen en een centraal aanspreekpunt te benoemen. Ook is er gebleken dat er problemen zijn in het gebruik van verandermanagement en databeheer, vooral in het gebrek aan coördinatie, de verkeerde timing van het initiëren van verandering, en geen beheersbare stappen. Extrinsieke motivatie om digitale werkmethodes in te zetten wordt vaak gemist. Dit onderzoek concludeert dat werknemers top-down aanmoediging nodig hebben om bottom-up initiatieven op te zetten. Ook bleek dat de toegankelijkheid van informatie- en data-systemen het delen van data verbetert. Dat wordt vooral veroorzaakt door het ervaren gemak van werknemers in het gebruik van procedures en tools. Daarbij neigen mensen ernaar om gemak boven kwaliteit te plaatsen. Ten slotte bleek vertrouwen en relaties tussen werknemers een effectieve factor om het delen van data te verbeteren. Dit is vaak vanzelfsprekend binnen projectmatige organisaties, maar kan verder nagestreefd worden door open en transparant te blijven, en collega's meer tijd te laten doorbrengen in elkaars fysieke aanwezigheid.

Er moeten maatregelen worden genomen om de meest activerende factoren te stimuleren en de meest beperkende factoren te voorkomen. Het delen van data kan zo wereldwijd verbeteren en alle lagen van de organisatie betrekken. Dit kan worden gerealiseerd door de manieren waarop data wordt gedeeld opnieuw vorm te geven in projecten, het portfolio en in de organisatie.

Aanbevelingen

Dit onderzoek geeft praktische aanbevelingen om de meest voorkomende hoofdoorzaken voor het delen van data te voorkomen of te stimuleren. Quick wins op projectniveau kunnen worden behaald door bij projectinitiatie af te spreken hoe, wanneer en met wie data wordt gedeeld, en door een centraal aanspreekpunt voor databeheer te benoemen. Ook dient de opdrachtgever betrokken te worden bij digitale ontwikkeling voor ondersteuning en tijd tijdens het project. Voor een langetermijnstrategie op portfolioniveau wordt geadviseerd te focussen op het gebruik van uniforme databeheerplannen, en om meer werknemers verantwoordelijk te maken voor het controleren van de strategieën. Er moeten ook wereldwijde data standaarden komen die slechts kleine aanpassingen toe laten. Ook zouden meer verplichte trainingen voor werknemers kunnen worden georganiseerd, variërend tussen individuele, team- en portfoliobehoeften. Om een data gedreven mentaliteit op organisatieniveau te bereiken, is het nodig om wereldwijd een tastbare visie en missie voor digitale transformatie te cultiveren. Dit kan worden gerealiseerd door bottom-up initiatieven aan te prijzen met top-down aanmoediging. Medewerkers moeten ervan overtuigd zijn dat het delen van gegevens hen ten goede komt door dit uitgelegd te krijgen vanuit hun eigen interesses. Ten slotte, reserveer voor alle werknemers tijd om aan persoonlijke ontwikkeling en training te besteden om zo de groei van digitale skills bij alle werknemers te garanderen en leervermogen van de organisatie te kunnen volgen.

Voor verder onderzoek zijn suggesties gedaan voor onderzoekers en afstuderende studenten die een studie op een vergelijkbaar gebied willen voortzetten. Binnen de sociale netwerkanalyse is er ruimte voor uitbreiding naar een longitudinaal onderzoeksdesign dat de dynamiek van datastromen over tijd meet. Ook zou een tool kunnen worden ontwikkeld die deze dynamiek kan tracken. In de root cause analyse zou directe impact van data uitwisseling op samenwerking en projectsucces kunnen worden gemeten. Ten slotte zou meer nadruk kunnen worden gelegd op de multinationale context door het effect van culturele dimensies van projectteams op het delen van data te beoordelen.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF CHARTS

LIST OF ABBREVIATIONS

BIM	Building Information Modelling
CME	Construction Management and Engineering
DSN	Data sharing network
EPCM	Engineering, Procurement, Construction and Management
IFC	Issued for construction (final contract drawings)
MP	Multinational portfolio
MEC	Multinational engineering company
MCP	Multinational construction project
NGInfra	Next Generation Infrastructures
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek
RCA	Root cause analysis
SNA	Social Network Analysis

Team roles

C	Costing
CM	Construction management
D/M/B	Drafting/ Modelling/ BIM
E	Engineering
P/DM	Project/Design management
PA	Project assistance
S	Other specialists
TC	Tender & Contracting

I EXPLORATION

1 INTRODUCTION

Berck, D.P. (2019) - This picture is blurred due to confidentiality reasons.

1 INTRODUCTION

This research is about data sharing in construction companies and the impact it can have on project success by breaking through data silos in multinational engineering companies. This chapter introduces the conducted research, starting with explaining the initial problem and relevant concept specifications (1.1). These insights result in an ensuing research design that will be elaborated on in section 1.2. Continuing with an introduction of the research team and their associated relevance to the research (1.3). Finally, this chapter closes off by providing a reading guide of the proceeding chapters in this research report.

1.1 Context and problem analysis

This section emphasizes the enforcing power of data in our inclusive society (1.1.1) and subsequentially, describes the current state of data and data sharing in the construction industry (1.1.2). Thereafter an explanation is provided, explaining the importance of intra-organizational data sharing for project success (1.1.3). Lastly, the urge to include the multinational context is clarified in subsection 1.1.4.

1.1.1 The power of data

Many sectors see data as one of their most valuable assets in corporate decision-making. They spend huge amounts of money and effort in becoming more data-driven and in building transformational data strategies. Research shows that over the last years, 92% of leading corporates increased the pace of investing in data technologies (Davenport & Bean, 2019b). Considering the great competitive advantage of smart data utilization, this is not a surprising fact. The uniqueness of generated data within a company offers great advantages. Only the company itself has the privilege of creating added value from their own private data if they manage to analyze it properly. This can improve understanding of business results and increase efficiency in business performance (Larrú, 2018).

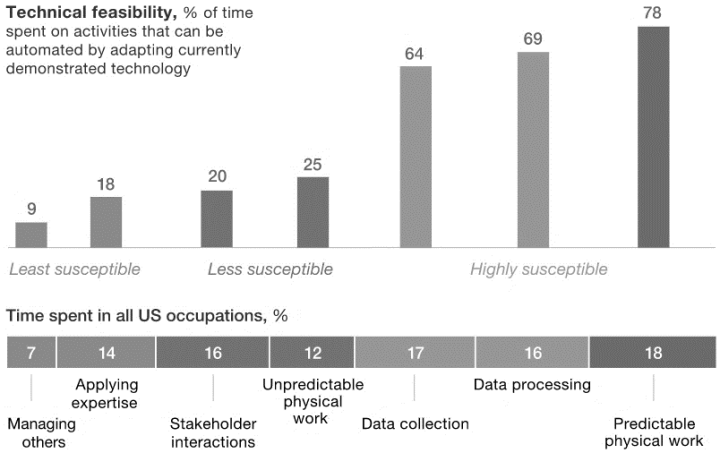


Figure 11: Time spent on work activities and susceptibility for automation (Michael Chui, James Manyika, & Mehdi Miremadi, 2016)

However, findings of recent research show that in all US occupations, the largest percentage of our time is typically spent on predictable work most susceptible to automation (figure 11) and that employees often feel burdened with these repetitive tasks (Vanson Bourne, 2017a). More time could and should be spent on managing tasks and applying expertise to endorse

organizational growth. Currently, the division of labor seems highly inefficient. By automating business processes with data, less time is required for simpler tasks. This type of work substitution by automation saves time to spend on tasks that involve cognitive skills, creativity, and human interaction (Schwab, 2016). Tasks that cannot be replaced by automated machinery since they need the human ability of adaptation and ingenuity.

Smart data integration reinforces all disciplines within an organization. Measuring success data, aligning available resources, and rationalizing investments improve operational efficiency as less time and money is wasted on irrelevant tasks or rework. Tracking cost data and applying analytics exposes optimization possibilities in budgeting and supply chain management (Opher, Chou, Onda, & Sounderrajan, 2016). Furthermore, analyzing trends and forecasting supports strategic decision making (Henke et al., 2016) which enables reliable communication important for an internal and external level of trust towards employees and clients (Bilal et al., 2019). Research proofs that companies who are data-driven perform better in achieving business objectives. By revealing which actions resulted in success and which in failures, future decision-making can be improved and increase overall business success (McAfee & Brynjolfsson, 2012).

1.1.2 Construction in the digital era

The construction sector is one of the largest sectors in the world. It has the expected, global revenue of $14 trillion by the year 2025 and employs over 100 million people (Sategna, Meinero, & Volontà, 2019). Due to the large impact of the construction sector on the world economy and the environment, great benefit can be reached by preventing project failures. Unfortunately, time delays and cost overruns are still rather the rule than the exception (Flyvbjerg, 2011; Flyvbjerg, Skamris Holm, & Buhl, 2004). This indicates that the construction industry must change the way it currently operates.

While companies in IT, Media, and Finance increasingly benefit from the power of data and improve their performances, the construction industry encounters difficulties keeping up with the pace of technology (Gandhi et al., 2016). The construction industry still seems to be one of the least advanced in adopting digital solutions into the workplace. What could be the reason that the construction industry faces these barriers? The problem does not lie in neglecting the possibilities of data in construction since this topic has gained increasing popularity in scientific articles (Appendix A1, chart 19). It is the typical characteristics of the construction industry, such as the high fragmented structure, uniqueness and complexity of projects, and the temporary nature of the organizational structures that make it harder to stimulate data exchange and improve collaboration in comparison with other industries (Martínez-Rojas et al., 2016). Ongoing pressure to improve efficiency and increase sustainability has resulted in an acceleration of adopting new tools and software like Building Information Modelling (BIM). But unfortunately, organizations often encounter problems in adopting them properly (Chen & Lu, 2019). The lack of skills and training, team members' resistance to change, and issues related to collaboration limit the retrieved benefit (Sun, Jiang, Skibniewski, Man, & Shen, 2017). Besides that, imposing tools is not the ultimate solution to solve all issues related to information management (Che Ibrahim & Belayutham, 2019). There are other factors that influence data use in organizations that should be managed with a different approach. Limiting and enabling data sharing factors will be further explored in the proceedings of this research.

1.1.3 Data sharing as a collaborative enterprise

Research indicated that many organizations do not get the desired results deriving from their investments in data initiatives and address that the right organizational collaboration is more critical than the technical capabilities or tools in their analytical effort (McKinsey, 2016b). Also, an extensive survey by Harvard Business Review states that 77% of leading corporates acknowledge that it is a big challenge to directly adopt data into the whole organization (Davenport & Bean, 2019b). In construction, organizational collaboration is still often considered as inefficient and much dependent upon individuals making an effort to move out of their silos (Driscoll, 2017). This silo effect is explained as groups of people that do not seek to connect with other groups of people within their own network. Breaking through the silo effect in the construction industry is harder to achieve as the sector is project-based, task-oriented, and often operates in fragmented departments (Saini, Arif, & Kulonda, 2019). Also, construction projects face high variability and must build up new organizational structures at every project kick-off. Besides that, literature revealed that over the years, the complexity in construction projects has increased (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011; Dubois & Gadde, 2001). Complexity can be defined by a high level of uncertainty and risk, many involved stakeholders and unpredictable and dynamic environments (Jalali Sohi, 2018; van Marrewijk, Clegg, Pitsis, & Veenswijk, 2008). These elements make it more difficult to establish good data sharing, and the pitfall of missing out on benefits within one's own network becomes more likely.

Adopting data in internal decision-making asks for stronger intra-organizational collaboration (Almeida & Soares, 2014; Castagnino, Filitz, Gerbert, Rothballer, & Renz, 2016; Oraee et al., 2019). To realize meaningful insights and adopting data analytics into everyday project decisions, people and processes must be organized in a more collaborative manner (Davenport & Bean, 2019a; Dossick, Osburn, & Neff, 2019). People decide what the value of data holds for their decision-making based on human elements like the number of people who contribute to data, how much they are willing to contribute, and how often (Grossman, 2017). The ideal scenario of data sharing would be to combine independent ideas more effectively with opportunities. A more rapid exchange of the data collected, and the results analyzed, so the connections between ideas can occur more efficiently. Some key aspects of data sharing need to be addressed to improve the system. How data sharing can happen to influence actions, having the data on hand when you need it, in the form you need it, and for the purpose you need it. Agreement on the value set for data sharing as a collaborative enterprise. What is collectively possible through data sharing, and what is not when keeping it independently?

A crucial barrier in effective data sharing and retrieving desired results seems to be more a human issue rather than a technological one (Alreshidi, Mourshed, & Rezgui, 2018). If industries want to improve their current results in data sharing, they need to start solving for the human aspects and identify the value proposition for data sharing as a collaborative enterprise. How people and organizations coop with fast-moving changes in data management is crucial since there is a high risk that this huge data potential turns into the biggest organizational struggle. Since more and more effort is needed to deal with the growing amount of data, we need to be aware that the amount is not exceeding our capabilities (Caniëls & Bakens, 2012). More is needed than just storing files and information in the cloud. This research aims to map and understand the current data sharing networks (DSNs) of an organization. This will enable the determination of factors that could optimize the intra-organizational data sharing capabilities of employees.

1.1.4 The complexity of globalization

In multinational engineering companies (MECs), there is an even higher amount of information available for decision-making and resource allocation. This can lead to managers becoming overwhelmed with information overload and poor decision-making (Teixeira, Xambre, Figueiredo, & Alvelos, 2016). Due to globalization, there is a growing need to support people involved in tasks related to construction project management since teams often work from separated parts of the world. And even though projects may have unique outcomes, many of the tasks that need to be performed are the same (Westin & Sein, 2014). This applies even more for similar projects that are executed for the same client. Multinational clients also expect that teams of a MEC are integrated and interact. Projects are not one-of-a-kind each time working for that same client. For these multinational construction projects (MCPs), it is important to see the synarchy and learn each time as one global team and integrate work. If teams can share their data and transfer lessons learned with their co-workers on the other side of the world this will increase efficiency and provides organizational learning opportunities that exceed the boundaries of the individual projects. The challenge is to manage to work for the same client in different countries and simultaneously work as a program in one integrated global team instead of separate local teams. But often the more global a company gets and works with global clients, the more difficult it becomes to collaborate internally (Woudenberg, 2019).

Crossing geographical borders is not a barrier to data sharing. Data can easily be shared through the cloud, and when it is uploaded on one side of the world, this information is instantly available on the other side. This fast exchange offers huge advantages but also creates potential pitfalls. When there is no direct contact possible, separated teams might have different interpretations of the data in dispersed offices (Javernick-Will, 2011). Also, in other countries, they might collect the data differently, use other naming conventions or apply other regulations for sharing data. These geographical factors that determine the level of data sharing should be considered in conducting this research. This research focusses on mapping the data streams between project teams and between members in project teams in a multinational construction portfolio or in this research referred to as a multinational portfolio (MP). An MP within an organization has overarching management that controls all local construction projects for one client worldwide. Studying multinational data sharing will provide insights on how to enhance it globally and benefit more from executing similar projects.

Retrieved observations from literature expose current problems in data integration. This research aims to increase the understanding of how to adapt organizational structures and benefit more from data initiatives. It is time to start seeking better solutions to break through traditional project management standards and disrupt the construction industry. The next section describes what knowledge gap will serve as the window of opportunity in this research and what research design will be applied to investigate it.

1.2 Research design

This section focusses on the research design resulting from the context and problem analysis. First, the knowledge gap is described (1.2.1), which serves as the foundation of this research. Then a hypothesis is provided (1.2.2) as a handhold towards formulating the conclusion. In order to come to this valid conclusion, the objectives are listed (1.2.3), the scope is demarcated (1.2.4), and research questions are formulated (1.2.5).

1.2.1 Knowledge gap

Scientific research on how to manage data sharing in MECs is limited. Most articles relate to the inter-organizational connections between individual companies working together on construction projects. Issues as unaligned information process tools (Zhu & Augenbroe, 2006), undefined agreements for data sharing (Bektas, 2013), and lacking mutual trust (Buvik & Rolfsen, 2015) are described as challenging factors. It is questioned if these issues have the same level of risk in intra-organizational data sharing. The interdependencies among key players internally are supposedly different. Also, many articles are dedicated to how to transfer knowledge and lessons learned within an organization (Almeida & Soares, 2014; Forcada, Fuertes, Gangolells, Casals, & MacArulla, 2013; Kasper, Lehrer, Mühlbacher, & Müller, 2013; Okere, 2017). But knowledge sharing differs from information sharing. This research aims to specifically look at the transfer of data, defined by a retrieved set of structured or unstructured values, facts, or statistics suitable for examination. After examination, data becomes information and can turn into wisdom and strategic decision-making.

Only a few existing articles performed similar studies focused on intra-organizational data sharing in a multinational context (Ahmad, Sein, & Panthi, 2010; Javernick-Will, 2011; Kasper et al., 2013; Ochieng & Price, 2010). It has been highlighted that in global project-based organizations, knowledge sharing can be harder as it does not only face the barriers of the organizational structures and managing individuals, it also encounters additional geographical barriers and cultural differences. When sharing project data, cultural barriers could also cause problems in the interpretation of that data across countries. This research incorporates how the multinational context influences the level of intra-organizational data sharing in an organization and what are the consequences resulting from that.

This research combines a Social Network Analysis (SNA) and a Root Cause Analysis (RCA), which is a suitable mixed research method to find answers for the formulated research questions and fill up the knowledge gaps (C. Y. Lee, Chong, Liao, & Wang, 2018). Applying an SNA will investigate the social connections (data streams) between people and teams within the organization of an MP. Whereas the early SNA studies in construction mostly focused on intra-organizational relationships, the trend shifted when the emphasis was put on the complexity of the inter-organizational network of construction projects (Zheng, Le, Chan, Hu, & Li, 2016). Thereafter most studies focused on this matter and currently is still the trend. This leaves room for deficiencies on the intra-organizational side and explains why recent studies emphasize the urge to conduct future SNA research on the intra-organizational fragmentation of organizations (C. Y. Lee et al., 2018). An SNA has not been applied before to achieve the equivalent research objective as in this research (Zheng et al., 2016) and will, therefore, expose new knowledge to the scientific field.

1.2.2 Hypothesis

The hypothesis of this research is that more benefit is retrieved from available project data when an organization succeeds in sustaining an effective and efficient DSN. By understanding the different types of factors that determine data sharing, intra-organizational data streams can be managed. Especially in an MP where comparable construction projects are realized for the same multinational client, data exchange between teams will increase project performance since more information becomes available for decision-making. Issues regarding rework, wasted time and

resources, and inefficient project delivery are tackled. This ultimately will reduce the chance of cost-overruns, time delays, and unreached quality standards in MCP. Therefore, it is beneficial for engineering firms to put effort into analyzing data streams and get a better idea of their current DSN. What is going well, and why and where is room for improvement? What is collectively happening through data sharing, and what is not by keeping it independently? Necessary further developments in data sharing in MCPs can only be realized when organizations are aware of their current status of data sharing and understand what data sharing behavior is present in their data networks. The focus of this research will not be on developing and testing a framework on how to create an effective DSN. But the aim is to understand what happens in a DSN regarding different data sharing roles. The Root Cause Analysis (RCA) will elaborate on what factors determine the level of data sharing in a network and influence project success.

1.2.3 Objective

Based on existing research, it has been determined that there does not yet exist any article that resolves the problem statement described earlier. However, the urge to solve for the data sharing problem is specifically appointed in several critical articles and reports. Organizations in construction can achieve better intra-organizational data-sharing in MCPs when understanding how to manage it. This research aims to achieve the following objective: Identifying what factors determine effective data sharing in organizational networks of multinational engineering companies. This main objective can be subdivided into the following sub-objectives:

1. Identifying data sharing patterns and structures in real data sharing networks.
2. Addressing what and how data sharing factors shape data sharing behavior.
3. Offering feasible recommendations on how to enhance data sharing in a global market.
4. Showing that combining the SNA and RCA is a valuable mixed research approach.

To achieve these objectives, the main research question is formulated and will be answered gradually with the support of four sub-questions. This will be explained in section 1.2.5., including the associated approaches. First, the boundaries of this research are defined in the scope demarcation in the next section.

1.2.4 Scope

The research scope determines the boundaries of this research (figure 12) and defines what is investigated and what is left out within this research. Due to the limited time of six months that is set for this research, only a selection of all interesting elements is incorporated.

In construction, data is generated before, during and after the project lifecycle. The time scope is focused on the timeline starting from project initiation till project delivery. This excludes the asset management phase and does not zoom in on a specific project phase. Including all phases enables to also explore data traffic in critical moments such as handovers and interfaces. The timeframe of this research is two months for preparations and six months for conducting the research itself and officially kicked off on the 18th of July 2019. The perspective scope of this research is of the engineering consultant who represents the client in civil works and operates in multiple countries. They play an important role in management and providing technical designs that suit the requirements of the client. During execution, they serve as the link between the client and contractor in order to ensure that all client's requirements will be fulfilled within

time and budget and with the aimed quality. As mentioned before, the construction industry is lagging in adopting digital technology at the same pace as other industries. However, limited research studies the direct contribution of the engineering consultant in implementing digital initiatives. It is said that digital solutions in construction are often driven by a group of pioneer design and engineering consultancies (Gerbert, Castagnino, Rothballer, & Renz, 2016). But research does not explicitly address the extent of data engagement of engineering consultancies compared to consultants in other sectors. This research aims to contribute to that cause. Lastly, the focus of this research is put on internal data sharing between employees within the same organization. Three intra-organizational levels are considered. First, at project level, analyzing three different brewery projects. Secondly, at portfolio level that focuses on one multinational client of RHDHV. The three case projects are all conducted for the same multinational brewing client that operates in many countries. Lastly, recommendations will also be given at organizational level so that RHDHV receives advice applicable to their organization, which can also be transferred to other client portfolios.

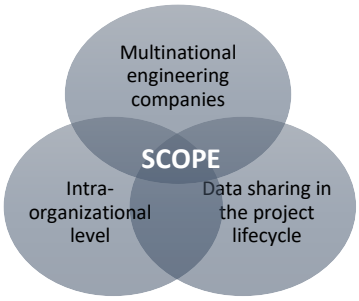


Figure 12: Overlap of the research scope (own illustration)

1.2.5 Research questions and approach

The main research question aims to find suitable measures for good data sharing in construction and incorporates the high impact it can make in multinational engineering companies. To achieve the mentioned objective, the main research question is formulated as follows.

RQ **How can intra-organizational data sharing be enhanced in multinational engineering companies?**

This question is formulated to ultimately lead to having insights about the purpose of data sharing in a multinational company. The focus is on creating awareness of the current situation of data sharing and what opportunities can be established to enhance it and increase overall performance in multinational construction portfolios. Multiple deliverables will follow from answering this research question:

1. Insights in the perception of data sharing in literature and in practice.
2. A guide to use social network analysis for mapping data streams in projects.
3. A list of enabling and limiting data sharing factors and associated measures.
4. Know-how about data sharing in a global market as a data-driven organization.

Four additional sub-questions have been formulated. Each of them is one step further in answering the main research question, and they serve as a guideline for this report. They provide detailed answers which are necessary to ensure a complete understanding of the research field. The sub-questions and corresponding research approaches are derived as follows.

Q1 *What does intra-organizational data sharing in the construction industry entail based on theory?*

The first research question will focus on gathering available information from existing literature about the meaning of data and data sharing. General concepts within data sharing are explained for a complete understanding of the field of study. Past researchers may have found interesting conclusions about the role of data sharing in intra-organizational structures. This information should be obtained to avoid rework in doing research. To model the DSN, it must be possible to recognize elements of a DSN. Therefore, existing articles on data and data sharing are investigated. Besides that, many perceptions of data and data sharing exist, and it is essential to determine the meaning it has within this research. To do so, relevant literature is consulted.

Q2 *What factors determine intra-organizational data sharing in multinational construction projects based on theory?*

In a DSN, different types of factors contribute to the existence of the network. Literature is consulted to identify these factors that limit or enable data sharing. In this, the contextual preconditions 'intra-organizational' and 'multination' should be retained. In literature, there might be more categories that arise. The added value of this sub-question is that later the presence of these identified data sharing factors from literature is discussed with team members from the case projects to determine how intra-organizational data-sharing can be enhanced.

Q3 *What are the maps of intra-organizational data sharing networks in multinational construction projects in practice?*

An important deliverable in this research is applying a social network analysis that models and analyzes network graphs. They consist of nodes and links that connect these nodes. Applying an SNA enables to identify key nodes in the data networks and data streams that connect them. Analyzing the nodes by identifying their roles and responsibilities, identifies their position as a data user in the network. Analyzing the data streams exposes network structures and the level of connectivity. More network analyses are performed to understand the dynamics. Surveys will be used to collect the data that create network models. Prior knowledge obtained from the first two sub-questions is used in answering this third sub-question.

Q4 *What enables and limits intra-organizational data sharing in multinational construction projects in practice?*

The final sub-question aims to find the underlying root causes for data sharing in the modeled DSNs of the case projects. By making use of an RCA, the factors that establish the current DSN are identified and provide reasoning on why the DSNs are structured the way they are. Additionally, it is discussed how these root causes of enabling and limiting factors can be used to enhance intra-organizational data sharing in the projects, the portfolio, and at organizational level. The data collection is done by conducting multiple in-depth interviews with selected respondents from the SNA. Employees that have interesting positions in the DSNs will be invited to explain their data sharing behavior.

The combination of all the above sub-questions will provide a conclusion on how intra-organizational data sharing can be enhanced in multinational engineering companies and will provide valuable new insights for both the TU Delft research group working on the NGInfra research and the engineering company Royal HaskoningDHV.

1.3 Research team and relevance

This research is conducted in cooperation with three parties and combines practical and scientific perspectives. The research team will work together with the aim to gain relevant insights and together develop the research. The graduating student will have a leading role in establishing this collaboration and maintaining the overall quality. In this section, the team will be introduced, and their individual relevance will be explained.

1.3.1 NGInfra research group

Currently, a NOW granted research is being conducted within the research group Integrated Design and Management at the TU Delft related to this research topic. The research is in the field of inter-organizational collaboration and data sharing performed for NGInfra. The aim is to establish better-integrated solutions between multiple external parties in large infrastructure projects by sharing data. The first findings indicate that investigated infrastructure companies do not have optimal internal data sharing. Only limited research is available in the subject of intra-organizational data sharing, while this should be the first goal for establishing external links. Therefore, this research provides added value and can be used as a relevant source for further research. The use of SNA is supported by the NGInfra research group as they confirm that SNA is a strong method to identify patterns, structures, and clusters in social networks that can be used to analyze DSNs. Applying this method can also be relevant for their research.

1.3.2 Royal HaskoningDHV

Secondly, this research will contribute to RHDHVs cause as they aim to put more effort into adopting digital strategies in their projects (RoyalHaskoningDHV, 2018). RHDHV is an independent, international, engineering, design, and project management consultant that has been operating in the field of construction for over 137 years. Their work in project management often consists of representing clients in complex projects everywhere in the world. The department Project Management & Consultancy Multinationals within RHDHV collaborates with the world's leading corporates and has built up strong multinational portfolios. In this research, the project portfolio for a multinational brewer will be used. This portfolio exists for many years and consists of greenfield (new) and brownfield (additions to existing) brewery projects. The multinational client insists on equal quality standards and project expectations worldwide. A central portfolio team at RHDHV is responsible for supporting all local projects and controlling information flows. Therefore, analyzing data networks to address potential improvements is valuable to them.

1.3.3 Graduating student

This master thesis subject is a good combination of previously obtained experience of the graduating student in Architecture, Systems Engineering, Policy and Management, and International Entrepreneurship. Interests of the graduating student are problem-solving in large and complex projects with many stakeholders involved and adopting innovative concepts. Expertise has been gained in techniques such as system- and business modeling, multi-actor analysis, and the student felt captivated by the building sector and multinational environments. Within CME, there was a preference for people management, specifically the role of innovation and how to manage dynamic environments for the better. An internship in Vietnam which

focused on digital procurement centralization in the APAC region for RHDHV resulted in a growing interest in digital technologies. It became clear that the role of data has an increasing impact on the construction industry, and the graduating student wanted to contribute to these developments and learn more about it by directing the thesis topic towards this field.

The personal aim of this research is to learn more about data, shaping the future way of how people work together in the construction industry and apply that in a multinational context. This research is relevant for the supporting professor and supervisors at the Technical University of Delft in a scientific way by creating more validated scientific content for related future research. For the graduating company, it contributes as a proof of concept and practical applicability in the further development of strong performance. The graduating student will be the link between these parties within the graduation committee and will respond to both their requests by combining theory and practice (figure 13). This will create a purposeful collaboration and increases knowledge exchange between all committee members to create overall research value.

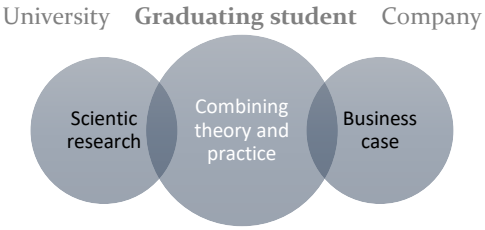
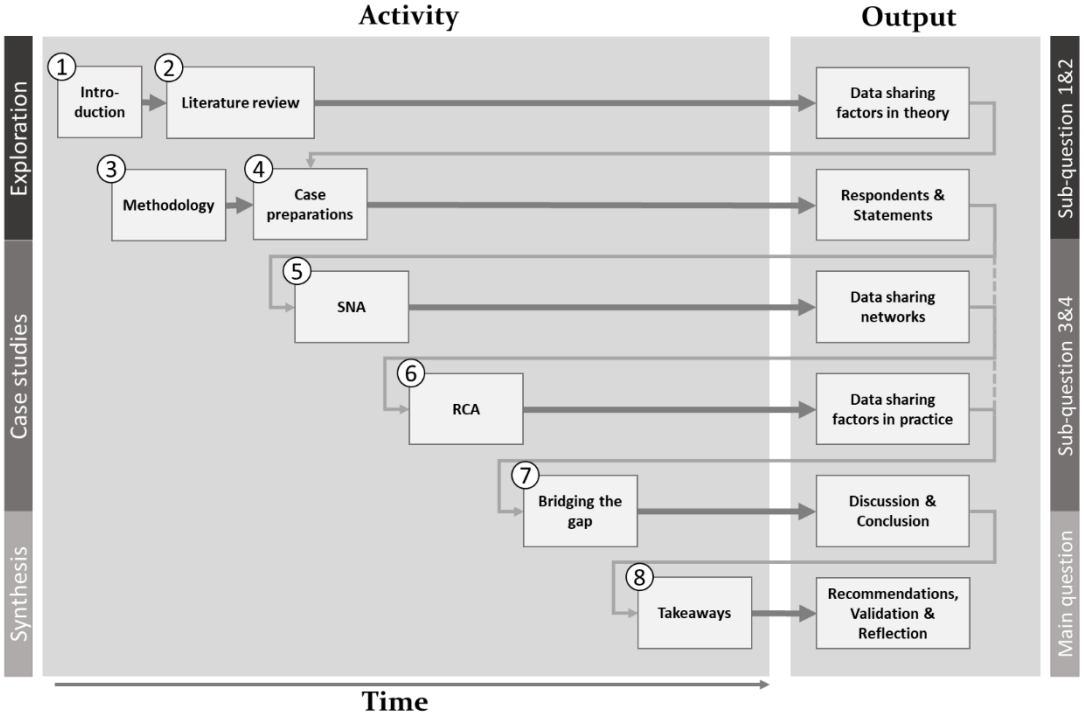


Figure 13: Overlap of the research team and relevance (own illustration)

1.4 Research structure and reading guide

Below an overview is provided that summarizes all the separate work phases, work methods, and related research questions. Together they are combined in a report of eight chapters that are linked to the formulated sub-questions and main research question of this research.

Table 1: Research structure overview



2 LITERATURE REVIEW

Kanic, V. (2017) Glitch Art – Destroying Art with Big Data.

2 LITERATURE REVIEW

This chapter provides a literature review that explores the theoretical concepts in this research, which is key in setting up scientific research (Verschuren & Doorewaard, 2010; R. K. Yin, 2009). By analyzing existing scientific articles, the theory is retrieved that supports the objective of this research. The systematical steps taken in this literature study have been detailed described in appendix A.

2.1 Data management in general

The term data has experienced an enormous increase in use over the last decade, and the data scientist is the number one wanted employee at the moment (Davenport & Patil, 2012). Despite this recent popularity growth, the concept of data has been around for quite some time already. According to DAMA, international data management is "the development and execution of architectures, policies, practices, and procedures that properly manage the full data life cycle needs of an enterprise." In this first part of the literature review, the development of data management is explored.

2.1.1 What is data?

One of the first references to data in the form we currently know it was formulated as "transmittable and storable information on which computer operations are performed" and originates from 1946. Later in the mid 50's the term data processing was first introduced (Etymology Dictionary, 2019), and since then, it kept evolving over time. Nowadays, data is a very broad concept that can appear in many different forms and definitions. In this research, the following all-purpose way to define data is used: "all sorts of quantitative and qualitative retrieved sets of (un)structured numbers, facts, statistics and documents which can be interpreted and used for decision-making" (Opher et al., 2016; Ramus, 2018; Schwab, 2016).

Data becomes information after it has been analyzed in some sort of way to ultimately converge into business intelligence supported by human interpretation and support decision-making (Bellinger, Castro, & Mills, 2003; Ramus, 2018). One of the first models describing the flows between data, information, and knowledge is the Data-Information-Knowledge-Wisdom (DIKW) hierarchy developed by Ackoff (1989) based on the initial research of (Zeleny, 1987). Ackoff visualizes a pyramid filtering data into information, information into knowledge, and lastly, knowledge into wisdom, as shown in figure 14.

Figure 14: DIKW pyramid (Ackoff, 1989)

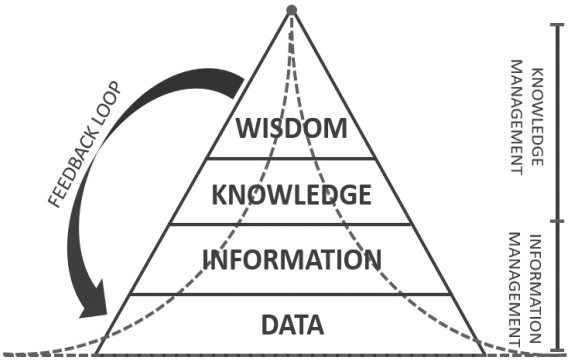


Figure 15: Adapted DIKW pyramid (own illustration)

After 1987 many adaptations of the DIKW hierarchy were proposed by other researchers who felt differently about the right representation of the model. In 2007 Rowley revisited the DIKW hierarchy considering all these articulations of the hierarchy. Particularly the definitions of the elements and the structure were reconsidered. Rowley found out that still typically "information is defined in terms of data, knowledge in terms of information, and wisdom in term of knowledge but there is less consistency in the description of the processes that transform elements lower in the hierarchy into those above them" (Rowley, 2007, p. 177). The transformation process seems to be a trigger for disagreement.

This makes sense considering the growing volume of data (dashed line, figure 15). Transforming data into meaningful insights becomes harder as data is now also way more complex and profound (McKinsey, 2016a; Schwab, 2016). According to Weinberger (2010), knowledge is not determined by information as the knowing process first decides which data and information are relevant and how it should be used. Next to that, a more complex process that is social, goal-driven, contextual, and culturally bound takes place in the creation of business intelligence. On the other hand, Westin (2014) states that data and information can be used interchangeably since the context in which the data is provided will make clear what kind of information the data is. In this research, we focus on information management, covering both the management of data and information in an organization. Therefore, also in this research data and information will be used interchangeably. Knowledge management, like capturing lessons learned, is out of scope. However, it is important to understand that it is essential for an organization to create a feedback loop from knowledge management to information management. Only then it is possible to capture enterprise knowledge and wisdom into data which after that can again be used for retrieving new knowledge and wisdom. This creates a closed DIKW system (figure 15).

The volume of generated data is increasing, the pace of processing data is faster and cheaper, and the number of data types is expanding (Bilal et al., 2016; Westin & Sein, 2014). All these factors increase the value extractable from data, and therefore software keeps being developed to expose that value to humans. This phenomenon is known as the five V's of big data: Volume, Velocity, Variety, Veracity, and Value. Big data is a concept on its own and can be defined as the extent of data that is getting so large it almost becomes uncontrollable, and traditional methods are not powerful enough anymore to process it (McAfee & Brynjolfsson, 2012). This research does not specifically focus on the possibilities of big data that mainly targets data mining of large amounts of unstructured quantitative data. But the five V's phenomenon also takes place inside organizations with enterprise data, at a slower pace but not less important. Especially when operating in an extensive global market, the five V's of data make achieving global collaboration more complex. Growth in enterprise data accelerates, which results in new challenges that ask for alternative strategies so that ineffective collaboration and missing opportunities due to data silos across the company can be prevented (Vanson Bourne, 2017a).

2.1.2 Different data types

The impact of data in the current fourth industrial revolution is explained by Marr (2018, p) as "exponential changes to the way we live, work and relate to one another due to the adoption of (…) smart systems" which is "disrupting almost every industry in every country and creating massive change in a non-linear way at unprecedented speed". Data is everywhere and does not know any geographical borders. To fully benefit, it is needed to understand the presence of data

in the construction industry. A literature search will indicate what kind of data types have been acknowledged in construction projects, when they are generated, and how they are used.

In each project, the main distinction can be made between structured and unstructured data that determines the nature and processability of the data source (Soibelman, Wu, Caldas, Brilakis, & Lin, 2008). Both have their own characteristics and are continuously being generated in every phase of the construction project life cycle (table 2). Structured data is quantitative and consists of numerical or organized categorical values. When organized well, structured formats can be stored in relational databases using Structured Query Language (SQL), which enables an applied analysis of the structured data that allows filtering, measure and compare different data sources (Bilal et al., 2019). Working with highly organized data is quick and easy and offers great advantages in business analytics like visualizing statistics, discovering trends, and identifying patterns.

Table 2: Characteristics of structured vs unstructured data (Bilal et al., 2019)

Structured	Unstructured
Quantitative data	Qualitative data
Can be displayed in rows, columns, and relational databases	Cannot be displayed in rows, columns, and relational databases
Numbers, dates, strings	Text, schedules, images, video
Structured Query Language	Not Only Structured Query Language
Estimated 20% of enterprise data	Estimated 80% of enterprise data
Requires less storage space	Requires more storage space
Easier to manage and protect	Difficult to manage and protect

Qualitative data does not know any pre-defined organized format and therefore is much harder to compare and process. Examples are textual documents, images, videos, schedules, emails, etc. All these data sources are more descriptive rather than measurable and compass more storage space. They do provide deeper insights into human reasoning and expose intentions and interpretations. But adopting unstructured data for business decision-making requires more complex handling of the data and is therefore often neglected. To not fully benefit from the value of the largest type of data in organizations is a missed opportunity, and therefore new techniques are currently being developed to profit more efficiently from this source. The Not Only Structured Query Language enables databases to analyze unstructured data without pre-defined relational tabs. Currently, approximately 80% of all data generated in project-based organizations is unstructured data (Grimes, 2013). In the future, unstructured data will keep increasing exponentially compared to structured data. If organizations do not start acting now, controlling their enterprise data will become even more complicated as unstructured data is more difficult to manage and protect (Bilal et al., 2016).

Besides structured and unstructured data, there are additional factors that determine the type of data in projects. The data types depend upon the time of data creation/data collection, upon the role of the data producer/data demander, and for what purpose the data is committed. According to ISO21500, the international standards for project management (ISO, 2013), each project broadly consists of five phases, namely initiating, planning, implementing, controlling, and closing. Each phase consists of own generated and required data, often managed in separated organizational silos. The information is being developed by project team members

having a specific role and responsibility in carrying out the work. Most of the key information indicated in the flow chart is present in the form of unstructured data. All the collected and created data belongs typically to project management activities within the life cycle of a project.

But other than on the project level, data can also be exploited outside the project's boundaries in a project transcending sense. You & Wu (2019) refer to this division as business management data and project management data. Their research delivers a framework for data-driven informatization that integrates project management and business management informatization as they state managers were not able to obtain the relevant data to project status in real-time and cannot support top managers for their strategic decision-making. This statement refers to the different purposes in which data can be used, namely for strategic, tactical, or operational roles involving structured, semi-structured, or unstructured decision-making.

In figure 16, the dependencies between the DIKW model, data types, management types, time, roles, and decision types are illustrated (Heras, 2019). Business management is more directed to top management in strategic roles making unstructured decisions for the future. Unstructured decisions consist of not predefined processes with not predetermined information and are often one-of-a-kind and unique. Project management is more focused on tactical and operational roles where unit managers or executors mostly make semi-structured or structured decisions for present activities and based on the past. Structured decisions are frequent and repetitive, follow a logical decision process, and consist of well-specified information. For both purposes, data is the foundation of their deliverables, as can be seen in figure 16. Both structured and unstructured data should be leveraged to capitalize on new insights in an organization.

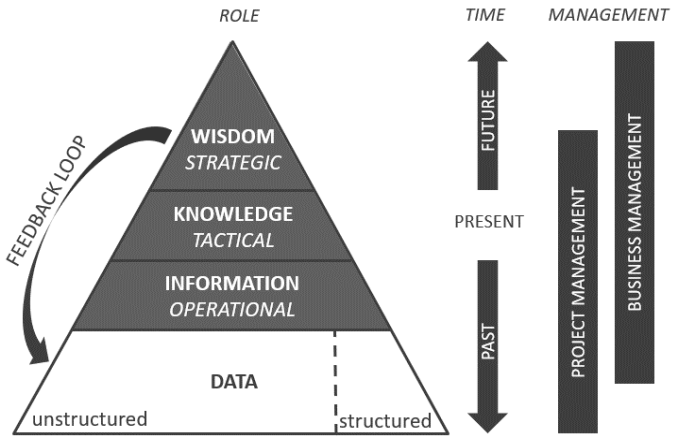


Figure 16: Adapted DIKW pyramid linked to the role, time and management types (own illustration)

2.1.3 Intra-organizational data sharing

Data-sharing is the process of, from one person to another, sending and receiving data that is needed to improve the efficiency of company operations and project delivery (Gerbert et al., 2016). During the whole project life cycle data is generated and follows a life cycle on its own (Wing, 2019). Figure 17 emphasizes the different stages that occur in the development of data assets. First, it is defined what kind of data is needed to perform the work, followed by a request to secondly either collect that data from available sources or create new data. Thereafter the collected or created data is being processed in some way so it can be analyzed to obtain the right information. After obtaining the right information, findings should be implemented in practice so it can be used for improved decision-making in strategic, tactical or operational levels of the

organization as mentioned before. After using the data, it should be stored in accessible environments so it can be retrieved again later. The next stage in the data life cycle is protecting and controlling the data. It should be determined who has access to the stored data, who is responsible for that data, who will evaluate the quality of the data. A solid protection of the data is essential to prevent hacks or any kind of misuse and to be aligned with General Data Protection Regulation (GDPR), implemented in 2018 by the European Parliament and Council of the European Union. The last step to close the loop in the data life cycle is maintaining and re-using the existing data. This includes preserving the right quality, keeping it up to date and recalling appropriate data in future work. Throughout the whole data life cycle, sharing of existing or new data with other people in the organization is a core activity. Without sharing the data in an efficient and effective way the other stages of the data life cycle cannot be performed. This makes data sharing so important for an organization.

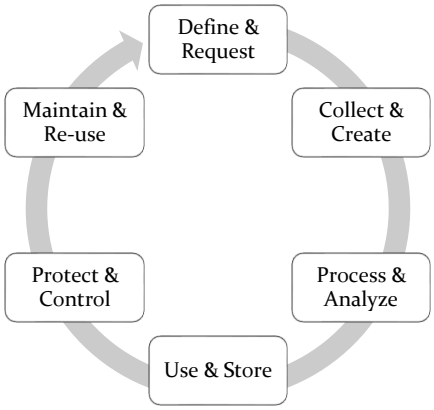


Figure 17: Data life cycle (own illustration)

A wide variety of tools and systems is available to support data throughout this life cycle and process, analyze, present, and store it (Dossick et al., 2019). These systems can be divided into three groups that relate to the type of roles mentioned before: management information systems (strategic), decision support systems (tactical), and transaction processing systems (operational) (Heras, 2019). Ideally backed up by a central database and enterprise resource planning (ERP) system.

This wide variety of tools and systems creates many possibilities but complicates the interoperability of data as multiple databases arise in one organization. Another reason for this is that data sharing can take place on different levels in the organization. Enterprise data can be shared between (1) functional units, (2) management levels, and (3) across geographically dispersed locations (Kavanagh, Thite, & Johnson, 2011). If no collaboration between these levels is established exists, companies will encounter problems in centralizing available data. This will lead to data sharing issues, affecting organizational learning and value creation in project-based organizations (Almeida & Soares, 2014). Also, a clear data governance strategy should be implemented throughout the whole organization that defines how data is accessed and treated. Data governance is part of the broader data management strategy. According to Aiken (2017), "most organizations have no idea what data they have, they have no idea how good their people are at using data, and therefore they have no idea how their organization is using data to support their strategies." This often results from inefficient, traditional data sharing structures, as illustrated in figure 18 on the left. In this structure, everyone is sharing data with everyone,

resulting in redundancy and inconsistency (Heras, 2019). Competitive advantage and operational efficiency can be achieved when organizations strive towards implementing a common data environment in which everyone stores data in one environment, where all data is accurate and accessible for everyone (Alreshidi et al., 2018).

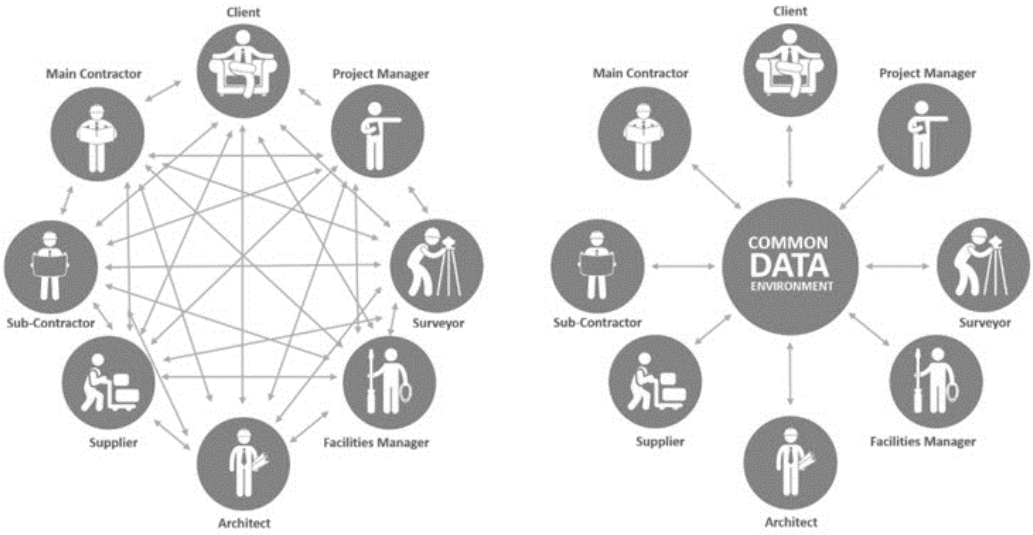


Figure 18: Conventional data sharing and Common Data Environment (Alreshidi et al., 2018)

2.2 Data management in construction

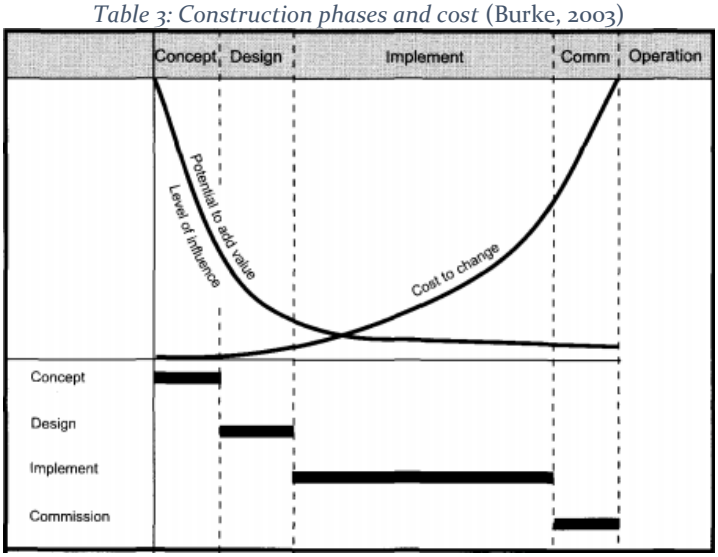
In this section, state of the art in construction data management is retrieved from literature. To explore how this research can contribute to data management in construction, current challenges are described. These challenges will define what the missing links in creating competitive advantage and operational efficiency by enterprise data management are.

2.2.1 Data types in construction

Construction projects produce enormous amounts of structured and unstructured data throughout the whole project life cycle. Examples of structured quantitative data formats are costs, staff hours, defects, waiting time, and any other numerical value (Soibelman et al., 2008). As mentioned before, construction companies still often face struggles in managing data. The specifically challenging factor is that most of the data generated in construction projects is text-based qualitative data in unstructured formats (Al Qady & Kandil, 2013; Coners & Matthies, 2018; Martínez-Rojas et al., 2016; You & Wu, 2019). Much research has been performed in identifying issues related to document management in construction since analyzing unstructured construction management data is way more complex and time-consuming (Matthies, 2015). Al Qady & Kandil (2013) addresses the difficult task of storing unstructured project data, which results in increasing complexity of data retrieval, poor interoperability between management systems and harder information re-use (Martínez-Rojas et al., 2016). It seems that the earlier mentioned data silo problem is a direct result of the type of data that is mostly used in construction projects. Examples of unstructured data forms are reports and presentations, emails, schedules, images and semi-structured spreadsheet files like change order lists, bill of quantities and evaluations (Soibelman et al., 2008). Structured and unstructured data exists in different project phases and tasks such as cost control, project planning, risk management, safety, progress monitoring, quality management and design (Martínez-Rojas et al., 2016).

The construction industry deals with temporary projects, including a lot of complex documenting, which makes it is hard to standardize project outcomes and generate uniform processes (You & Wu, 2019). Akinyemi, Sun, & Gray (2018) mention that due to the fragmentation in the construction process, stakeholders have limited interactions, and they generate construction information based on individual work requirements. Especially between global offices, it is often hard to establish accurate awareness of remote activities and create integrated teams. This hinders optimal efficiency as teams miss the opportunity to learn from each other's successes and failures and keep "reinventing the wheel" (Javernick-Will, 2011). To have accurate data at hand at the right time, in the right format, and by the right person in current and future projects is hard to manage. Besides that, construction projects are often subject to tight delivery schedules. This makes project managers forced to proceed with partial information, and engineers forced to use preliminary data values that are inserted while waiting for the correct data to come (Westin, 2014). This is a dangerous phenomenon in construction because it often leads to unforeseen, high costs later on in the project. Changes and rework in the late stages of a construction project are the most expensive while the ability to influence the total project costs are highest in the early phases of the project (table 3). This means that if in the early phases the right decisions are made based on the right information, more potential can be added to the project, and design changes and rework closer to project completion can be prevented. Therefore, it is key to have appropriate data and improve estimations from the beginning onwards.

Table 3: Construction phases and cost (Burke, 2003)



When data is assumed as appropriate and fit for purpose in construction is researched by Westin & Sein (2014). According to the research, the quality of data is determined by a set of dimensions. It was pointed out that accuracy, completeness, consistency, and timeliness of data have been emphasized most frequently in data quality methodologies. Westin and Sein identified accessibility, security, relevancy, and logical coherence as additional quality dimensions most important in engineering organizations. They assess the usefulness and value of that data when being shared. If shared extensively, but the data does not comply with these domains, just limited value can be retrieved. Two assessment types can be distinguished. The subjective data quality assessment reflects the needs and experiences of stakeholders involved with that data, and the objective measurements based on task-dependent, or tasks-independent assessment

(Pipino, Lee, & Wang, 2002). Tasks-dependent assessment does take into account the contextual knowledge of the application, and task-independent does not. Subjective assessment of data quality specifically may influence whether people are committed to data sharing in an organization. This research aims to find more insights on this matter.

2.2.2 Data sharing in construction

Data-sharing is basically the beginning of open communication in construction projects, which has been proven to be essential for project success (Kähkönen & Rannisto, 2015). Appropriate data needs to be shared across the different phases to increase the decision-making process throughout the whole project life cycle. But Martínez-Rojas et al. (2016) state that each construction phase generally manages its own project data individually, which limits the reach of open communication. On top of that, project data in construction companies is often only exchanged verbally, which results in the vanishing of tangible project data for future use.

Inadequate coordination and inefficient means of communication of project information in construction limit the re-usability of valuable data. Coners & Matthies (2018) even identified that reusing of project data is one of the main problems in construction due to the high amount of unstructured data. The challenges specifically are twofold. First, not being able to effectively identify or efficiently retrieve relevant data due to the information overload in project-based organizations (Almeida & Soares, 2014; Dave & Koskela, 2009). Secondly, not having the capability to present various combined sources and summarize retrieved analysis. Files are mostly just stored in folder-based environments in a redundant manner (Javernick-Will, 2011), causing unnecessary data re-entry and interoperability problems (Kähkönen & Rannisto, 2015).

Companies confirm that a lot of money is spent inefficiently. Disconnected data results in unnecessary long searches for stored data, and therefore constant duplication of employee effort, which causes a waste of time and resources. The accessibility of data increases the frequency and quality of the exchange (Zhu & Augenbroe, 2006). When employees must put a lot of effort into finding or setting up the connections, they are probably more unlikely to establish data sharing and the opportunity to act fast under time pressure and have access to relevant data are therefore missed (Vanson Bourne, 2017a). Construction companies working should invest more in technical training and skill development for employees. Additionally, extra costs are needed for continuous coordination to ensure constant data management quality and development of information procedures. But still, studies indicate several barriers in adoption information tools such as BIM (Alreshidi et al., 2018). For example, many employees in project-based organizations simply do not have the time for undertaking extensive training or putting extra effort in processing data, especially when they were used to completely different working methods. They can be resistant to change as they are not convinced of the added value. Secondly, not all companies have enough budget to implement completely new information systems and invest in internal transition programs. Costs for software, hardware, training, and staff hours all add up to the total economic costs (Qin & Fan, 2016), and since the direct profit of the implementation of information systems is not established in construction yet, companies can get reluctant with their investments. Still, these investments together can eventually optimize project outcomes when broken processes are connected, and seamless data sharing is realized within project phases, between project phases and ultimately project transcending.

Mentioned phenomena are acknowledged problems in the construction industry, and many studies suggest new frameworks on how to share data effectively. For example, You & Wu (2019) delivered a practical framework for data-driven informatization specifically for the construction industry. It covers all independent phases and work packages in a construction project and enables strategic business analytics outside the projects. Many other studies also come up with management frameworks and design of information procedures (Akinyemi et al., 2018; Bilal et al., 2019; Wang, Zhong, Zhang, Yu, & Li, 2015). But what studies mostly do not cover are the requirements and implementation criteria for organizations to make the transition towards applying the suggested frameworks. This research assumes that the way data is handled by people in an organization is influenced by the different types of data present, data having different purposes, and data being created and collected by different organizational roles. Liu, van Nederveen, & Hertogh (2017) also imply that various project roles have different perceptions of using BIM. Nevertheless, this human element is very rarely discussed in other literature.

Generally, many different disciplines work simultaneously on one construction project. As mentioned before, different roles handle data by different means. Killingsworth, Xue, & Liu (2016) talk about the intrinsic and extrinsic motivations that influence knowledge sharing behavior. For information sharing, these factors determine the effort an employee takes to contribute to data sharing. Intrinsic motivation could come from the willingness to contribute to the total information storage and updating data. Extrinsic motivation can be translated into rewarding systems or external incentives such as standard data process procedures offered in the online organizational environment. Both intrinsic and extrinsic motivation could be promoted more in one department than in another, causing uneven contribution to the system.

People are sensitive to their environments and adjust their work methods and behavior to them. For example, often during the construction phase, a limited amount of data is being collected and stored for analysis by construction workers (You & Wu, 2019). Data supply is less reliable and consistent during this phase because the considering work on-site is more dynamic and hands-on. Workers on site are therefore less triggered to contribute to the common data environment. Project managers, on the other hand, also show different behavior against data use. Caniëls & Bakens (2012) indicated in their research that using information systems feels advantageous to project managers. But the research also concludes that in case of information overload, the project managers feel that information systems are more valuable to them then under normal project conditions, and they start to use the available information systems more consistently in order to master that data and make better decisions. It seems that project managers are triggered to use available systems more when work pressure is high, while during normal conditions leveraging data also leads to better decision-making (Martínez-Rojas et al., 2016). Different attitudes towards data use are dependent on project roles and context, which makes integrated collaboration more complex.

2.2.3 Data sharing for project success

Enhancing data sharing is key to increasing success in construction projects since these projects rely on the actions and decisions that are made mainly based on project information. Sharing between people is a form of collaboration. According to recent research, collaboration is defined as ”the interdependent work of people together to achieve a greater interest and goal than they can attain individually” (Sohi, Nezami, Bakker, & Hertogh, 2019, p. 4). Lu, Elmaraghy, Schuh, &

Wilhelm (2007, p. 617) define collaboration as follows: "any effort to collaborate to exchange information, ideas or useful resources necessary to create a shared understanding for a common and creative purpose". Both definitions emphasize the connectedness of people and resources through physical or intellectual systems. Combining forces in achieving shared goals creates a bigger impact, then pursuing people's individual effort. Trust is an often recurring element in establishing a collaborative foundation for data sharing (Killingsworth et al., 2016). According to Alreshidi et al. (2018, p. 2), collaboration is "people working together by sharing information and processes via interacting, communicating, exchanging, coordinating, and approving; …". Collaboration and data sharing are often mentioned interrelated (figure 19) when striving for higher productivity in construction projects and general project success (Vanson Bourne, 2017b).

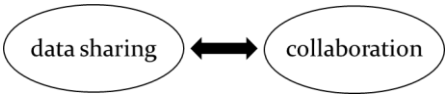


Figure 19: Correlation between data sharing and collaboration

Collaboration contributes to delivering expertise, raising enterprise revenue, and realizing projects more successfully (Cross, Martin, & Weiss, 2006; Oraee, Hosseini, Papadonikolaki, Palliyaguru, & Arashpour, 2017; Suprapto, Bakker, & Mooi, 2015). Research states that when working on a complex project, there is a strong need for collaboration among team members (Alreshidi et al., 2018). Since construction projects experience rising complexity (Jalali Sohi, 2018), the need for collaboration should increase alongside this rise of it. Project complexity, defined by practitioners, can be distinguished in technical, social, financial, legal, organizational, and time complexity that is perceived during the implementation of construction projects (Hertogh & Westerveld, 2010). Literature reveals that the main difference in complexity is defined by detail complexity and dynamic complexity. Detail complexity refers to the many involved components in a project and their high degree of interrelatedness. Dynamic complexity is associated with the potential of a project to evolve over time, having a high degree of uncertainty. Data and information play a role in all complexity domains mentioned by the practitioners. Detail complexity refers to systems in which there are many variables which can be interpreted as the available information systems and their continuously varying information content. And uncertainty in dynamic complexity is described in literature as "the lack of information," which constantly changes over time (Hertogh & Westerveld, 2010). Therefore, the level of complexity can be related to the control of data and information. Also, Alreshidi et al. (2018) state that the magnitude of data sharing correlates with the complexity of the project.

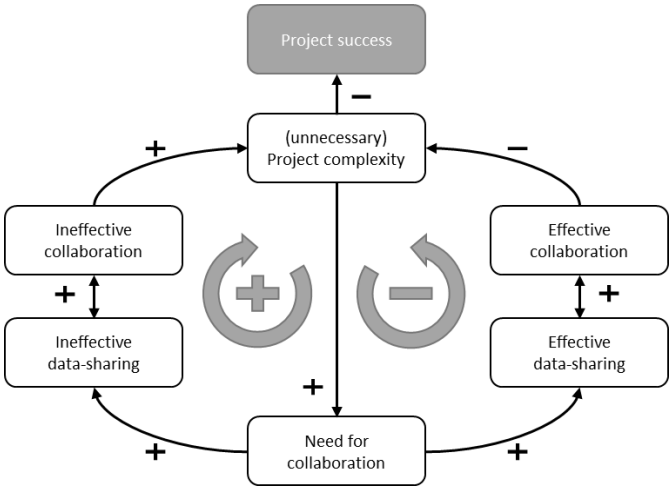


Figure 20: Data sharing, collaboration and project success (own illustration)

When data sharing is managed effectively, this will result in effective collaboration and decelerates uncontrolled complexity in the project. Without this so-called 'unnecessary complexity' or 'information overload', the probability of project success increases (right feedback loop in figure 20). But improving sharing performance is easier said than done. What regularly happens in practice is that information sharing is messy (without purpose, double data entry, redundancy, not following agreed procedures, etc.) (Wilson et al., 2019). This kind of unmanaged data sharing does not contribute to effective collaboration. It even increases project complexity by means of information overload (Matthies, 2015). Unnecessary complexity in a project will negatively affect the overall project success. In figure 20 on the left side, this undesired feedback loop is presented. It can be disrupted when an organization is aware of how to shift from ineffective data sharing to effective data sharing and take suitable measures.

Complexity also occurs on the intra-organizational level. Despite the fact that organizations mostly strive towards universal visions and unambiguous business processes within the whole company, often great variety exists between departments and organizational units, which creates separated data silos (Vanson Bourne, 2017b). Besides that, reaching out for intra-organizational collaboration often only happens when there is a project- or problem-based need (Javernick-Will, 2011). Otherwise, teams tend to stick with their own network of direct colleagues. This leads to missing opportunities in expanding the relevant information reach. The productivity of the whole organization can rise as intra-organizational data sharing and collaboration are improved. Individual projects might be executed well enough in an organization, but when there is no collaboration, sub-optimal solutions are used that limit further improve organizational performance. Mentioned by RHDHV, collaboration should be purposeful and add value to the project outcome. In a good collaboration, everybody in the team is adding value to the process, but in bad collaboration, people might distract that process of adding value. People naturally have a limitation in their mental capacity and time to process new information (Kasper, Lehrer, Mühlbacher, & Müller, 2010). Therefore, the benefits of data sharing can be retrieved if an organization achieves to create a purposeful sharing culture and facilitates encouraging environments for all employees to contribute.

How project success, collaboration, and data sharing influence each other is explained by examining their individual meanings. This research aims to find suitable measures, depending upon different factors in the organizational ambiance, to enhance intra-organizational data sharing among people and across disciplines to increase project success.

2.3 Multinational engineering companies

Globalization is a highly accurate trend that is captured by the ways in which the world increasingly interconnects on all levels. It forces an understanding of local influences on global issues and global influences on local issues (J. M. Cain, J. Glazier, H. Parkhouse, & A. Tichnor-Wagner, 2014). The construction industry also encounters an expanding global market, and the number of multinational project portfolios is increasing. According to Mossolly (2015), a global project is a cross-border cooperation with a project team made up of individuals from different countries, working in different cultures, business units, and functions with differences in regulatory frameworks. The research of Binder (2007) points out the characteristics of global projects as different distant locations, different organizations, country cultures, different languages, and time zones and calls them the dimensions of global projects (figure 21).

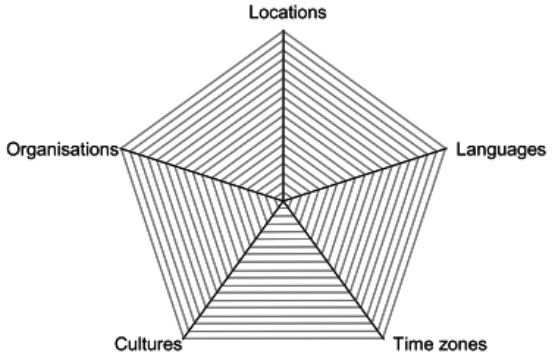


Figure 21: Global dimensions of projects (Binder, 2007)

This research focusses on data sharing within one organization, but the case projects are part of multi-organizational collaboration projects. The term MCP is used to indicate the extent of the multinational level of a certain construction project. This extent can be explained in twofold. First, when realizing multiple projects for the same client, those construction projects have many similarities. Therefore, companies now often maintain global program management in which "a group of related local projects are managed in a coordinated way to obtain benefits and maintain control not available when managing them individually" (Project Management Institute (PMI), 2017). An MCP is a local construction project as part of a transcending MP. Secondly, realizing MCPs as a company means that the company itself also is a multinational engineering company (MEC) that consists of MPs. MECs market their services using the same name and are present in many countries. Generally, there is one corporate office that is responsible for the coordination of all local projects and maintaining the global strategy. A MEC has direct foreign investments, mostly in a limited amount of countries, and does not tend to homogenize its services but is more responsive to local preferences (Porter, 2007).

The rise of globalization is mainly caused by the development of the World Wide Web and the possibility to share information within global teams (Shen et al., 2010) which keeps getting faster, cheaper, and easier. This rapid worldwide communication has resulted in construction projects being developed in dispersed locations far away from the actual construction site (Ochieng & Price, 2010). MECs need to adapt their business, technologies, and collaboration strategies to keep up with the intensely competitive global market (Shen et al., 2010). This also resulted in faster delivery schedules to stay ahead of the competition, and tasks previously performed in sequence now have to be performed in parallel, making business riskier (Westin, 2014). That is why MECs open new offices in different countries to operate closer to the concerning project hubs. As a result, it becomes even more common to be geographically dispersed as a company.

Other strategic issues now also come into place. Project teams can now be established based on skills and discipline requirements, but also financial considerations and employee availability are determining factors. Mossolly (2015) explains this execution strategy as appearing to be mostly financial to optimize project performance by integrating low-cost global centers, but these decisions can also be more long-term investments to enhance local presence in emerging areas while providing competency support from headquarters. MEC often collaborates with local entities, and companies based in the project area or temporality employees are deployed (Ochieng & Price, 2010). All these changes have a big influence on the cultural dynamics in a project and in an organization. But MECs do not take enough responsibility to respond to cultural factors affecting their teams (Ochieng & Price, 2010).

Therefore, collaboration in MCPs is becoming a more challenging task. First, the distance between team members is making it problematic to maintain high collaboration, especially when coming from different disciplines (Oraee et al., 2017). The loss of face-to-face explanations and meetings can lead to misunderstanding and misinterpretation (Ochieng & Price, 2010). Also, lacking non-verbal signals such as eye contact and body language reduces trust and confidence in delivering work. Building up relationships takes more effort and can be misleading, which causes unwanted confusion. Coming from different backgrounds also creates a natural language barrier as people speaking different mother languages tend to hold back in open communication. According to Kähkönen & Rannisto (2015, p. 8-9), "the cultural background of professionals or the regional industry practice strongly affects the nature of actual communication is strongly affected by the cultural background of professionals which can often filter and direct the communication in a certain manner". These challenges are naturally tried to be overcome by increasing the magnitude of interaction by geographically distributed teams (Alreshidi et al., 2018). But having control over interactions and supervise that the whole project team is integrated and going towards the same understandable objectives is difficult for a project manager. Especially since dispersed team members know divergent methods, procedures, and contract forms and team members respond differently to the same issues or tasks because they have distinct perceptions of environmental opportunities and threats (Ochieng & Price, 2010).

But literature also highlights the advantages that multicultural teams often have and when integrated well even perform better. MECs should actively promote diversity and the promising results that come from them in improving team effectiveness. These teams can generate a higher amount and more inclusive ideas with higher quality (Ochieng & Price, 2010). To facilitate that process, MECs should come up with measures that make data sharing more efficient and effective. First, it is important to guide global employees by providing standards and protocols that are universally accepted and developed with optional engaging all practitioners. Setting up a reliable and strong DSN that suits the needs of all employees is a must in building collaborative environments (Ahmad et al., 2010). Only by active participation and mutual understanding of the regulations, an MCN can manage to grow and integrate all global teams in achieving shared goals. Solutions like these allow for separated teams to work more closely, collectively increase efficiency, and reduce unwanted errors and bring greater profitability to their organizations (Moses, El-Hamalawi, & Hassan, 2008).

2.4 Factor identification

Literature is consulted to grasp what data sharing behavior in a project-based MEC determines. Reviewing the literature resulted in the identification of a set of 20 data sharing factors. This list of 20 factors will be used as starting points for the further proceedings of this research, which will be explained in the next chapter. The aim is to eventually test their presence in three case projects and detecting their root causes in practice. In this manner, theoretical findings will be examined in practice. In the following overview, all factors are presented by a short description, the type of factor, and the corresponding literature. See Appendix B1 for the detailed descriptions.

Table 4: Overview of data sharing factors retrieved from theory

#	Data sharing factors from theory	References
1	Extrinsic motivation by external rewarding or incentives	(Killingsworth et al., 2016; Westin & Sein, 2014; Wiewiora, Liang, & Trigunarsyah, 2010; You & Wu, 2019)
2	Intrinsic motivation by individuals own incentives	(Killingsworth et al., 2016; Pipino et al., 2002; Razmerita, Kirchner, & Nielsen, 2016)
3	Global affiliation and integration of teams	*(Alreshidi et al., 2018; Javernick-Will, 2011; Killingsworth et al., 2016)*
4	Global awareness of remote activity and communication	*(Javernick-Will, 2011; Ochieng & Price, 2010)*
5	Institution authority by developing information sharing infrastructure	*(Akinyemi et al., 2018; Bilal et al., 2019; Martínez-Rojas et al., 2016; Qin & Fan, 2016; Wang et al., 2015)*
6	Institution authority by establishing legal frameworks and formal policy	*(Alreshidi et al., 2018; Qin & Fan, 2016; You & Wu, 2019)*
7	Operation ability by employees' skills and experience	*(Gerbert et al., 2016; Javernick-Will, 2011; Qin & Fan, 2016)*
8	Operation ability by information infrastructure accessibility	*(Al Qady & Kandil, 2013; Qin & Fan, 2016; Westin & Sein, 2014; You & Wu, 2019; Zhu & Augenbroe, 2006)*
9	Organizational compatibility of systems and files	*(Coners & Matthies, 2018; Martínez-Rojas et al., 2016; Qin & Fan, 2016; Soibelman et al., 2008; Westin & Sein, 2014; You & Wu, 2019)*
10	Perception of information security	*(Qin & Fan, 2016; Westin & Sein, 2014)*
11	Distinct cultural perceptions of capabilities and mentality	*(Kähkönen & Rannisto, 2015; Ochieng & Price, 2010)*
12	Increasing detail and dynamic project complexity	*(Caniëls & Bakens, 2012; Hertogh & Westerveld, 2010; Jalali Sohi, 2018)*
13	Intra-organizational relationships between employees	*(Alreshidi et al., 2018; Gerbert et al., 2016; Killingsworth et al., 2016; Qin & Fan, 2016)*
14	Personal demographic details	*(Alreshidi et al., 2018; Killingsworth et al., 2016; Razmerita et al., 2016)*
15	Role specifications and role responsibilities	*(Alreshidi et al., 2018; Caniëls & Bakens, 2012; Liu et al., 2017; Martínez-Rojas et al., 2016; You & Wu, 2019)*
16	Competitive market causing faster project delivery	*(Javernick-Will, 2011; Shen et al., 2010; Westin & Sein, 2014)*
17	Economic costs including investments in infrastructure, training & coordination	*(Alreshidi et al., 2018; Qin & Fan, 2016)*
18	Misunderstanding due to cultural differences	*(Javernick-Will, 2011; Killingsworth et al., 2016; Ochieng & Price, 2010)*
19	Perception of control and overview of data streams	*(Almeida & Soares, 2014; Dave & Koskela, 2009; Matthies, 2015)*
20	Perception of personal lack of time and work pressure	*(Razmerita et al., 2016; Westin, 2014)*

2.5 Wrap up

This section provides the concluding remarks of the literature review. All findings will contribute to answering the main research question. This section closes off by explaining what the next steps of this research that are derived from previous sections are.

2.5.1 Bottlenecks embedded in construction nature

The literature study found that due to the fragmented and project-based nature of the construction industry, construction companies and project teams must deal with complex and often unstructured documents and work deliverables (Coners & Matthies, 2018). This results in

various bottlenecks when dealing with data. Examples are the storing of unstructured project data, the increasing complexity of data retrieval, poor interoperability between systems, and hard information re-use due to the lack of compatibility (Martínez-Rojas et al., 2016). As a result, data silos arise, and it becomes even harder to benefit from others' experiences and expertise across the organization to learn from other successes and prevent failures.

The fact that the hardest difficulties are embedded in the nature of construction is a serious issue since it is not an option to change this nature. Introduced measures to manage data adoption within organizations should be in line with this nature; otherwise, implementation will not be effective. This research aims to find aligned solutions for dealing with data sharing in a MEC and implies to maneuver with the nature of construction, aiming to provide applicable recommendations for future use.

2.5.2 Data sharing grows business

The potential that data sharing has is acknowledged as very significant. Since projects become more complex over time and this will most likely keep increasing in the far future, the need for effective collaboration also becomes more intense. The key in this situation is to establish effective data sharing facilities in an organization and increase the chances of project success. In this manner, construction companies can manage their data streams, make decision-making more effective, reduce delays and cost overruns, and ultimately grow their businesses.

Also, globalization is becoming more important to stay ahead of the competitive market, having multicultural insights into global teams and remote projects can even add more value to the organization in becoming more successful. But a requirement for this is that DSNs are managed well, and everybody contributes to performing as an integrated team.

2.5.3 Insights for improved data sharing

There does not yet exist literature that explains the data sharing behavior of specific project roles on project level, on expertise level, and on organizational level. However, understanding the role attitude towards data sharing is essential as it can explain their needs towards integrated collaboration by data sharing. It is assumed that each role has a different approach to handling data and acts accordingly. When in fact, this data sharing behavior is unaligned between team members, it will result in handover and interface issues within and after the project. Also, when it is understood how certain project roles handle data sharing, this can be used in setting up new project team organizations and data sharing approaches.

2.5.4 Revealed data sharing factors

In order to do that, it is necessary to understand what influences data sharing behavior in engineering companies. The literature study described many different reasons why data sharing takes place or does not take place, and these reasons can all be related to certain data sharing factors. These factors have been elaborated on in the previous section and will be used in the proceedings of this research. By understanding what the characteristics of a DSN are, testing what factors determine the level of data sharing in that network, conclusions can be formulated how that specific data network uses measures in order to enhance intra-organizational data sharing. This research is focused on data streams of enterprise data, data that is shared in one organization across teams, departments, and regional locations.

3 METHODOLOGY

Berck, D.P. (2019) - This picture is blurred due to confidentiality reasons.

3 METHODOLOGY

In this chapter, the methodology resulting from the conducted literature study is explained, which consists of the following sequential steps. First, the mixed research method is further described (3.1). Then the case preparations are explained (3.2). Thereafter comes the application of the Social Network Analysis (3.3). The output of the SNA will serve as the input for the final method in the form of the Root Cause Analysis (3.4). How the case phases are combined is described in section 3.5, and in section 3.6 is explained how these combined findings will be validated with a group of experts.

3.1 Mixed research method

This research will be performed in a mixed research method, combining forms of both quantitative and qualitative data collection and analysis. According to Yin (2009), mixed methods are, by definition, more difficult to execute but do address broader and more complicated research questions. The main research method in this study is in the form of case studies investigating contemporary projects, including behavioral events towards data sharing in an organization. Yin (2014) describes these project-based elements, together with having a 'how' research question, like in this research, as important indicators for performing a case study.

This research investigates the multinational data network of one MP within RHDHV. This is considered as a single case design that can also be used to gain generalizable findings (Flyvbjerg, 2006). This research investigates multiple projects that are part of a multinational portfolio at RHDHV. This type of case study is called an embedded case study design (figure 22), where the case projects are embedded units of analysis within a larger case context (figure 23). Having multiple units of analysis reduces the sensitivity of orientation slippage, which is a risk in single case study designs (Yin, 2009). The case projects serve as the main sources for gathering both quantitative and qualitative data and should, therefore, be chosen carefully (Yin, 2009). The data will be collected mostly sequentially, in which analysis output on earlier gathered data will serve as input for later analysis. Integrating data at one or more stages of the research process is a typical characteristic of a mixed-methods study (Creswell, Clark, Gutmann, & Hanson, 2007).

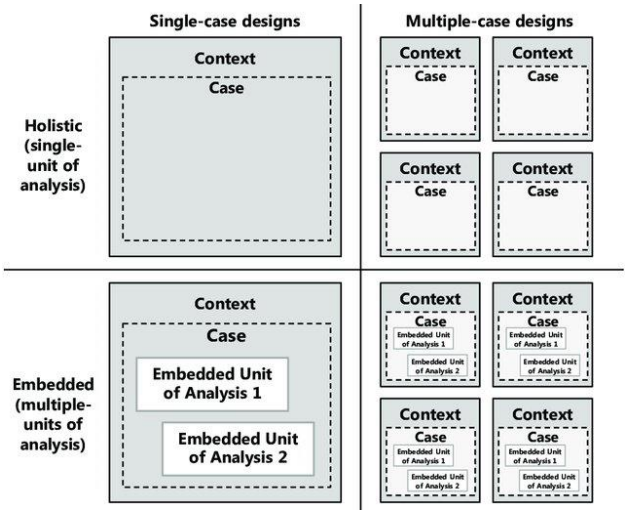


Figure 22: Basic types of designs for case studies (Yin, 2009)

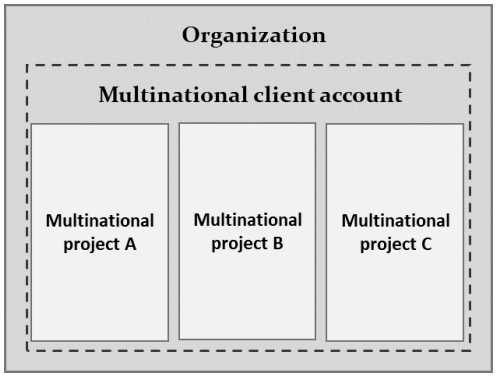


Figure 23: Embedded case study design

First, quantitative data collection is conducted through a closed-question survey. This method can gain an overall picture of a comprehensive phenomenon spread out over space and time

(Verschuren & Doorewaard, 2010). Results expose a broader understanding of the research variables and the relationships between them, as the data must be retrieved from a relatively large sample of random respondents representing the researched population. This supports the generalization of the survey outcomes.

Secondly, reaching the desired in-depth level in the case study can be achieved by applying qualitative research. Several qualitative methods, such as exploratory interviews, document investigation, qualitative factor analysis, and in-depth interviews, are combined to gain a variety of evidence sources (Yin, 2009). Next to that, in any data collection and analysis method, it is important for the researcher to take on an objective role and be transparent in its findings (Resnik, 2015). Qualitative data collection can be assembled with a relatively smaller group of people but is also more time-consuming (Verschuren & Doorewaard, 2010).

3.2 Case preparations

This research focusses on analyzing DSNs in a multinational portfolio of the graduation company RHDHV. This portfolio has been selected because it roots from many years ago and consists of a significant number of already delivered and currently running local brewery projects. Available information and knowledge in the company need to be analyzed as preparation for the case study to get a better understanding of the context of the portfolio. The following methods will be used to conduct the case preparations.

3.2.1 Exploratory interviews

Exploratory interviews are an unstructured way to explore what are the possibilities in gathering relevant data. At this stage, the objective is to discover new information rather than confirming the available information (Wünderlich, 2009). Often a list of topics that needs to be covered in the interviews is used to be better informed when continuing the research. From those interviews, new ideas and statements can be developed to obtain a better-verified research direction and set the right boundaries. In this research, the following items are the main reasons for conducting exploratory interviews:

1. Selection of suitable case projects that fit the case requirements;
2. Exploring the general organizational and work structure of the case projects;
3. Understanding current data sharing practices within RHDHV.

The respondents for these interviews have been selected based on their expertise in the portfolio and the mentioned items. The three selected respondents and the related interview topics are listed in table 5. In appendix C1 the exploratory interview protocol for all three interviews is presented. After completion of the exploratory interviews, the findings will be used for the case selection, general project understanding, and insights in current data-sharing practices.

Table 5: Respondents exploratory interviews

Job role	Interview topic
Portfolio manager	Multinational portfolio in general, case project selection, and data management in the portfolio
Project and tender manager	Project phasing and scheduling, and data management at the portfolio
Project and digital manager	Digital Project Delivery, information flows and responsibilities, and data management at the portfolio

Selecting the right case projects has a big influence on what conclusions will finally be retrieved and should be done carefully (Yin, 2009). Therefore, pre-defined conditions for the case selection in line with the research objectives must be formulated to conduct a plausible case study. The conditions for this research are shown in table 6.

Table 6: Pre-defined case project conditions

Condition focus	Description
Project phase	All the case projects should be in either one of the last project phases or already have been delivered during the investigation.
Data network	All the case projects should have (had) a well-operating, complete, and representative DSN.
Project location	All the case projects should have (had) different project locations in order to compare their multinational context.
Project size	All the case projects should have (had) around the same volume of beer produced per year [hl/year].
Project team	All the DSNs of the case projects should have (had) a medium to a large number of people contributing to the network.
Project scope	All the case projects should have (had) a medium to large project scope compared to all the projects in the portfolio.
Project type	This study does not consider a difference in greenfield and brownfield projects since both project types consist of comparable DSNs.

3.2.2 Desk research

The research company owns a large and secured, semi-organized cloud environment with project data. Most relevant project information is being stored in a certain folder structure. During the desk research, this information will be analyzed and aims to gather knowledge about the organizational structures of the selected case projects. The organizational charts and team divisions will be analyzed to identify who reports to whom, what are the team roles, and what are the associated work shares of the concerning team members.

The main deliverable of the exploratory desk research is a statistically identified list of respondents that will be asked to participate in the first data collection. This selection results from the work shares of the team members and must be high enough to let that team member be a significant contributor to the DSN of the concerning case project. This requirement is necessary as team members with lower work shares do not qualify as valuable respondents to take part in the following SNA.

3.2.3 Qualitative factor analysis

Another activity within the case preparations is qualitative factor analysis, analyzing the data sharing factors retrieved from the literature study. This is necessary to generate a list of statements that can be tested during the in-depth interviews. The qualitative factor analysis searches for the categorized factors and can be explained as "describing the variability among observed correlated variables, and to retain those factors whose meaning is most comprehensible to the researcher" (Sovacool, 2013, p. 396). This method assumes to be somehow subjective, but qualitatively identifying key factors still has proven to be useful in relevant scientific research (Bosch-Rekveldt et al., 2011; Reio & Shuck, 2015).

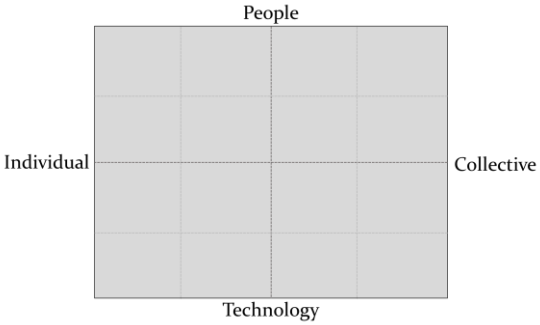


Figure 24: Qualitative factor grid

A grid has been used to apply this in a structured way. It consists of two acknowledged data management dimensions, 'people-technology' and 'individual-collective' (DeLone & McLean, 2003; Lee & Yu, 2012). The retrieved 20 data sharing factors from the literature will be positioned in this grid to find similarities and identify clusters. This makes it possible to combine multiple related factors into one categorized factor and formulate statements accordingly. The aim is to arrive at approximately ten statements, as this is a manageable number to examine during the in-depth interviews. These statements, combined with findings from the SNA, are qualitatively tested during the in-depth interviews, making use of an RCA approach. How the findings from the SNA are retrieved, is explained in the next section.

3.3 Social network analysis

This research selected the SNA to identify patterns and structures in the data-sharing networks of the case projects and in the combined data-sharing network of the portfolio. In order to conduct an SNA, several steps must be taken. First, the principle is explored (3.3.1). Thereafter the data collection method in the form of a quantitative survey is explained (3.3.2.), and lastly, the analysis techniques performed in a Python environment are described (3.3.3).

3.3.1 SNA principle

The Social Network Analysis is a quantitative and qualitative research method that investigates social structures in networks making use of graph theory. The term was officially first introduced in the mid-1950'5 (Barnes, 1954), years after the first pioneering work of Moreno (1934) on social life (figure 25) (Freeman, 2011). Recently the method has gained increasing popularity since our society is expanding with an increasing number of all kinds of complex networks (Serrat, 2017). Especially considering the growing pace of information, data, and knowledge flows, the SNA offers great insights into how these social networks operate. An SNA can be carried out in many different forms and with different intentions, but the basic principle stays the same: analyzing a group of nodes (individuals, groups, organizations, hubs, computers, etc.) that are connected through a set of links (data streams, friendship, transport routes, internet, etc.) in a shared social network (OGL, 2016).

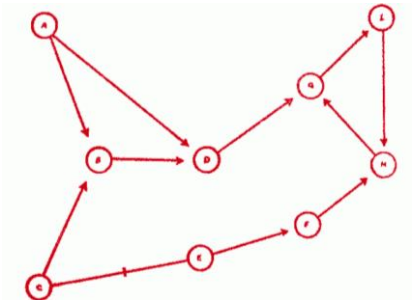


Figure 25: Pioneering work on social life (Moreno, 1934)

The SNA is proven to be an appropriate research tool to examine complex project management networks and maps formal and informal relationships between actors in large construction projects (Chinowsky & Taylor, 2012; Freeman, White, & Romney, 2017; C. Y. Lee et al., 2018; Pryke, 2017) and is also applied within a multinational context (Javernick-Will, 2011). Five key abilities of SNA in construction projects are mentioned by Zheng, Le, Chan, Hu, & Li (2016, p. 1216): "interdependence in project-based network organizations, cross-boundary organizational relationships, accurate representation of project structures and process methods, multiple levels of analysis with the involvement of micro-macro linkages and integration of quantitative, qualitative and graphical data for a thorough and in-depth analysis". Most SNA studies are quantitative and have a focus on an inter-organizational analysis (Zheng et al., 2016). This research combines quantitative and qualitative methods in an intra-organizational setting.

3.3.2 Survey

Most SNA-based studies make use of a case study, in which data collection takes place through a survey or interviews (Chinowsky & Taylor, 2012; Zheng et al., 2016). In this research, a survey is used to collect data about the case projects and the associated DSN. The aim is to address all types of data, data users, data generators, and data streams in the network to maintain a general overview of how a DSN could be mapped. Team members with a considerable work share are invited to participate. Combining the input of the portfolio manager and scanning the organizational charts and work hours, the potential participants will be selected. This limits a biased outcome and increases the consistency and representation of the networks (Chinowsky, Diekmann, & O'brien, 2010). The survey retrieves quantitative data about people (nodes), their social connections (edges), the tools they used, and certain preferences they experienced when sharing data in their projects. The survey protocol is presented in appendix E2 and is based upon a typical SNA survey setup developed by Durant-law (2007).

3.3.3 Graph analysis

After data collection, the next steps are visualizing and analyzing the data to complete the SNA. First, the SNA will be conducted for the case projects separately, and after a combined SNA will be performed on the total portfolio. Many options are available to present the data, and help the researcher to communicate the findings (Freeman, 2011). In this research, the programming language Python is used in combination with the Python libraries Networkx and Matplotlib. The libraries offer pre-coded possibilities in drawing graphs and analyzing networks. Each network graph contains a set of graph elements that, on their turn, consist of attributes. These attributes are explained below, including how it has been decided to visualize them.

Table 7: Graph elements

Graph element	Attributes and visualization
Nodes *Individuals that contribute to the network.*	• *Role* – each node has a specific role that is defined by the color of the node. The following roles and colors can be distinguished: ○ Project/Design management: yellow ○ Project Assistant: blue ○ Engineering: red ○ Tender & Contracting: green ○ Drafting/Modelling/BIM: pink ○ Costing: purple ○ Construction management: orange ○ Other specialists: silver (HSE/Building Physics/Finance/etc.)

Edges
Data streams between individuals.
	• *Frequency* – each edge has a specific frequency in which the data sharing takes place that is defined by the width of the edge. The following frequencies and widths are defined:
	  ○ Daily frequency: 10.0 (with: 10.0)
	  ○ Weekly frequency: 7.0 (width: 7.0)
	  ○ Monthly frequency: 4.0 (width: 4.0)
	  ○ Occasionally frequency: 1.0 (width: 1.0)
	• *Value* – each edge has a specific value definition that is defined by the style of the edge. The following values and styles are defined:
	  ○ Very high value: 10.0 (solid line style)
	  ○ High value: 7.0 (dashed line style)
	  ○ Moderate value: 4.0 (dash-dot line style)
	  ○ Low value: 1.0 (dotted line style)

Tools *Used tool to transfer data over data streams*	• *Preferred tool* – tool that has been indicated as the initially preferred tool to use when sharing data with other individuals in the network. • *Most used tool* – tools that have most been indicated for sharing data with other individuals in the network.

Graph
The total graph representing the data-sharing network
	• *Direction* – the graph is presented by undirected edges that do not address source and target nodes. This has been decided because:
	  ○ To not make a distinction between respondents and team members added by respondents in the network.
	  ○ It is assumed that the mentioned data streams between nodes are two ways and not only one way.
	• *Layout* – the total graph is drawn by using the Kamada Kawai layout. This algorithm positions the nodes and edges based on a force-directed layout using a path-length cost-function. Explained by the following:
	  ○ The graph is considered a system of springs.
	  ○ Springs can be stretched or compressed and contain energy.
	  ○ Stored energy is equal to work ($W = 1/2\, kx^2$), where k is the positive spring constant, and x is stretched or compressed distance, i.e., difference between the length to equilibrium state.
	  ○ The Kamada-Kawai algorithm minimizes the energy of the whole system of springs (Pospisil, Hasal, Nowakova, & Platos, 2015).

In an SNA-based study, graph theory concepts can be applied to analyze the graph and the relationships between the present nodes and edges (Chinowsky et al., 2010; C. Y. Lee et al., 2018). Discovering patterns and structures contributes to understanding the visual appearance of the graph. Centrality is a measure that indicates the importance of nodes in different applications with values between 0-1. The following concepts are analyzed:

- **Network density** – the actual number of connections present in the network divided by the potential number of connections. In networks with high density, the number of nodes is relatively low compared to the number of edges in the network.
- **Network clustering** – the actual number of triangles present in the network divided by the potential number of triangles represents the clustering coefficient. Networks with high clustering show more groups between nodes.
- **Degree centrality** – a measure to calculate the number of connections a particular node has in the network compared to other nodes in the networks.
- **Eigenvector centrality** - decides the connectivity of a node by measuring if that node is connected to connected neighboring nodes and addresses the power of that node.

- **Betweenness centrality** – the amount of information that flows through a specific node to be distributed to the rest of the network. Having a high betweenness as a node indicates the strong dependency of the network on that single node.
- **Closeness centrality** – calculates the average of all shortest paths from a particular node to all other reachable nodes in the network coming from that node. A high closeness centrality indicates the efficiency of data sharing.
- **Eccentricity** – This type calculates the maximum distance of the path from one particular individual node to all other nodes in the network. It indicates how easily a node can make connections with surrounding nodes.

These techniques expose unique insights into network patterns and different node types (figure 26). The desired level of depth in this research is reached by combining these insights with the additional RCA to uncover why certain connections are made and why others are not, to understand the data sharing behavior in the networks.

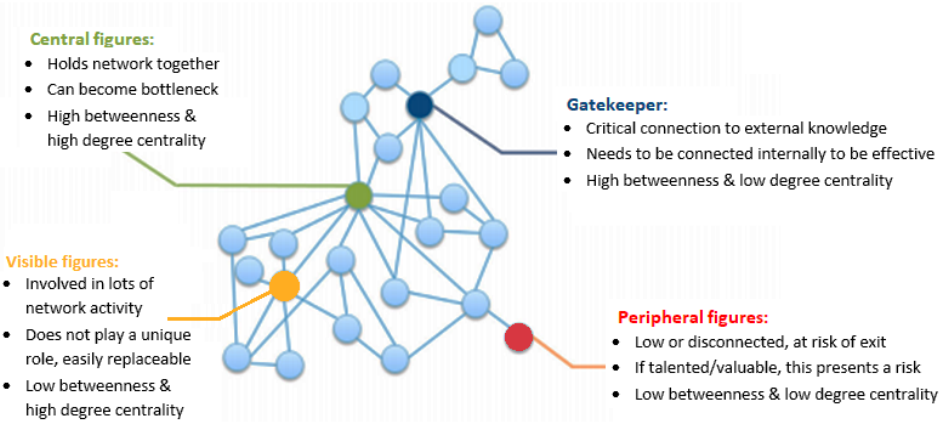


Figure 26: Node types in the network (based on McDowell, Horn, Witkowski, & Miller, 2016)

3.4 Route cause analysis

Applying an RCA is needed to reach a desired level of depth. In combination with the factor identification from literature and the findings from the SNA, a set of statements will be validated with experts from practice to address the root causes of their data sharing behavior in the case projects. In this section, first the RCA principle is explained (3.4.1.), followed by describing the data collection technique in the form of in-depth interviews (3.4.2.). In 3.4.3. it is explained what steps results in the validation of the formulated statements.

3.4.1 RCA Principle

In this part of the research, the findings from the literature study and the SNA come together. The qualitative RCA focusses on 'why' and 'how' certain phenomena happen. By the identification and understanding of the 'root causes', occurring problems can be solved in a systematic way (Vliet, 2010). This RCA-based study aims to get a more in-depth understanding of the formulated data sharing factors and the findings from the practical SNA. RCA is a valuable method as the outcome adds to more long-term instead of short-term solutions (Vorley, 2008). Knowing how to solve the core of problems increases productivity and efficiency in a company. It prevents that employees are structurally working on quick fixes and therefore miss out on opportunities to grow their organization. Being aware of root causes will contribute to the development of solid business strategies and gives understanding of current results.

An RCA can be applied in many different forms and consists of a sequence of steps to ultimately come to the desired conclusions (Barsalou, 2015). One of the applications that is underestimated as not much scientific research has been dedicated to it is the root cause analysis of success. Instead of solving problems, it can also be applied for analyzing successes (Whitney & Trosten-Bloom, 2016). This application is in line with appreciative inquiry, organizational development focusing on strengths rather than weaknesses. For this research, we apply both to identify the root causes that led to limited data sharing and the root causes that led to enabled data sharing. The following steps are the basic principles of an RCA and will in this research be conducted accordingly:

1. **Define the observation** – describe the occurring situation and give understanding of what it entails. In this research, this is done by performing a problem analysis and context definition of intra-organizational data sharing in the construction sector.
2. **Collect data** - gather factual evidence and create a complete overview of the desired situation. In this research, this is done by analyzing existing literature and collecting evidence from practice in the case studies.
3. **Identify the possible causal factors** – address all potential factors that could have resulted in the phenomenon. In this research, factors and patterns from the SNA have been classified and formulated into statements that can be tested.
4. **Identify the root causes** –discuss what the root causes of the possible causal factors are by asking the why-question multiple times. In this research, the in-depth interviews with selected respondents are used to find the root causes for data sharing.
5. **Recommend and implement solutions** – conclude what measures can solve the identified problem root causes or what measures can further activate successful root causes. In this research, the final recommendations will provide advice on how to enhance data sharing based on these findings.
6. **Monitor the effectiveness** – The final step in RCA is to monitor and measure if the suggested solutions have a fundamental effect on solving the problem or activating success. In this research, the productivity of the project teams and the MP as a whole regarding data sharing should increase when implementing the recommendations. However, monitoring is out of scope for this research but should be performed by the research company itself or could be analyzed in further research.

3.4.2 In-depth interviews

The data collection of the RCA is in the form of in-depth interviews. This method allows gathering explanations from a relatively smaller group of respondents (Verschuren & Doorewaard, 2010). Ten respondents are selected systematically for the in-depth interviews to ensure dispersion of various team member perspectives, positions, and roles. Discussing the ten statements will explain their data sharing behavior. Formulating understandable statements helps in achieving this purpose. This can be realized by having statements that make simple assumptions, are not too specific, and have a way in which to disprove them (Barsalou, 2015).

During the interviews, an RCA approach is applied by asking the why-question at least five times to come to the root causes of data sharing addressed by that specific respondent (Rooney & Vanden Heuvel, 2004). This method is called the 5 why's method or Gemba Gembutsu (Sarkar, Mukhopadhyay, & Ghosh, 2012; Vorley, 2008). The interviewees' reaction to a statement can be

framed in one out of four categories (table 8). The first two categories indicate root causes of enabling factors for data sharing, and the last two categories indicate root causes of limiting factors for data sharing. The time taken for the interviews is limited to 60 minutes. There will be questions included about sharing data within projects and between projects in the portfolio, depending on the interviewee. The full protocol is shown in appendix F2.

Table 8: In-depth interview categories

Agree with statement and applies to me in the project because …	**Disagree with statement but applies to me in the project because …**	**Agree with statement but does not apply to me in the project because …**	**Disagree with statement and does not apply to me in the project because …**
Five times why?	Five times why?	Five times why?	Five times why?
Root cause of enabling factor	**Root cause of enabling factor**	**Root cause of limiting factor**	**Root cause of limiting factor**

3.4.3 Statement analysis

After conducting the interviews and retrieving the root causes of limiting data sharing and enabling data sharing factors in practice, the results will be further evaluated. First, conclusions can be made by analyzing the positions of the interviewees in the data sharing networks. Secondly, it is analyzed what factors influence data sharing the most and what explaining root causes were mostly mentioned. The difference between a root cause and a factor is that causes produce an effect; eliminating the cause will eliminate the effect. Factors influence the likelihood of, accelerate, or affect the consequences of an effect. Eliminating a factor does not directly eliminate the effect (Gluzman, 2020).

Lastly, the root causes retrieved from the interviews are focused on practice and will be compared with the data sharing factors retrieved from theory. This will provide insights about what factors from theory are root causes in practice that directly enable or limit data sharing in multinational engineering companies. In the next section, it is explained how these deliverables contribute to answering the main research question and how the components come together.

3.5 Synthesis

The final goal of this research is to converge into answering the main research question and reaching the research objectives. Prior explained methods all contributed to separate parts of this research supported by dividing sub-questions.

In this research, the focus has been put on understanding dynamics in the data-sharing network of a multinational construction portfolio by analyzing embedded multinational construction projects within that portfolio. In embedded design, a major pitfall is when the embedded research units are only analyzed separately, and the researcher fails to derive back to the transcending focus. When this is not done, the research gets stuck at a multi-case project study where the individual employees are the research units instead of an organizational program case study where the projects are the research units (Yin, 2009). By taking the case projects as research units and combine and compare the findings, it can be concluded how intra-organizational data sharing can be enhanced in the total portfolio and subsequently can be transferred to other client portfolios and the organization.

3.6 Wrap up

The following flowchart shows the different methodology activities and their output that together eventually realize this research and answer the main research question.

3.6.1 Unique mix of research methods

This report combines a set of research methods that reinforces the reliability of the overall results. First, literature is consulted to understand and be aware of the current body of knowledge within the scope field. These factors will be tested in practice and prevent reinventing the wheel and knowing how to focus. The following quantitative SNA maps the actual reality in visual representations, that expose the factual data streams between people. The qualitative RCA enables a deeper understanding of those factual data streams and exposes what is underneath those visualizations. In this research context, solely conducting quantitative research methods limits the validity of the results, since it only tells half of the story. Solely conducting qualitative research tells a story, but who knows if that story is truly reflected in reality. These two methods complement each other and together create a stronger interpretation of the results.

3.6.2 Inductive approach

The aim of this research is to analyze how data sharing can be enhanced and under what circumstances can take place? What are the network requirements to perform effective data sharing, resulting in effective collaboration and, ultimately, project success? This is achieved by applying an inductive approach that aims to build a theory based on observations and patterns. A few steps need to be completed to derive the desired results and make valuable conclusions. The sequence of steps of this inductive approach is showed in figure 27.

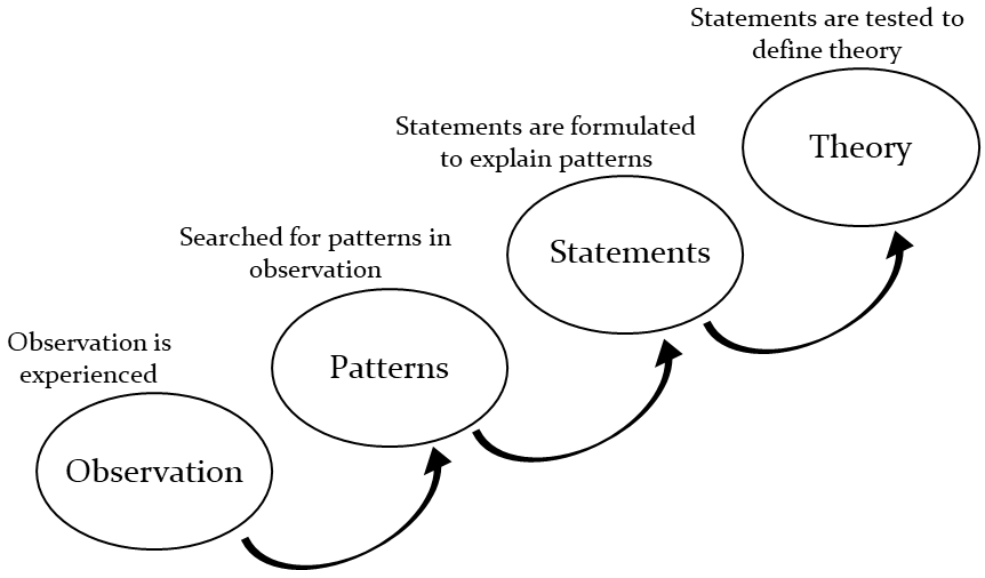
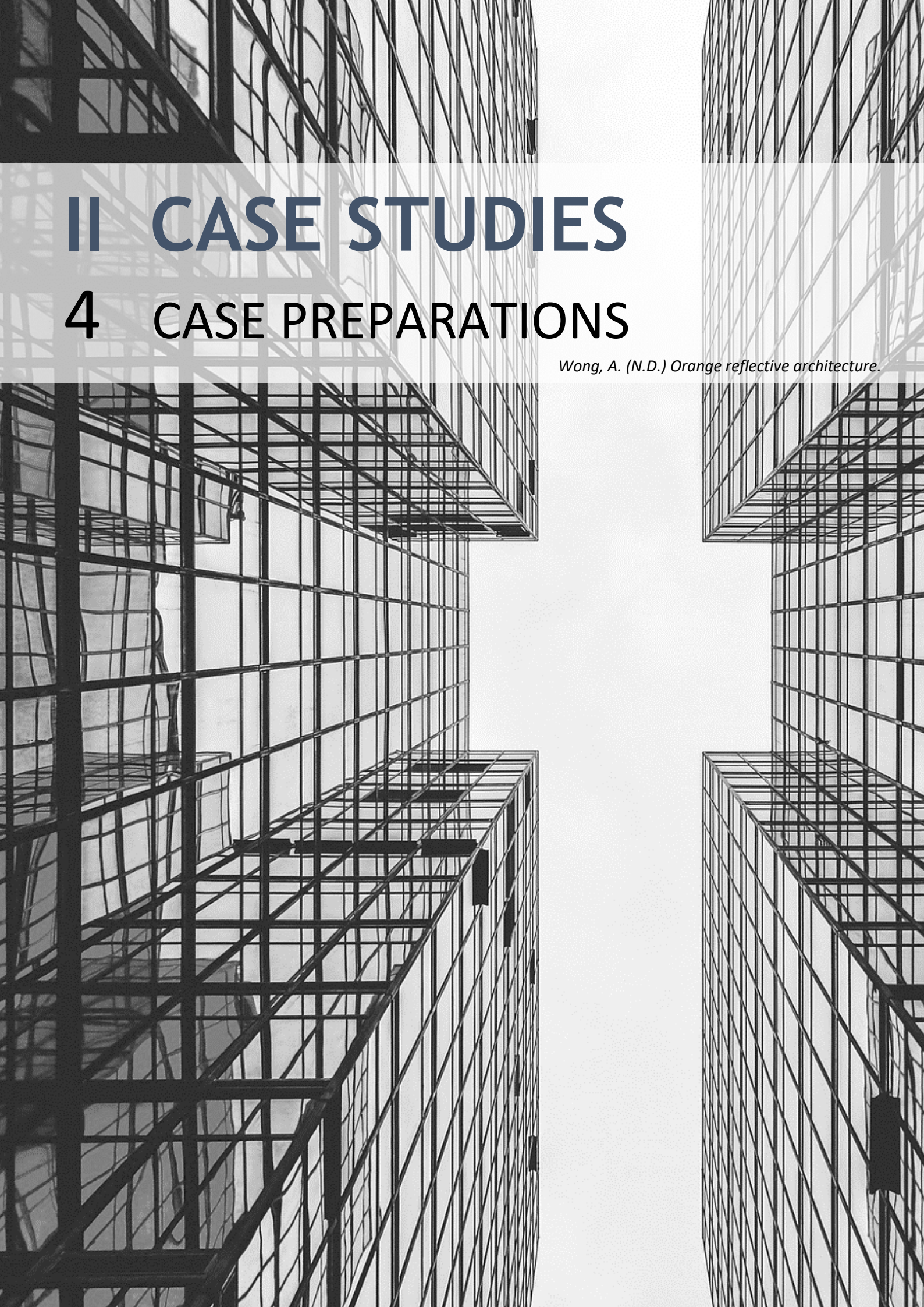


Figure 27: Inductive research approach (own illustration)

II CASE STUDIES

4 CASE PREPARATIONS



Wong, A. (N.D.) Orange reflective architecture.

4 CASE PREPARATIONS

This chapter explains the results of the case preparations, performed to get a better understanding of the context of the case study. First exploratory interviews support a careful case selection and gain a better understanding of the organizational environment (4.1). Secondly, individual desk research gathers available information stored in the company's online databases (4.2). Finally, the findings from the literature study will be further analyzed in a qualitative factor analysis to be later applied in the case study (4.3.).

4.1 Exploratory interviews

In three exploratory interviews, the first findings are retrieved for conducting the case study. The selected items zoom in on the subjects: the case project selection, organizational and work breakdown structures of the projects, digital project delivery, and current data sharing practices.

4.1.1 The multinational portfolio

The multinational client and RHDHV have been collaborating for 135 years and realized over 70 brewery projects together, the first being in 1884. Working together for so many years brings advantages to the table as understanding each other's work mentality, standards, and requirements, and experience with the brewing process to optimize the integration of work. On the other hand, long-lasting relationships may also lead to expectations about company culture and work performance or ingrained power tensions (van Marrewijk et al., 2008). The client also expects RHDHV to optimally utilize generated project data and information from previous projects to improve their work, lower costs, and increase work efficiency.

To comply with these clients' expectations, RHDHV aims to keep developing their work and organizational structures. The main knowledge hub of RHDHV for these projects is situated in the Netherlands, close to the global headquarter of the multinational client. Most conceptual and basic designs are developed here, but to benefit from lower staff hour expenditures, a new knowledge hub is growing in Vietnam. Here most detailed engineering work is performed of all portfolio projects. This results in a mixed projects team, with different cultures, languages, and arising barriers such as distance and time difference. Costs, capacity, and local contextual know-how are key factors that determine the composition of project teams. It must be decided what the most economical balance between labor costs and coordination costs is. Often smaller projects are carried out in the Netherlands and larger projects in cooperation with Vietnam. Collaboration with freelancers and local partners often support construction work on site.

Mostly traditional DBB contracts are established between RHDHV and the multinational client ranging from smaller scope projects to full EPCM projects. In this research, three case projects have been selected that fulfilled the pre-defined case project requirements best. In appendix C3 the full case selection overview is presented based on the exploratory interview held with the portfolio manager of RHDHV. It can be concluded that the brewery projects in Vietnam (phase 5.1), Ethiopia (phase 3), and Haiti (phase 1-2) comply the most with the pre-defined requirements (table 9). Appendix C3 shows the organizational division of work phases and the project details. The smaller brewery project in Haiti was conducted in the Netherlands, the brewery in Ethiopia at both the Netherlands and Vietnam office, and the brewery in Vietnam was completely conducted in Vietnam.

Table 9: Case project selection

Project	Project type	Project status	Project size	Project scope
Brewery in Vietnam (Asia)	Greenfield	Delivered in 2019	Large	Full EPCM
Brewery in Ethiopia (Africa)	Brownfield	Delivered in 2019	Large	Design, tender, IFC, PM and CM for extension brewery
Brewery in Haiti (Central America)	Brownfield	Delivered in 2019	Medium	Design, tender, IFC and PM for extension brewery

4.1.2 The brewery project life cycle

The project life cycle of these brewery projects has not drastically changed over the last years. What has changed is that the projects need to be completed in shorter time frames with tight milestones and work phases. As RHDHV is responsible for the civil works of the brewery and the client remains responsible for installing the brewing process, critical situations often occur in which the integration of the civil works and the process installation are not completely streamlined. Civil decisions must be made in the early phases of the project without having access to complete and definite information about the process. This often results in time delays and additional costs due to change orders in the construction phase.

For RHDHV, it is key to respond to the project planning and with the project schedule and splitting of work packages. When the project tends to get behind on schedule, the work breakdown structures could be divided into smaller parts to save time by bringing later planned tasks forward in the planning. In appendix C3 a complete overview is shown of a typical brewery project life cycle consisting of milestones, responsible parties, and collaboration links. It also provides a clear timeline and appoints the challenges that may arise at certain moments in time. The schedule can be divided into two main phases for the RHDHV scope of work: the design phase and the construction phase, both consisting of several work packages. These work packages are subdivided into the phases tender, design, manufacture, (shipping), and build/ install. Subdividing the scope of work into a number of smaller units increases the level of detail and control over the project (Burke, 2003).

4.1.3 Digital project delivery at RHDHV

In 2018 the Strong22 ambition and vision document of RHDHV had been created to be achieved before 2022. This document also sets goals for the implementation of digital project delivery and the application of BIM in projects. More specific this is described in the BIM22 guidelines and standards for the whole company. Very recently, all projects are obliged to apply BIM level 2 requirements, consisting of Common Data Environment (CDE), naming convention, Asite document control, pre- and post-appointed BIM execution plan, and the master information delivery plan. These requirements are based on the ISO-19650 standards describing organization and digitization of information, including BIM (ISO 19650, 2018).

The contribution of the client is important in the realization of digital project delivery. The client must decide beforehand what information is available and what is needed to deliver their asset. As the client also desires to apply fast tendering, the mobilization phase should start early in the project. RHDHV could structure all available company information to realize faster mobilization lead times. In appendix C3, three charts are presented that explain this ideology for effective information management, CDE use, and responsibilities. RHDHV can play an active role in

supporting the client if their own data management strategies can be pursued. Traceability of data towards the client and other RHDHV employees during and after the project can really help to understand why certain decisions have been made and to what actions they have led. Eventually, projects will be delivered more successfully with increased quality and efficiency.

4.1.4 Data management in the portfolio

The current status of data management in the portfolio has been discussed with all three respondents from the exploratory interviews. All of them mention that the potential of data is slowly being utilized better, but there is still a lot of room for improvement. The transition from only generating and collecting project data to developing a system that enables leveraging data. This includes the active engagement of employees with the aim of reshaping the current mindset of the company regarding digital technology.

There are many tools available for dealing with data and information, but they all contain small parts of the information that fragments the total overview causing diffusion in the company. There is a gap in the current network of knowing who the right person is, or what is the right place to go to when certain questions need to be answered. Projects always must follow up with tight deadlines, which leave only limited time for process developments in data management. Currently, digital innovation is only happening at a slow pace. The multinational client is demanding for change but also does not set strict requirements for handling information. Brewery projects now include digital project delivery elements presented in figure 28.

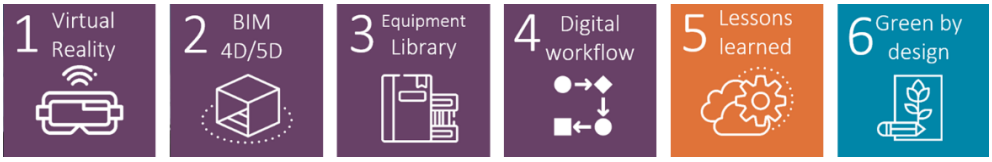


Figure 28: Digital Project Delivery in brewery projects

In the portfolio, there is now a special focus on people in transforming information management. Roadshows are organized to create awareness and let people understand digital possibilities. Digital environments, knowledge platforms, and training are being offered. The structures of the brewery projects across the world are similar, but work procedures, project control, and organizational structures are different for each RHDHV office. It is important to pay special attention to coordinate this part of the digital transition. Now the total RHDHV network is not strongly connected, and therefore it would be valuable to see what the currently active data streams are, who is connected, and where are the missing links. This research aims to close that gap in the current data sharing practices in the multinational portfolio.

4.2 Desk research

The desk research resulted in an overview of project details for each selected case project. The total overview can be seen in appendix D1, including a geographical print of the local sites in Haiti, Ethiopia, and Vietnam. For all three projects, a list of employees and associated staff hours of work has been retrieved from the online RHDHV database. In appendix D2, these lists are presented, showing the individual share of staff hours spend on the project per employee and the cumulative percentage of work hours. For each project, only employees with at least a 1%

individual work share are selected as potential respondents for case studies. For all three projects, the cumulative percentage of staff hours covered remains around 90%-95%, meaning that the employees that covered for 90%-95% of the total project hours spend will be invited to participate as respondents in the case study. The people that are highlighted in red have either left the company or worked as freelancers on the project. Reaching them through their company email was not possible anymore. The next chapter provides an analysis of the actual respondents that participated in the SNA.

4.3 Qualitative factor analysis

The performed qualitative factor analysis starts with positioning the 20 data sharing factors alongside two axes 'people-technology' and 'individual-collective (figure 29). The upper half of the grid represents the people-focused factors of data sharing, aka the soft factors. The individual people's side shows people's inner perceptions, being in control, intrinsic motivation, and personal demographics. The collective people's side is organizationally focused and entails cultural impact, company-broad policies, and shared procedures. The grid shows many factors in this section, which can be explained by the fact that data sharing takes place in large social networks of people.

On the lower side of the grid, the hard technology factors are represented. It is assumed that establishing effective data sharing is more difficult on the human side (more factors are positioned in the upper half). Still, hard factors are also important to control. Individual technology focusses on having access to and time for increasing personal skills. Role specifications and responsibilities should be considered in offering bespoke and diverse training. Collective technology focusses on the development and the resources to develop and maintain systems, procedures, and infrastructure. It is a continuous process to implement state-of-the-art and create a competitive advantage.

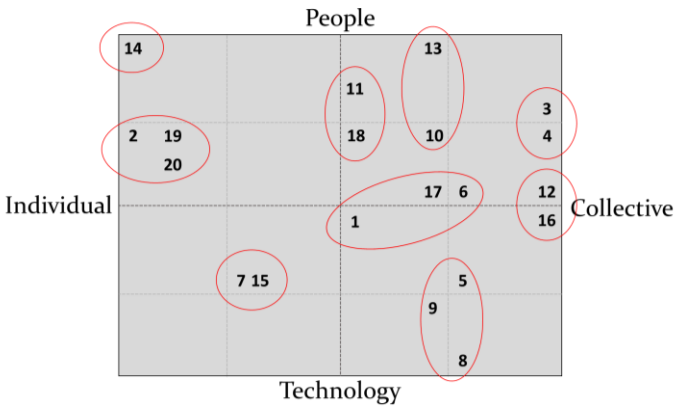


Figure 29: Data-sharing factors in qualitative factor grid

From the grid above, the 20 data sharing factors have been combined to create a smaller set of categorized data sharing factors. The result of this process is presented in table 10. See Appendix B2 for the detailed descriptions of the categorized data sharing factors retrieved by performing the qualitative factor analysis. By combining these categorized factors with the findings from the following SNA, a set of eight statements will be formulated and used during the RCA interviews. At this point, the quantitative research method is combined with the qualitative research method to get a more in-depth understanding of the results.

Table 10: Data sharing factors from literature

#	Data sharing factors from theory	#	Categorized factors
5	Institution authority by developing information sharing infrastructure	1	Access to up-to-date and central data sharing infrastructure
8	Operation ability by information infrastructure accessibility		
9	Organizational compatibility of systems and files		
1	Extrinsic motivation by external rewarding or incentives	2	Support and triggers from higher management
6	Institution authority by establishing legal frameworks and formal policy		
17	Economic costs and investments in infrastructure, training & coordination		
12	Increasing detail and dynamic project complexity	3	Clear and flexible and data sharing environment
16	Competitive market causing faster project delivery		
7	Operation ability by employees' skills and experience	4	Room for personal development and training in data sharing
14	Personal demographic details		
15	Role specifications and role responsibilities		
10	Perception of information security	5	Trust in people and the data sharing environment
13	Intra-organizational relationships between employees		
2	Intrinsic motivation by individuals own incentives	6	Reliable and valuable data sharing environment
19	Perception of control and overview of data streams		
20	Perception of personal lack of time and work pressure		
3	Global affiliation and integration of teams	7	Facilities for consistent global integration and interaction
4	Global awareness of remote activity and communication		
11	Distinct cultural perceptions of capabilities and mentality	8	Global standardization and alignment in data sharing
18	Misunderstanding due to cultural differences		

4.4 Wrap up

This section provides the concluding remarks of the case preparations. All findings will contribute to answering the main research question.

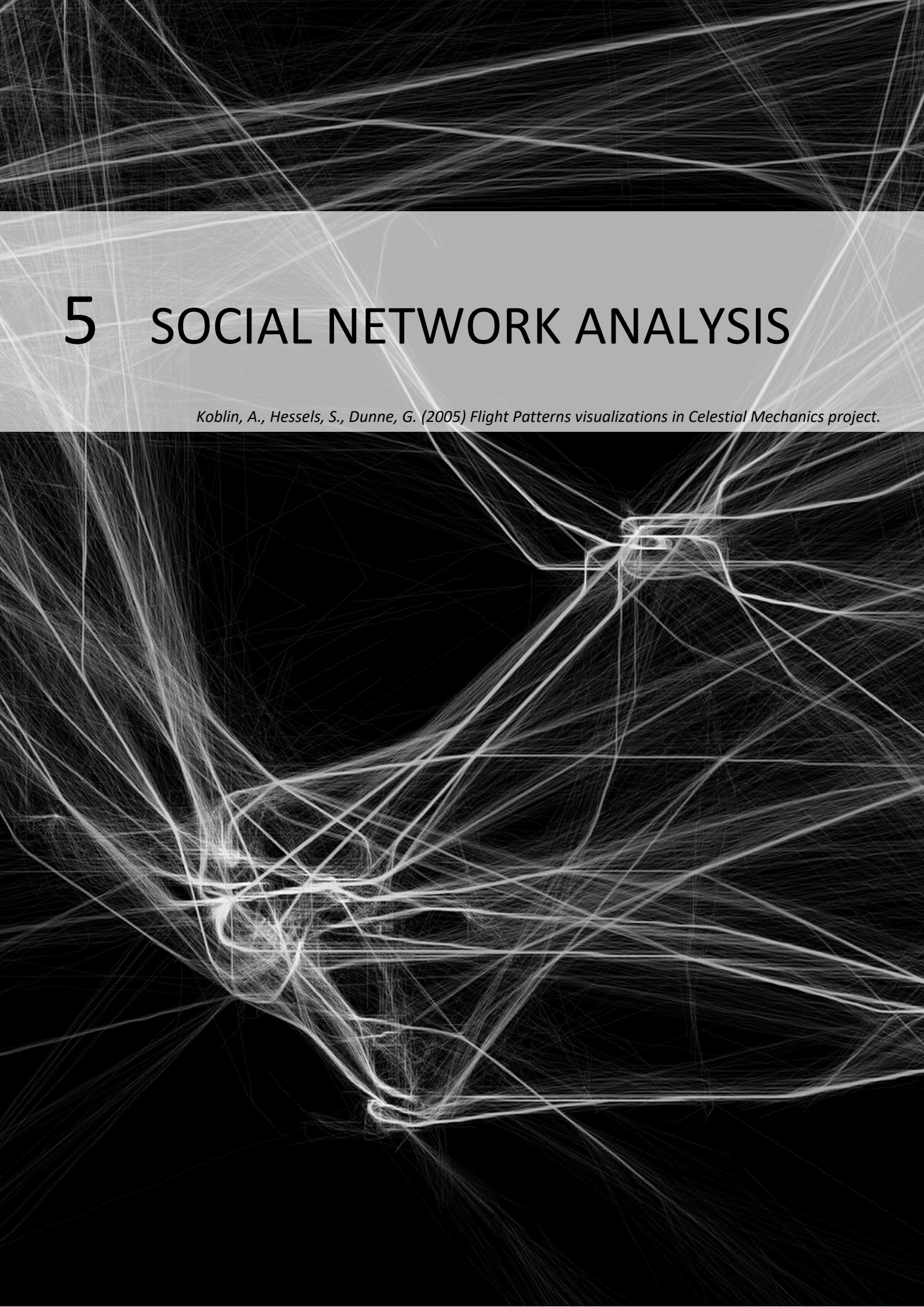
4.4.1 Time for change

It is very noticeable that currently, RHDHV has put high priority in improving digital workflows. Just like many other organizations in the construction sector, they understand that digital transformation is needed in order to remain serious competition in the market. Staying ahead of the competition is very important in this competitive industry. Therefore, new initiatives are rising within RHDHV in which employees have quite divided views on how to deal with these changes. Digital roadshows, introduction training for information systems use, and surveys to monitor employee satisfaction are being organized, but still, full commitment and growing engagement are coming short. This research aims to find organizational measures to backbone investments in digital technologies and set recommendations on how to incorporate them in future digital strategies that can be applied at different levels of the organization.

4.4.2 External collaboration

In the explorative interviews, one aspect was a recurring factor. The level of data sharing and digital improvement is highly influenced by the collaboration with the portfolio client. Data management plans should be realized together with the client, and their contribution is needed to define what asset information is already available and what asset information should be created. When information and data flows are organized from the beginning onwards, the clients are able to maintain their assets much better in the future. For RHDHV, this means that if they can support the client with this, their work will be more appreciated, and new collaboration will follow from that. Therefore, this report can be used as a means of communication towards future clients to explain the importance of right data utilization in projects and the portfolio. During these temporary organizations in the form of MCPs, all parties want to make a profit and gain some of the total project success. By being open and transparent about available information, this can better be realized since project delays, rework, and unnecessary budget overruns can be prevented.

5 SOCIAL NETWORK ANALYSIS



Koblin, A., Hessels, S., Dunne, G. (2005) Flight Patterns visualizations in Celestial Mechanics project.

5 SOCIAL NETWORK ANALYSIS

This chapter presents the SNA, analyzing data streams between employees, and giving insights into the maps of data-sharing networks in MCPs. First, data collection is explained (5.1). After that, it is investigated who is sharing data with whom, providing the results and analyses of the data-sharing networks of the separate case projects (5.2, 5.3, 5.4) and the combined portfolio (5.5). Appendix E4 shows all the detailed DSN graphs. The discussion (5.6) and the concluding remarks (5.7) complete this chapter.

5.1 Survey collection

Based on the desk research, 85 potential respondents have been invited to participate in the survey. Of these 85 employees, 40 are RHDHV employees located in NL and 45 in VN. From the 85 invited employees, a total of 41 employees returned the completed survey after three reminders at most (chart 1). This is a response rate of 48%, which is above average for surveys (Lindemann, 2019). In the charts below, the specifications of the survey respondents are provided. A near 50/50 ratio of Dutch and Vietnamese respondents was achieved. Also, the division of respondents over the three case projects is comparable to the size of the corresponding projects (chart 2). The division of project roles is representative of the average role division in the case projects (chart 3). Overall the respondents give a correct representation of the case projects.

In appendix E2 the survey protocol is presented. Each respondent indicated with whom they shared the most data during one of the case projects. Additionally, they addressed the frequency of data sharing, the perceived value, and what tools they used. With the collected data, the data-sharing networks can be visualized and analyzed. These will be discussed in the following sections.

Chart 1: Nationality division of respondents

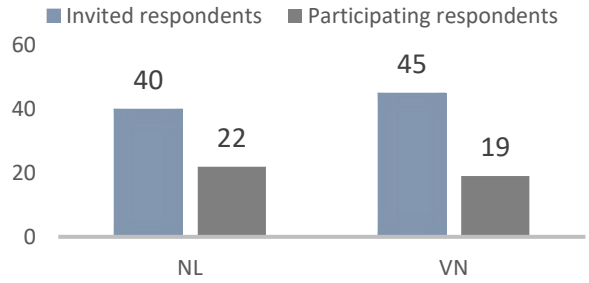


Chart 2: Project division of respondents

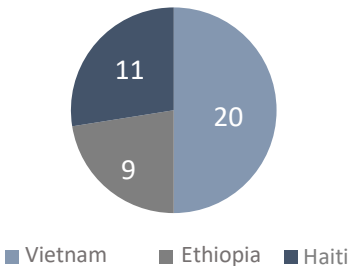
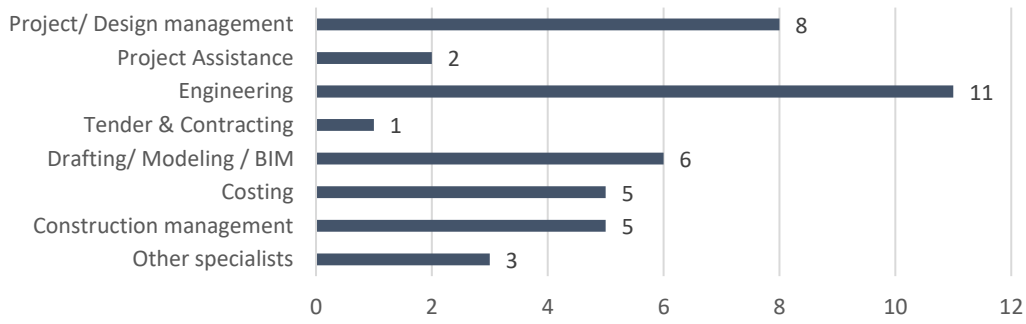


Chart 3: Role division of respondents



5.2 Project A network: The Haiti brewery

Project A in Haiti, Central America, concerns a brownfield project of which phase 1-2 is delivered in 2019. The scope of RHDHV included design, tender, IFC, and project management for the extension of the brewery and led to an increase of brewing capacity up to 2.24 mil hl/year. In total, 52 RHDHV employees worked for 1250.0 hours on this project, which makes it the smallest of the selected case projects in this research. Noticeable is that the whole project was conducted in The Netherlands, except for the realization phase in Haiti with back-office support from the Netherlands. This reflects in a high number of 24 NL-based nodes, and only 1 VN-based node in this network.

5.2.1 Results: mapping the data-sharing network

By programming the survey data in the Python environment, the network graph of project A is exposed (figure 30). The network appears to be highly connected and shows many data streams linking all the involved team members. The network contains 25 nodes and is connected by 77 edges, which results in an average degree of 6 edges per node. In total, 300 potential connections could have been established in this network. The established 77 connections, as a proportion of the potential 300 connections, resulting in a network density of 25.7%. The average clustering coefficient measures the amount of grouped triangles in the network. In project A the clustering coefficient is 0.405, which means that the neighbors of each node are, on average, 40% interconnected. All the network details are listed in table 11.

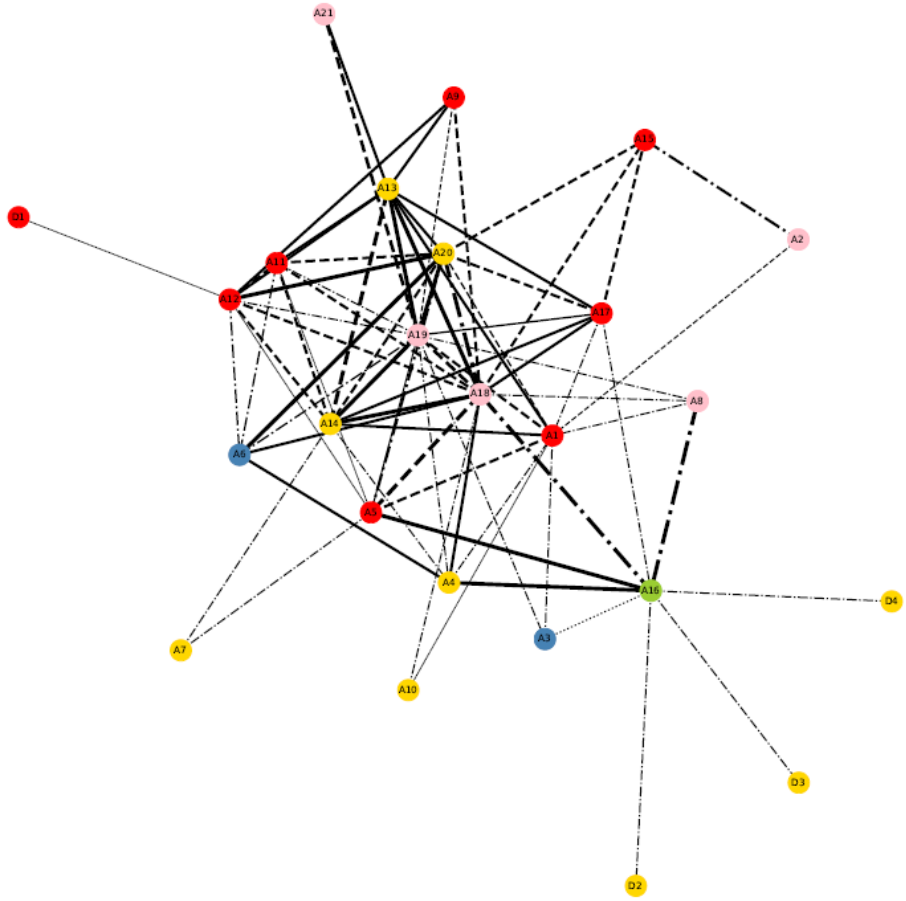
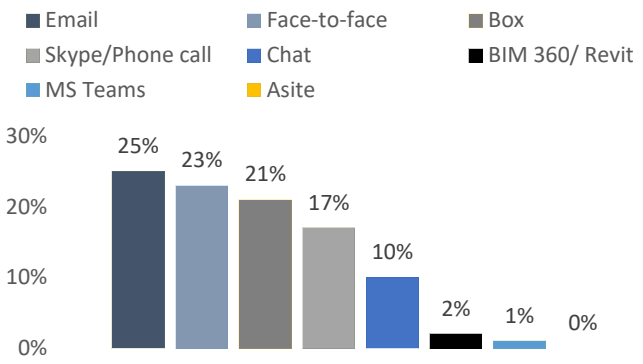


Figure 30: Data-sharing network project A (own illustration)

Table 11: Project A network details

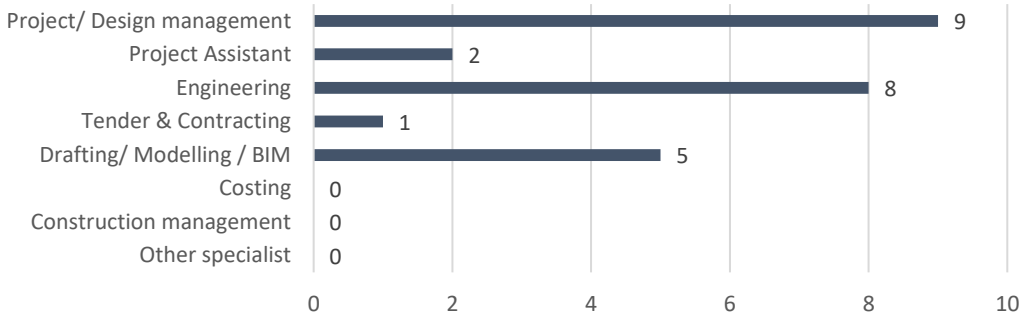
Items	#
Number of nodes	25
Number of edges	77
Average degree	6.160
Network density	0.257
Average clustering	0.405
Average frequency	6.318
Average value	6.884
Most used tool	Email
Most preferred tool	Email

Chart 4: Tool use in project A



The average frequency in project A is 6.318 on a scale from 1-10; this means contact on a monthly and weekly basis. The average perceived value is 6.884 on a scale from 1-10 and indicates an average of just below high value. From the 11 respondents that participated in the survey for this case project, most indicate that they prefer email as a tool to exchange data. Chart 4 shows what tools have actually been used the most to transfer data between the team members in the network. Email and face-to-face meetings have been mentioned the most in project A, closely followed by Box.

Chart 5: Role division of respondents in project A



The network shows a role division that is presented in chart 5. Not all role types occur in project A, which is probably due to the missing scope in the realization phase of the project. The engineering and the project managers are the most prominent team roles in this network. The Kamada Kawai layout positions all the nodes with higher degrees more central and nodes with lower degrees in the outer circle of the network graph. The color indicates the team role of the nodes. In this network, two pink nodes (drafting/modeling/BIM), and one yellow node (project manager) lay most central.

To verify whether these central nodes are indeed the most connected, all nodes and edges are further analyzed by measuring their centralities for degree, eigenvector, betweenness and closeness, and their eccentricity, as explained in the methodology. In appendix E5, the full overview of all the node and edge values is provided. These techniques provide more insights on the importance of the nodes in the network and indicate which nodes are the strongest connected nodes and which ones are the weakest connected nodes in the graph. In the next section, the three most connected nodes and two least connected nodes are analyzed.

5.2.2 Analysis: people and data streams

The two pink nodes A18 and A19, together with the yellow node A20, serve as the three most connected nodes in the network regarding data sharing. A19 has a slightly higher eigenvector centrality, which means that it is connected with other more high connected nodes than A18. However, A18 has a higher value for betweenness, which indicates that the total network is most dependent on A18. The highest closeness centrality of A18 indicates that this node is the most efficient in data sharing, which is also reflected in the lowest maximum path of 2 edges to all other nodes. A20, the project manager, also has high importance in this network but is overruled by the two drafting/modeling/BIM team members. Especially his betweenness centrality is six times smaller than A18, which indicates that the project manager is easily replaceable and that the network does not highly depend on him regarding data sharing. Many other nodes in the network have higher betweenness rates than the project manager as can be seen in appendix E5.

The weakest mentioned nodes in this network are D1, D2, D3, and D4. These D-nodes all are team members of the client and have been mentioned by survey respondents from RHDHV because their work required direct contact. This research focuses on intra-organizational data sharing; therefore, in the proceedings of this research, only the weakest connected nodes of RHDHV will be further analyzed. The two weakest connected nodes from RHDHV are A7, in the role of project/design management, and A2, in the role of drafting/modeling/BIM. Their contribution to this project is relatively low, which is indicated by their low centrality values presented in table 12. Remarkable is that the eccentricity of both nodes is not that different from the highest connected nodes. This means that this network consists of short ties between all team members when it comes to data sharing. One of the low connected nodes in this network is node A7; he is the main project manager of project C. His low importance rate for this project could be explained by his involvement being limited to the advice in exceptional cases rather than being involved on a regular basis. The low importance of A2, a drafting/modeling/BIM team member, is more difficult to explain based on the centrality values. Limiting factors for A2's could be missing skills, limited responsibility in the project or a lack of intrinsic motivation to contribute, among others. The RCA will further elaborate on these remaining questions and will seek to find underlying reasons that declare the network position of this node.

Table 12: Project A nodes and edge analyses

Node	Degree	Degree centrality	Eigenvector centrality	Betweenness centrality	Closeness centrality	Eccentricity
A18	15	0.625	0.358	0.200	0.727	2
A19	15	0.625	0.367	0.135	0.667	3
A20	11	0.458	0.317	0.034	0.600	3
…	…	…	…	…	…	…
A7	2	0.083	0.057	0.001	0.414	3
A2	2	0.083	0.073	0.000	0.414	4

Mapping the data-sharing network and analyzing the present people and data streams result in various findings. This quantitative method retrieves factual observations from the networks and enables a comparison with acknowledged social network phenomena from literature. Some observations ask for further qualitative elaboration, which will be investigated in the qualitative RCA. The following summarizes the findings.

- *The density in the network is 25.7%.* On a scale of 0-1, this seems below average. Considering, however, that a network density of 1 is highly unusual (Pryke, 2017) as all nodes should have connections with all other nodes, the density level increases in relative value. The RCA should indicate whether this density level evokes effective data sharing.
- *The clustering coefficient is 40%.* Observing the graph, it stands out that all nodes gather around one central hub in the middle. This can be related to the fact that the whole project is conducted in the Netherlands, and most team members worked in Rotterdam. Clusters are made more easily between employees that work at the same location. All team members have interconnections, and no role cohesion or isolated clusters are present in the network. This implies that data silos do not occur within the project team. Also, the internal exchange is high among the different disciplines. The high amount of bilateral data exchange indicates conventional data sharing. Alreshidi et al. (2018) warn for this type of file-based data exchange as it comprises loss of data integrity and an increase in errors. A large amount of exchanged data can become inefficient, and the probability of data loss and intractability increases (Heras, 2019).
- *Two drafting/modeling/BIM team members have the highest centrality values in this network.* Their contribution to data sharing in this project has been of significant influence in the emerged structure of the data-sharing network. The reason why their contribution is this high should be further explored in the root cause analysis but could be explained by their responsibility and level of expertise as drafters. The level of data sharing increases for employees with clarity on roles and responsibility towards data sharing is (Alreshidi et al., 2018).
- *The respondents of this project indicated that they prefer to use email over the other tools.* Email is considered to be a fast way to contact others, but it is not very transparent. Inefficiency in sharing data by email is a common pitfall, as the chances are high that double information circulates, an overview of the available data is lost, and people are not aware of the latest files. Box, a common data environment tool, comes in third. Why are these conventional tools used the most in the network? Chen & Lu (2019, page 1522) argue that the accessibility of data and systems determines the frequency and quality of data sharing. Information users are inclined to use data and tools that are "the most conveniently accessible', regardless of the quality of the information of systems".
- *The average frequency and average perceived value both are moderate.* The highest frequency (solid lines) and the highest value (thickest lines) are centered around the most connected nodes (A18, A19, A20, A13). Comparing the values for frequency and perceived value of data streams between all case projects should provide a better interpretation of the values.

5.3 Project B network: The Ethiopia brewery

This project site is located in Ethiopia, Africa, and is a brownfield brewery extension. In 2019 phase 3 has been implemented. The scope for RHDHV included design, tender, IFC, PM, and CM for the extension of the brewery and increased the brewing capacity. In total, 120 RHDHV employees worked on the brewery project in Ethiopia with a duration of 30.197 work hours. This project has the middle size of the three case projects. The project was mostly executed in the Netherlands, but parts of the detailed design were eventually transferred to the Vietnamese office to lower costs.

5.3.1 Results: mapping the data-sharing network

This network graph of project B is presented in figure 31 and shows a different structure than the network graph of Project A. The network of project B seems less crowded, which is also reflected in the network analysis details in table 13. The total number of nodes is 34, and 46 edges hold all of them together. The average degree for the nodes is 3 edges per node rounded up. The network density and average clustering coefficient are respectively 8,2% and 18.9%. The network graph shows a wider and more spread layout with fewer connections between team members. The most connected and central node is the yellow node B3, the overall project manager. There is a division of the Dutch (left upper side) and Vietnamese office (right lower side). Only one data stream between the project manager in the Netherlands (B3) and the Engineering manager in Vietnam (B30) links the two groups. There are no isolated nodes present in the network.

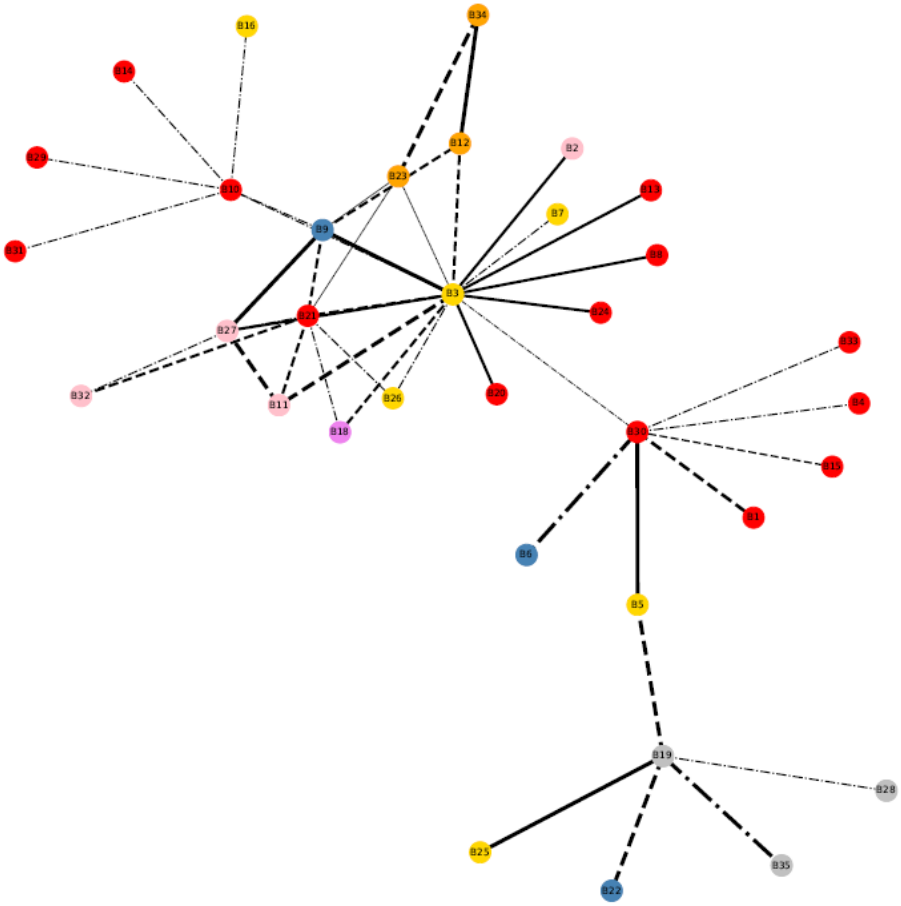


Figure 31: Data-sharing network project B (own illustration)

The average value of the frequency of data sharing in the network is 6.185, and the average added value of the data streams is 6.543. This is only slightly lower than in project A. In chart 6, the most used tools in project B are displayed. Just as in project A, the most preferred and most used tool is Email, followed up by face-to-face meetings. In this network, skype/phone call has a higher rate than Box. This could be explained by the fact that this project has been conducted partly in The Netherlands and partly at the Vietnam office. Skype and Phone are useful tools to realize global communication.

Table 13: Project B network details

Items	#
Number of nodes	34
Number of edges	46
Average degree	2.706
Network density	0.082
Average clustering	0.189
Average frequency	6.185
Average value	6.543
Most used tool	Email
Most preferred tool	Email

Chart 6: Tool use in project B

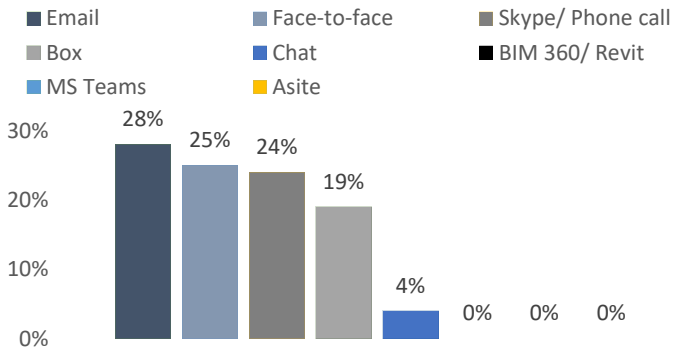
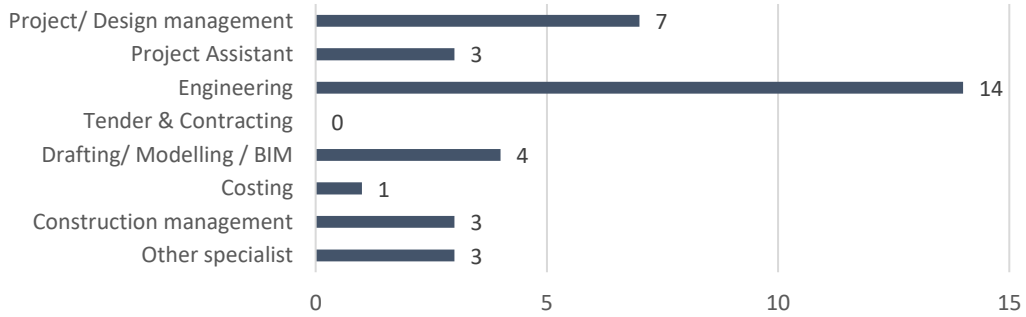


Chart 7: Role division of respondents in project B



The role division in this project shows similar peaks for the engineering and project/design management role. Due to the full EPCM scope, the network consists of almost all team roles. Except for the tendering & contracting role, which is not present. This can be explained by the fact that the project managers have taken on the role of tender & contract managers, which often happens at RHDHV. Furthermore, the team roles are scattered across the network, and only costing and construction management show role cohesion.

5.3.2 Analysis: people and data streams

Table 14 shows the values for the different centrality analyses of the most extreme nodes. In appendix E5, an overview is given, including the values for all the nodes in the network. In this network, one specific node stands out in being the most connected. This is node B3, the project manager of the Ethiopia brewery project. His contribution to data sharing in the network is very high in comparison with the other nodes. This is mirrored in the twice as high number of connections compared to B21, the lead structural engineer in The Netherlands and B30, the lead structural engineering in Vietnam. Following the by far highest connected node is B3, he is also most connected to other high connected nodes. His betweenness centrality is also high, which indicates that the network highly depends on him. Remarkable is that the second most connected node, B21, has a relatively low betweenness rate of 0.046. Apparently, this node is not that often part of the shortest path between team members in the network and can, therefore, be replaced in data sharing more easily. B30 has a higher rate of betweenness because he is the linking node between the project manager in The Netherlands and the Vietnamese team. The Vietnamese team depends highly on his contribution to data sharing between the two countries. The RCA could find out why there are not more connections between the Vietnamese team and the Dutch team in this network. Also, it should provide insights into the question of how the project team deals with the high dependency on the project manager in this project when it comes to data sharing.

A large number of nodes have low centrality values in project B. More than half of the mentioned team members in the network consist of only one connection (19 nodes). The survey respondents all indicated other team members as their most important connections. The level of interconnectedness is therefore much lower than in project A. In table 14, a low connected financial controller from Vietnam (B35) and a low connected engineer from The Netherlands (B29) are listed. All centrality values are low for both nodes, and it takes them six connections to reach the most distanced team members within their team. The eigenvector and the closeness centrality of the Dutch employee are slightly higher, concluding that the Dutch hub in data sharing has a higher influence on data sharing in this project.

Table 14: Project B nodes and edges analysis

Node	Degree	Degree centrality	Eigenvector centrality	Betweenness centrality	Closeness centrality	Eccentricity
B3	16	0.485	0.542	0.757	0.559	4
B21	8	0.242	0.393	0.046	0.402	5
B30	7	0.212	0.126	0.534	0.478	3
…	…	…	…	…	…	…
B29	1	0.030	0.035	0.000	0.289	6
B35	1	0.030	0.001	0.000	0.224	6

Below, the main findings are summarized and, if adequate, additional literature is included to provide further clarifications.

- *The density coefficient is only 8,2%.* This is lower than the one in project A. Lower density rates in relation to data sharing is said to be an indicator of the hierarchical nature of information exchanges (Pryke, 2017). Additionally, it should be noticed that it is easier to establish high density for smaller networks (fewer connections needed to reach high density). As projects A and B have comparable project sizes, it can be concluded that project B has a more hierarchical structure.
- *The clustering coefficient is 18.9%.* Fewer triangles are formed in the network, which can be seen in figure 31. The division of the Dutch and Vietnamese office makes the occurrence of data silos within the project team more likely. The RCA should indicate if this division is a result of cultural differences, missing facilities, or affiliation.
- *The project manager is the most central point of contact.* In research, this is referred to as the most prominent disseminator of information (Pryke, 2017). The structure of the network is oriented around him, which also indicates the hierarchy in the project. Specifically, in this situation, it is essential that all project information is stored in a common data environment to make it accessible for all team members.
- *The most used and preferred tool is email. Conventional tools cover more than 75% of the data exchange.* The risk in this network is that the project data is not accessible and transparent to all team members, which discourages their participation in data sharing (Qin & Fan, 2016). When the project manager needs to be replaced, which is the case for B3 as he will soon retire, chances are higher that valuable data gets lost.
- *Same moderate averages for frequency and perceived value of data streams.* Frequency and value of the data streams are similar to project A, while the two networks have very different structures. Having more data streams in the network does not make them more valuable (Westin & Sein, 2014). Additionally, people find it hard to estimate the value perceived of data streams. This could explain why both projects have comparable averages.

5.4 Project C network: The Vietnam brewery

The brewery project located in Vietnam, Asia, involves a greenfield brewery (phase 5.1) that has been delivered in 2019. The scope for RHDHV included a full EPCM contract and resulted in a brewery with a capacity of 5.1 mil hl/year. In total, 130 RHDHV employees worked on this project, which covered 84.750 hours of work. This is the biggest case project and was conducted fully in Vietnam, except for some document reviewing. During the project, some Dutch employees joined the team in Vietnam temporarily for extra support and to exchange knowledge.

5.4.1 Results: mapping the data-sharing network

Since twice as many respondents participated in project C, compared to the other two, more nodes and edges are present in the data-sharing network presented in figure 32. This is in line with the size of the project and therefore gives a good representation of intra-organizational data sharing. The total number resulted in 49 nodes, connected by 107 data streams. The average degree of 4 lies in between the average degree of Project A and Project B. However, for this amount of nodes and edges the network density of 9,1% is almost as low as in Project B. The clustering coefficient of 0.186 is similar to project B. This indicates that 18% of each node's neighbors are interconnected. It is harder to decide what the most connected nodes are in project C based observations.

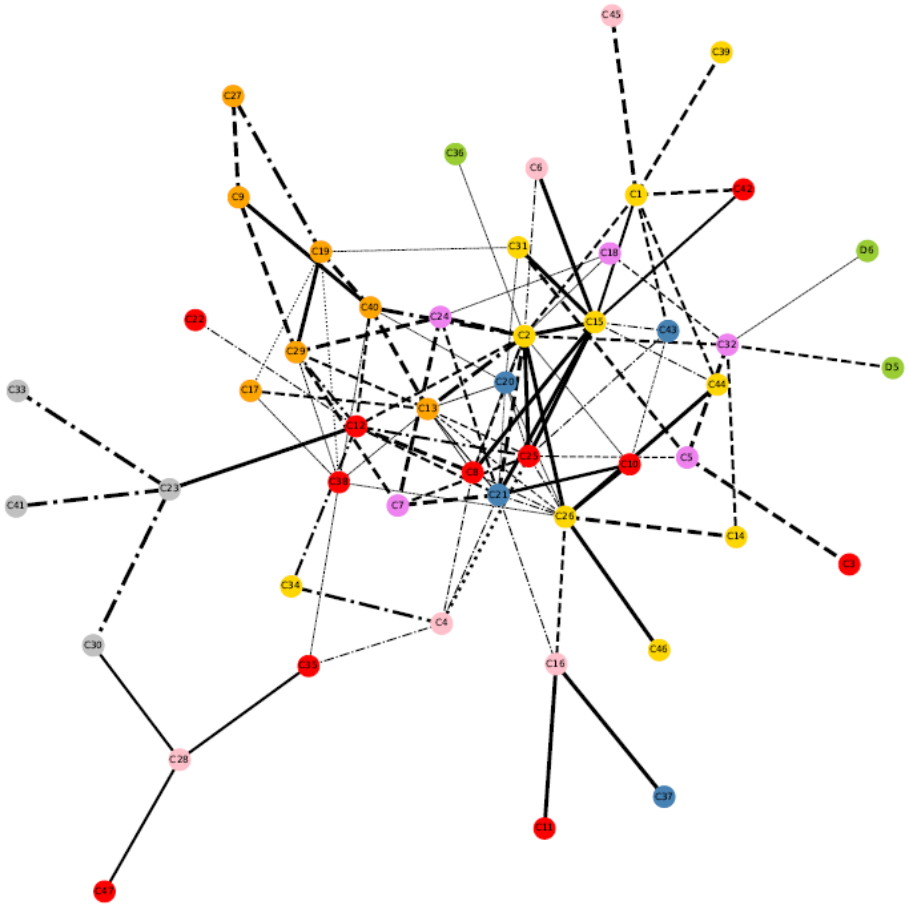


Figure 32: Data-sharing network project C (own illustration)

Also, for this project, the average frequency and perceived value of the data streams have comparable values to the ones in projects A and B. The average frequency is 6.383, and the average value is 6.636. The most preferred and most used tool for data sharing is email, followed

by face-to-face meetings and skype/phone calls. While this project almost only took place in Vietnam, Skype and Phone calls are mentioned to be more prominent than Box. This could be explained by the unreliable internet facilities, which decreased the accessibility of Box. This project shows a 5% BIM360/Revit tool activity, which represents the highest rate of all three projects in this tool category.

Table 15: Project C network details

Items	#
Number of nodes	49
Number of edges	107
Average degree	4.367
Network density	0.091
Average clustering	0.186
Average frequency	6.383
Average value	6.636
Most used tool	Email
Most preferred tool	Email

Chart 8: Tool use in project C

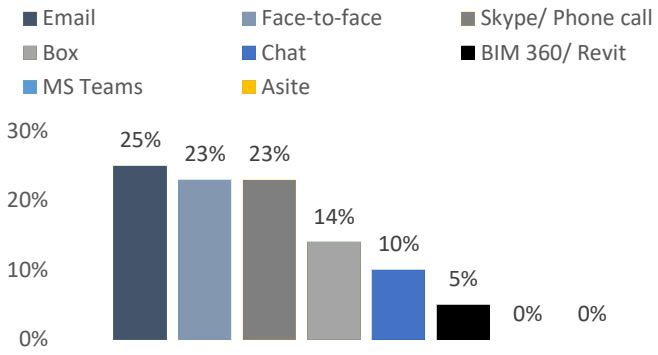
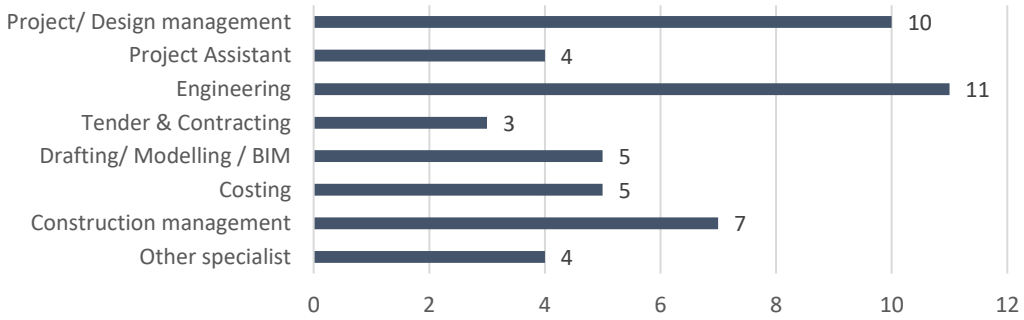


Chart 9: Role division of respondents in project C



The division of roles in project C has a proper representative distribution of the team roles for a full EPCM contract. The engineering and project/design management teams are again the largest disciplines, followed by construction management. Construction management took a large part of the scope in this brewery project. Team cohesion is more evident in the network graph as the team roles show high interconnectedness. It is assumed that this has to do with the larger project and team size. For example, the orange construction management nodes preferably form a team with more data streams within their own discipline than with any other team roles. The same applies to the silver nodes on the left side of the graph, representing the financial controllers. The costing team (purple nodes) shows interconnectedness in their team, but they are also strongly connected with other roles in their neighborhood. In this graph, it is not immediately clear what nodes are the most connected, as there are multiple high connected nodes and more high-density hubs present in the network. Therefore, this will be further analyzed in the next section.

5.4.2 Analysis: people and data streams

From the node and edge details in table 16, it can be concluded that it is logically unclear from the network graph which of the nodes is the most connected one. This is due to the fact that the centrality values of the most connected nodes lie in a small range. The most connected node is C2, which is the project manager of this project. His eigenvector, betweenness, and closeness

centrality are also the highest in the network but lay much closer to C26, the mechanical, electrical, and plumbing (MEP) team lead and C21, the project assistant in project B. Other nodes than the project manager can also serve as important points of contact for data sharing in the network and make the data sharing network less reliant on one person. C26 is the second most connected node in the network and holds the role of the MEP team leader. This work package is one of the most extensive during the realization phase, as found in the brewery project life cycle (Appendix C3). His responsibility in delivering a successful project and controlling the concerning information flows within the team is therefore high. C21 is the project assistant for the Vietnam project and is highly connected in the network. Her role has a considerable influence on the structures in the data sharing network of project C. She was mentioned by half of the respondents from this project. The RCA will further find out why the network depends on her, why she is an efficient data sharer, and why she is connected with the most connected nodes in the network.

The nodes with the weakest positions in the network are the engineer C47, only mentioned by one drafting/modeler/BIM team member and the engineer C42, who works at the Dutch office in an engineering role and has been mentioned by two Dutch employees. The closeness centralities of these employees are still relatively high, but the other values are much lower than the most connected nodes in the network. This implies that the network does not have a wide dispersion of team members. The RCA further investigates the specific explanations for the occurring structures in this network.

Table 16: Project C nodes and edges analysis

Node	Degree	Degree centrality	Eigenvector centrality	Betweenness centrality	Closeness centrality	Eccentricity
C2	16	0.333	0.399	0.299	0.516	5
C26	12	0.250	0.310	0.160	0.462	4
C21	11	0.229	0.305	0.118	0.471	4
…	…	…	…	…	…	…
C42	2	0.042	0.045	0.000	0.306	6
C47	1	0.021	0.001	0.000	0.211	7

The mapping of the data-sharing network of project C gave additional insights into how data sharing is organized in multinational construction projects. The following findings supported by relevant literature can be listed

- *The density coefficient in the network is 9.1%.* Larger networks are often more sparse, as it is harder to establish high-density rates (Pryke, 2017). Therefore, comparing projects based on their density is difficult. A better alternative is making a comparison based on the average degree of the network (Stokman, 2001). The average edge degree (4.4) in project C is higher than the average edge degree in project B (2.7), and therefore, it can be assumed that the connectivity between team members in project C is higher.
- *The clustering coefficient is 18.6%.* This is similar to the clustering coefficient of network B, while the structures of the graphs are quite different. Apparently, the neighboring nodes of each node are, on average, not that well connected for both networks. Since project C has mostly been conducted at the Vietnam office, this is a remarkable finding. Vietnamese employees in project C seem to form fewer triangle relationships in the network compared to the Dutch employees in project A. This could be an indication of cultural differences in work mentality and cultural mindset (Kähkönen & Rannisto, 2015).

- *Multiple, equally connected nodes are present in the network.* While the project manager is the most connected node in this network, it stands out that more team members consist of similar high centrality values. Large projects are more complex and need more competent people to make a difference in the project outcome (Hertogh & Westerveld, 2010). This is in line with the mapping of the larger project C as multiple information hubs exist. The competences in the data sharing networks seem to be in accordance with an overall high responsibility towards the project or a high responsibility towards data sharing in the project.
- *The most used and preferred tool is again email.* On a shared second place, stand face-to-face meetings and skype/phone calls. Despite the difference in graphical locations between the three projects, the use and preferences of the tools are the same. This assumes that there is no effective encouragement in any of the two dispersed offices to transfer to less conventional tools for data sharing, or the employees are reluctant to change (Razmerita et al., 2016). Project C shows the highest rates for the use of BIM360/Revit. The RCA will be used to find the reasons why this project has the highest BIM360/Revit rates and will identify why the overall rates are still relatively low for the adoption of BIM.
- *The frequency and perceived value of the data streams are again moderate.* For all projects, comparable values have been identified for the frequency and perceived value of the data streams. This makes it hard to draw any definite conclusions based on these findings. Letting employees make estimates on the average frequency of data sharing with their team members is assumed to be easier than making estimates on the perceived value of those data streams. Ultimately, the respondents cannot assess exactly and uniformly what the added value of their data flows in conducting their work has been.

5.5 Portfolio network: The multinational client

In the previous section, the three separate case projects have been analyzed, but in this embedded case study design, the aim is to analyze the overall picture of data sharing between project for the same multinational client. Therefore, the three case projects have been combined in one DSN representing the portfolio to identify whether data silos are present. Also, the individual networks per team role have been visualized using Python. The detailed DSNs can be found in Appendix E4.

5.5.1 Results: mapping the data-sharing network

In figure 33, the portfolio network is presented. People that appeared in multiple project networks are represented in the portfolio graph with a single node. This should indicate existent links between the silos. The network has become large, and the total number of nodes is 84. The number of data streams between these nodes is 224, with an average degree of 5 edges per node. At this point, the number of potential edges in the network is 3.500. This represents a very high amount of possibilities to share data and information. The question is to what extent it is still possible for employees to profit from this high amount of potential data streams effectively and when the turning point of perceiving an overload of information is reached. Looking at the network detail, the network density is decreasing to 6,4%, but the average clustering coefficient of 0.239 is slightly higher than experienced in Project B and Project C.

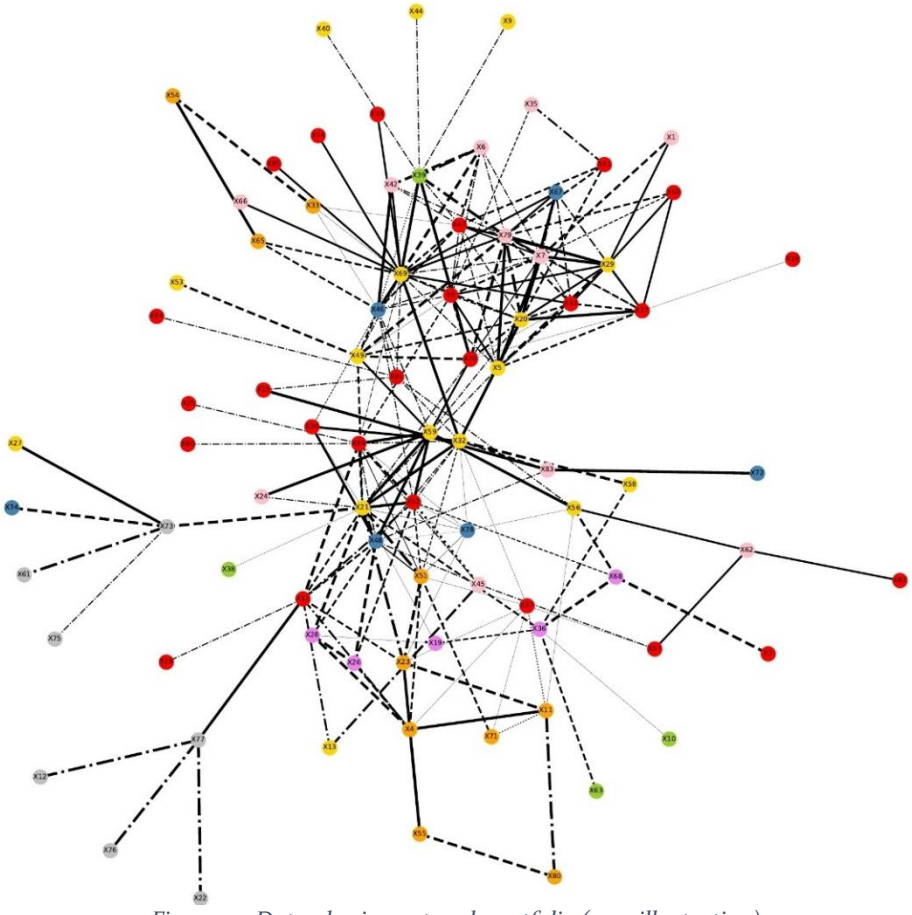


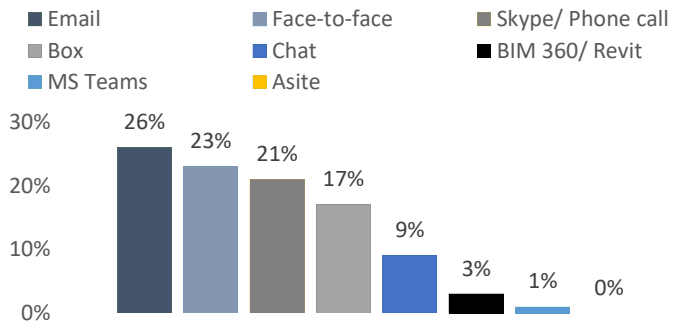
Figure 33: Data-sharing network portfolio (own illustration)

Combining the averages for frequencies and perceived values of the data streams results in logical results around the same values as seen before. These averages, however, provide little added knowledge to this research. Email is indicated as the most preferred and most used tool in all three projects and, therefore, also in the total portfolio. This finding is a reason for concern, as email is not the most efficient way of sharing data. Secondly, face-to-face meetings are used, followed by skype/phone calls, and then Box comes in line. The other more digital and central data sharing tools as BIM360/Revit, MS teams, and Asite are not that popular.

Table 17: Portfolio network details

Items	#
Number of nodes	84
Number of edges	224
Average degree	5.333
Network density	0.064
Average clustering	0.239
Average frequency	6.317
Average value	6.679
Most used tool	Email
Most preferred tool	Email

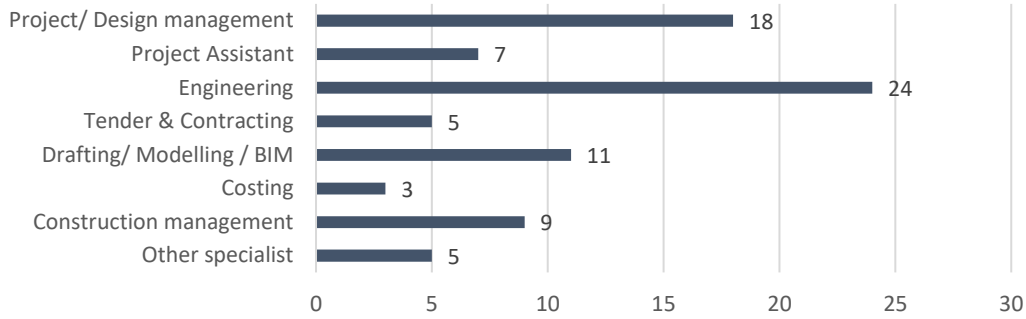
Chart 10: Tool use in the portfolio



The portfolio network consists of the role division, as presented in chart 11. The most occurring team role is the engineer, which makes sense as the case company is an engineering consultant. This is followed by the PMs and the drafting/modeling/BIM team members. Observing the clusters and interconnectedness of the different team roles is hard as the network is very large,

consisting of many data streams. In the next analysis section, the role networks within the portfolio network will be further researched. Highlighting their subgraphs will indicate their data sharing networks and interconnectedness. This enables to see whether any data silos are present in the portfolio network at the role level.

Chart 11: Role division in the portfolio



Making assumptions about the node connectivity in the portfolio network is challenging. There are multiple hubs where nodes with high connections are centered in the middle. On the upper side, the strongly connected Project A is positioned, and below, some structures from Project C can be recognized. This marks the division between the Dutch and the Vietnamese offices. In the middle of the graph are the people that connect the NL and VN team. The analysis techniques will further zoom in on the centrality values of the most interesting nodes.

5.5.2 Analysis: people and data streams

The most connected node in the total portfolio is X69, the project manager of Project B. The second most connected node is the project manager of project C, represented as node X21. Third, comes the modeler from project B, which is node X79. All these nodes are also the most connected nodes in their own project. Node X69 has been mentioned by six people from outside his project, node X21 has been mentioned by three external employees, and X79 has only been mentioned by one other employee outside his own project. This implies that the most connected nodes in the portfolio are not the ones where the most exchange takes place between project teams in the portfolio. These vertical data silos bring disadvantages, such as the lack of awareness and internal competition (Carrillo & Chinowsky, 2005). Another observation is that X69 and X79 have more connections to other connected nodes than X21, but X21 has a higher betweenness centrality. This indicates that most information flows through node X21 to be distributed to the rest of the network. This means that the total network is most dependent on this node when sharing data around the portfolio. X21 is seen as the link between the Dutch and the Vietnamese office, which puts a high responsibility on him in transferring valuable information from one group to another. The research of Burt (2004) indicates these types of nodes as gatekeepers tying nodes that otherwise would be disconnected. These people gain the broadest insights and diverse information, which increases individual benefit but limits group benefit.

The nodes that have the lowest connectivity in the network are listed in table 18. These also had low centralities in their own projects. Their low centrality values are not necessarily linked to their portfolio contribution but are more dependent on their position in the project network. From all survey respondents, 60% indicates never to have contact with other employees outside

their own project which means that they do not contribute to data sharing in the portfolio. Half of the nodes in the portfolio network are survey respondents and the other half was mentioned by them in the survey. The reasons for this will be further explored in the RCA in the next chapter.

Table 18: Portfolio nodes and edges analysis

Node	Degree	Degree centrality	Eigenvector centrality	Betweenness centrality	Closeness centrality	Eccentricity
X69	22	0.265	0.316	0.213	0.439	4
X21	19	0.229	0.153	0.307	0.466	4
X79	16	0.193	0.296	0.027	0.366	5
…	…	…	…	…	…	…
X35	2	0.024	0.030	0.0003	0.283	6
X16	1	0.012	0.018	0.000	0.249	7

To understand role specific interconnectedness and data sharing behavior, the role networks in the portfolio have been analyzed. This exposes role differences in data sharing and identifies whether there are data silos within disciplines. In appendix E4, all the role-specific network graphs are presented, and appendix E5 shows the centrality analyses for the role-specific networks. These findings will also contribute to the selection of respondents for the in-depth interviews in the next chapter to gather inclusive information about how data is shared in the portfolio.

- **The Project/Design management (P/DM) network** shows a connected graph that links the NL and VN office. Some outlier nodes are positioned at the outsides of the network. These P/DM team members are client team members that were mentioned by some of the respondents. The most used and preferred tools in this network are email, and face-to-face meetings, and the value perception and frequency of the data streams are relatively high.
- **The Project assistance (PA) network** does not have a single connection between one of the nodes, which indicates strong data silos in this role. Project assistants support the P/DMs and might not need to interact mutually. Still, they can learn from each other by sharing common mistakes and promoting effective work procedures, which is currently not happening.
- **The Engineering (E) network** is the largest role network, consisting of 24 nodes. The network is quite fragmented and less centralized than the P/DM network. This is probably because all types of engineers (structural, architects, mechanical, etc.) are combined in one group. The separate disciplines might have limited mutual interaction. The most preferred and used tools are email and skype/ phone calls.
- **The Tender & Contracting (TC) network** is completely scattered in the portfolio. The reason for this could be that tender & contracting might be a role that is often performed by the P/DMs and therefore the network seems very small.
- **The Drafting/ Modelling/ BIM (D) role network** shows a division in the Dutch office (upper cluster) and the dispersed layout of the Vietnamese office (lower half). Also, no interaction takes place between the two offices. The data sharing that takes place is preferred by Email and BIM360/Revit but happens mostly via Box /Email and face-to-face. It is interesting that the preferred and most used tools differ.
- **The Costing (C) network** forms a close cluster in the Vietnamese office, but do not have support from costing employees in the Netherlands. They are positioned close to the

construction management cluster, which indicates their collaboration during the realization phase when change orders needed to be evaluated. The most used tools are face-to-face and email, and the most preferred are email and Box.

- **The Construction Management (CM) network** shows a division in the Dutch and the Vietnamese office. Another observation is the distant position of these disciplines towards other team roles. It seems that construction management works quite isolated. Only a few nodes have contact with other nodes in the portfolio. They mostly use email and face-to-face meetings to share data but prefer email and Box.
- **The Other specialists (S) network** is the last group of all other specialized team members. Only a few have been mentioned in the total network, except for a small group of financial controllers and a small group of HSE specialists. It makes sense that these two groups are not connected with each other but do show internal links. The most used tools are email and face-to-face, but the most preferred is face-to-face.

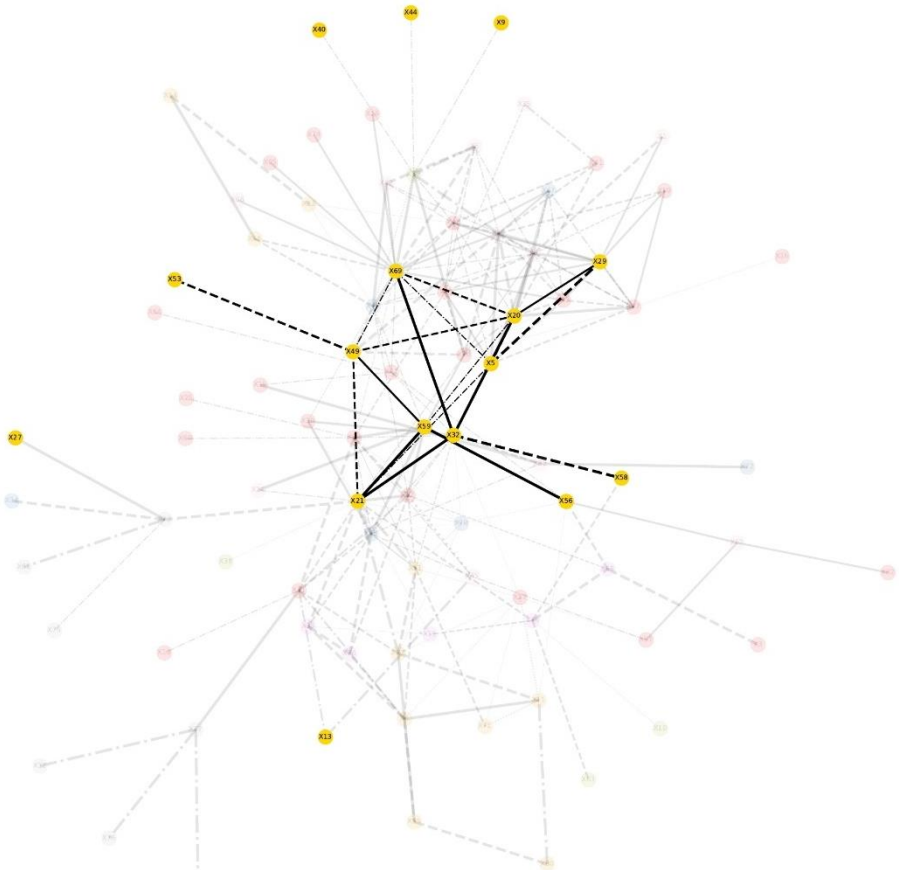


Figure 34: Project/ design management network in the portfolio

Combining the three project networks in one portfolio network exposes the linking nodes between the projects and indicates whether there are any data silos present in the network. The individual embedded units of analysis (brewery projects) are combined to analyze the single case (portfolio) in the larger case context (multinational engineering company). The following findings can be retrieved.

- *Network density is 6.4%, the average clustering is* 23.9% *and the average degree is 5.3.* Since the portfolio network is much bigger than the individual project networks. It is difficult to determine whether this network is considered highly connected. The connecting nodes in

the portfolio are the employees that either have worked for multiple projects or have been mentioned as connections by employees from another project. These people are the links between the separate brewery projects and have the potential to break through the data silos in the portfolio. It is, however, possible that these employees do not actively transfer project data between projects and actually preserve the data silos in the portfolio. The RCA indicates how those nodes utilize their position in the portfolio to enhance data sharing.

- *Division of the Dutch and the Vietnamese office.* The figure below identifies the Dutch employees in the upper area and the Vietnamese employees in the lower area. The overlapping area shows the nodes that serve as so-called gatekeepers between these two groups. Gatekeepers are nodes that have unique links to others in the network and hold the network together (Hawe, Webster, & Shiell, 2004). It is important to understand who the linking nodes are and why they act as gatekeepers. It can be concluded from the network graph in figure 35 that most gatekeepers in the middle compartment are project/design managers or engineers.

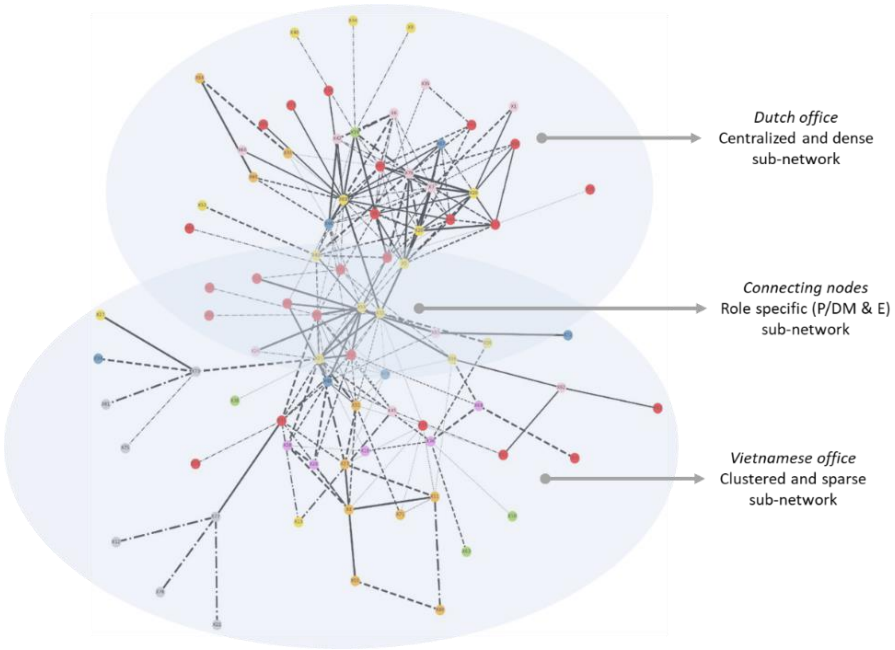


Figure 35: Sub-networks in portfolio

- *The highest connected nodes in the portfolio are most often the project managers.* This seems to be obvious, but the question is whether it is the best strategy to let them carry all the responsibility in data sharing. Engaging the whole project team in sharing data is important to benefit from all expertise and encourage information diffusion. Undefined roles towards data sharing, which is often the case for project managers, decreases the quality of data sharing (Alreshidi et al., 2018). Other roles can also take over tasks when better adopted to the data sharing environment (Liu et al., 2017).
- *Most employees in the portfolio have the role of engineers.* Their work mentality and attitude towards digital innovation can be different than other disciplines (Razmerita et al., 2016). The organization should be aware of this and anticipate the behavior of this majority.
- *Data silos are present in the role-specific data sharing networks.* It was found that from the seven observed role-specific networks, five networks consist of data silos within their discipline in the portfolio. Such silos can limit the productivity and quality of projects (Wanberg, Javernick-Will, Taylor, & Chinowsky, 2015).

- *Email remains the most used and preferred tool in the portfolio.* It is important to understand why this tool is mostly used. Alreshidi et al. (2018) suggest that new tools need governance solution requirements to stimulate adoption. This might be lacking in the current digital and cloud-based tools available and will be further investigated with the RCA in the next chapter.
- *Frequency and perceived value of data streams remain moderate.* It is hard to estimate value. Especially when success and issues resulting from data flows are not monitored, employees cannot be aware of their direct effect. The frequency is expected to be more accurate as people can say more definitely whether they share on a daily, weekly, monthly or occasional basis.

5.6 Discussion

This chapter analyzed social connections in the form of data streams between employees within multinational construction projects and between multinational construction projects being part of a single client portfolio. The aim was to find out whether there are data silos in these networks that can be prevented in the future. Comparing the projects based on the social network analysis is more difficult due to the different sizes and locations and a lack of additional explanations on the data sharing behavior of the team members. However, existing literature on social networks provides more insights on how to interpret the findings and compare the results.

5.6.1 Cross-case comparison

By analyzing the three case networks separately, it is clear that all of them show different structures and patterns. In all three projects, the project managers have one of the highest centrality measures in the networks. Therefore, the project managers have the biggest influence in determining the data sharing strategy and the arising data sharing structures. Their personal style could determine the effectiveness of data sharing in their projects. The literature distinguishes gatekeepers (high betweenness, low degree centrality), highly visible figures (low betweenness, high degree centrality), and central figures (high betweenness, high degree centrality) (OGL,2016). In project A the project manager is considered a highly visible figure who carries a lot of information but does not play a unique role in the network. In project B, the project manager is a very central figure that plays a key role in a more hierarchical setting and aims to gather all information. In project C, the project manager is more of a gatekeeper because without him the network will fragment. Project managers should be aware of the impact their data sharing style has on their project team. In the project, a uniform digital framework is missing and therefore data sharing is not organized in a similar or comparable way. Martínez-Rojas et al. (2016) emphasize that data technology can become useless if not accompanied by a standardization process. The benefits of integration will only be kept local and interoperability is hard to realize. This makes monitoring, controlling and reusing project data much harder to establish.

Whether the project managers should play a prominent role in the development of digital strategies is questionable. Project managers are often senior employees in the company, being very experienced in project management but less in applying digital technology. Without a standard data sharing procedure and defined responsibilities towards data sharing for all the roles in the project team, team members tend to rely on their managers and less often take the initiative (Alreshidi et al., 2018). This could also explain the use of conventional tools as email in all the investigated networks. If there is no tool governance available when implementing new

tools, team members logically keep using easily accessible tools as this is less time consuming (Westin & Sein, 2014). Apparently, employees are inclined to use email as it is the most conveniently accessible tool, which can strongly impede appropriate decision making (Chen & Lu, 2019). Therefore, qualitative data and tools should be more accessible for employees to use.

5.6.2 Strength in the numbers?

Based solely on the structures and patterns in the networks, it is not possible to tell which one consists of effective data sharing and which one consists of poor data sharing. A big difference is observed in the density of the networks. But do more data streams necessarily mean better data sharing in the project? Closer relationships increase trust and data sharing but diminishing barriers to sharing data may also increase the chance of information overload. Science has often described a positive relationship between team cohesion and team performance, but Wise (2014, page 710) discusses the dark side of network density. He claims that higher density rates are not necessarily better and states that "too much of a good thing can be negative." Also, dense networks tend to generate a lot of redundant information, generate many constraints, and are inefficient for creative solutions. Burt (2004) introduces 'structural holes', an indication for the separation between non-redundant clusters, or in relation to this research between data silos. Nodes that connect these structural holes have a higher betweenness are more likely to receive non-redundant information and, therefore, generate more creative and innovative ideas (Burt, 2004). This increases individual opportunities for this specific node but seems less profitable for the network as a whole. Collaboration nodes can thrive by merging their individual insights and generate good ideas together.

Another research included cultural diversity in the assessment of network density and centralization on team potency (confidence in ability to perform) and actual team performance (Tröster, Mehra, & van Knippenberg, 2014). Chart 12 shows that network density increases team potency, and in high cultural teams, this level even becomes greater. Chart 13 shows that team performance is optimal at a moderate level of centralization (the extent to which one or more nodes are very central in the network), and beyond that point, the effect becomes negative. In high cultural networks, this optimal turning point lies higher. Reflecting on the SNA results, the portfolio network consists of high cultural diversity, which implies that higher density and centralization rates should be established to optimize team potency and team performance.

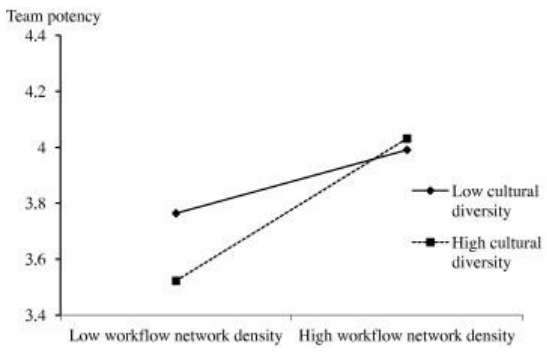


Chart 12: Team potency against density and cultural diversity (Tröster et al., 2014)

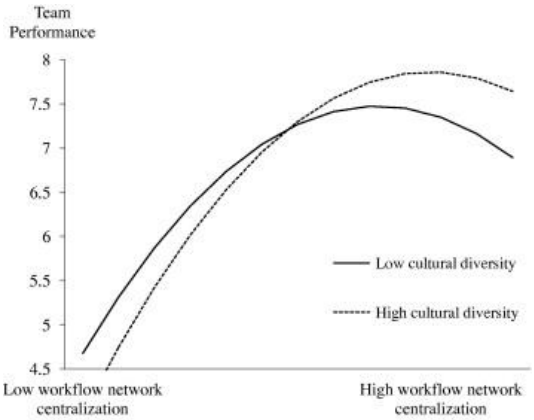


Chart 13: Team performance against centralization and cultural diversity (Tröster et al., 2014)

5.7 Wrap up

This section provides some concluding remarks of the social network analysis. Data was gathered about who is sharing project data with whom through a survey. In total 41 project members from three multinational brewery projects participated in the survey. This resulted in three project data sharing networks and one combined portfolio network consisting of 84 nodes and 224 edges in total. The graphs have been analyzed and the most and least connected nodes have been identified based on centrality values in the network. The centrality measures analyzed are degree (number of connections), eigenvector (number of highly connected contacts), betweenness (unique links to others), and closeness (efficiency of data sharing).

The project networks exposed structures and patterns regarding data sharing. Highly connected nodes either have high overall project responsibility (information users) or have high responsibility focused on data sharing (information controllers). In each project, the project manager was one of the most connected nodes in the network, which seems logical because they are supposed to be most aware. Despite this commonality, the networks also showed very diverse layouts. Project A and C both show denser structures without explicit data silos. Both these projects were mainly run from one office. Project B was delivered in a mixed NL/VN team and resulted in a much sparser network. Only one weak data stream holds the two offices together which indicates potential data silos. Project A shows high density and decentralization. Project B shows high centrality around the project manager, who is by far the most central node in the network. Project C shows multiple fragmented data sharing hubs in the project.

The portfolio network shows a clear division of the Dutch and Vietnamese office. A number of project/design managers and engineers hold the two groups together. The highest connected nodes still do not have that many connections with employees from other project teams, and only 15.6% of the data streams is between project teams. Email is the most used and preferred tool to share data, which limits optimal, transparent and traceable data utilization. Data silos exist across geographically dispersed employees and between projects. Team roles in the portfolio network show distinct data sharing behavior. Some of the disciplines have interconnected sub-networks, but most do not seem to seek many connections with employees with the same discipline in other projects or even within their own projects. This implies vertical data silos and can cause a lack of awareness, internal competition, limited productivity, and reduced quality (Carrillo & Chinowsky, 2005; Wanberg et al., 2015).

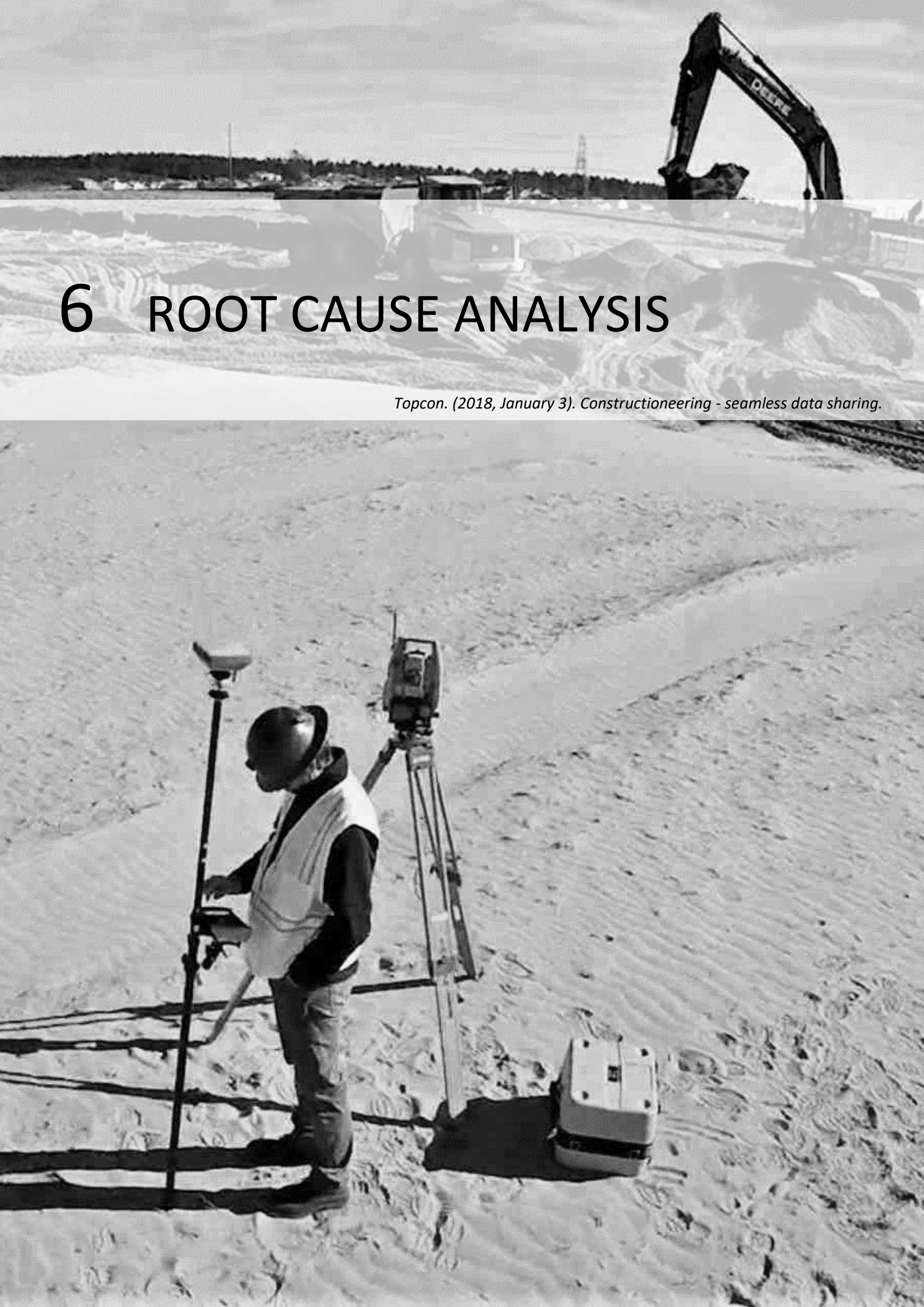
Based on the main findings from the social network analysis, four data sharing factors have been identified, and two additional statements are formulated to be evaluated in the root cause analysis. These statements will be added to the eight statements that have been retrieved from the literature review in chapter 2. Appendix B2 summarizes all the factors that have been used to formulate the statements.

Table 19: Statements from SNA

#	Data sharing factors from SNA		Statements from SNA
1	Intrinsic motivation by individuals own incentives	1	Interest and expertise in digital technologies improves data sharing.
2	Role specifications and role responsibilities		
3	Intra-organizational relationships between employees	2	Project involvement improves data sharing.
4	Role specifications and role responsibilities		

6 ROOT CAUSE ANALYSIS

Topcon. (2018, January 3). Constructioneering - seamless data sharing.



6 ROOT CAUSE ANALYSIS

This chapter applies a qualitative RCA, to explore in-depth explanations for patterns and structures in the data sharing networks. Root causes of problematic and successful data sharing are defined. First, the data collection is explained (6.1), and thereafter the results are discussed for the separated case projects (6.2) and the combined multinational portfolio (6.3). Appendix F3 shows the detailed interview answers; Appendix F4 an overview of all retrieved root causes.

6.1 Interview collection

The interviewees for the in-depth interviews have been carefully selected based on their positions in the data-sharing networks. This is to ensure a broad perspective on data sharing by a diverse group of interviewees. The ten formulated statements in table 20 are used to retrieve their root causes. All the interview results have been validated by the interviewees themselves to ensure the correct interpretation.

Table 20: In-depth interview statements

#		Interview statements
1		An accessible and up-to-date data sharing environment enhances data sharing.
2		Support and triggers from higher management enhance data sharing.
3		A clear and flexible data sharing environment enhances data sharing.
4		Personal development and training enhance data sharing.
5		Trust in people and the data sharing environment enhance data sharing.
6		A reliable and impactful data sharing environment enhances data sharing.
7		Facilities for global interaction and awareness enhance data sharing.
8		Global standardization and alignment enhance data sharing.
9		Digital interest and expertise enhance data sharing.
10		Project involvement enhances data sharing.

Appendix F1 shows the lists with the most connected and least connected nodes. This is derived from the results of the SNA in the previous chapter. Each node's importance at portfolio, project and role level is addressed. The criteria below have been considered for the selection process of the interviewees:

1. At least three high connected nodes at project, portfolio level and role level.
2. At least one less connected node at project, portfolio and role level.
3. Representative distribution of project A, B and C nodes.
4. Representative distribution of Vietnamese and Dutch nodes.
5. Representative distribution of project roles.
6. Availability of the interviewees to conduct a 60-minute interview.

Due to cancellations of some interviews, the role distribution could be more optimal. All other criteria have been achieved since some interviewees meet multiple criteria. In table 21 below the final ten interviewees are listed including their project details.

Table 21: Interviewee details

#	Project	Project Code	Portfolio Code	Role	Located	Nationality
1	A-Haiti	A18	X79	Drafting/ Modelling/ BIM	NL-RTM	NL
2	A-Haiti	A20	X20	Project/ Design management	NL-RTM	NL
3	A-Haiti	A2	X35	Drafting/ Modelling/ BIM	NL-NIJM	NL
4	B-Ethiopia	B3	X69	Project /Design management	NL-RTM	NL
5	B-Ethiopia	B30	X84	Engineering	VN-HCMC	VN
6	B-Ethiopia	B19	X73	Other specialists	VN-HCMC	VN
7	C-Vietnam	C2	X21	Project /Design management	VN-HCMC	NL in VN
8	C-Vietnam	C42	X70	Engineering	NL-RTM	NL
9	C-Vietnam	C32	X36	Costing	VN-HCMC	VN
10	C-Vietnam	C13	X51	Construction management	VN-HCMC	NL in VN

In this section, the root cause analyses for the individual case projects will be discussed. For each project, the statement and their belonging root causes are evaluated. What statements and root causes have been most determinative for data sharing in each case project and in the total portfolio? Thereafter the positions of the interviewees in the networks are considered and compared with their answers in the interviews.

6.2 Project A network: The Haiti brewery

Interviewing three team members of project A conceived their digital performance. The project started chaotic without a solid data sharing plan. At kick-off, it was unclear who was responsible for document control, storage of project information, and maintaining an overview. This led to confusion on the latest updated files and agreements. The project manager did not have the appropriate digital skills to put clarity in data sharing himself, so he appointed two drafters to take on this responsibility. Thereafter, a workable data sharing approach was built, and team members were able to find data in the online environment. During the project, a scrum pilot was introduced to exchange information and knowledge about the project. The interviewees of this project emphasize the importance of limiting unnecessary data exchange to prevent that people get disturbed from their work and receive irrelevant or incomplete information.

6.2.1 Results: enabling and limiting factors

Table 22: Root causes in project A

Reading guide

Agree with statement and applies to me in the project because [Root cause of enabling factor]	Disagree with statement but applies to me in the project because [Root cause of enabling factor]	Agree with statement but does not apply to me in the project because [Root cause of limiting factor]	Disagree with statement and does not apply to me in the project because [Root cause of limiting factor]

STATEMENTS ABOUT DATA SHARING ENHANCEMENT

INTERVIEWEES	1 *Accessibility*	2 *Incentives*	3 Practicality	4 *Development*	5 *Trust*	6 *Impact*	7 *Interaction*	8 *Alignment*	9 *Expertise*	10 *Involvement*
A18	Pushing deadlines	Lack of coordination	Simplicity in communication	Eager to learn	Physical presence	Lack of commitment	Missing budget	Shared agreements	Eager to learn	Physical presence
A20	Missing skills	Missing drive to change	Adjustable structure	Pushing deadlines	Simplicity in communication	Information overload	Fast problem solving	Taking small steps	Missing work speed	Feeling responsible
A2	Too much effort	Missing drive to change	Conveniently accessible tools	Missing drive to change	Open and transparent	Integration of work	Open and transparent	Shared agreements	Open and transparent	Pushing deadlines

6.2.1.1 Root causes of enabling factors

Statement three about the practicality of the data sharing environment in terms of clarity and flexibility was considered favorable in project A and stimulated effective data sharing. The first root cause that explains that behavior, is the use of their online Box folder structure, which was a basic structure that can be finetuned to the project specifications. This way it remains recognizable but also flexible to work with, making it easier to use for sharing data with the team. Also, other tools, such as meeting and emails are convenient and accessible to use and allows the team to share at the desired level. Simplicity in communication and limiting the number of data streams makes it much clearer to adopt data in work tasks. Secondly, the level of trust among colleagues was good and helpful for data sharing. It was mentioned to make people more approachable, especially when being in the physical presence of colleagues. The barrier to share vanishes and less data traffic is needed when the trust level is high, which makes communication simpler and increases efficiency. It was also mentioned that the trust levels did not influence data sharing directly. Openness and transparency are perceived despite the trust level between colleagues. Lastly, the interviewees were positive about global alignment and standardization between offices. This was achieved by making shared agreements and transforming procedures by taking small steps and. A recurring topic was aiming for simplicity in data flows, tool use, and minimizing unnecessary data traffic to prevent constant distraction.

6.2.1.2 Root causes of limiting factors

In this project, the inaccessibility of the data sharing environment was experienced as a barrier and hindered efficient data sharing in the opinion of all interviewees. The root causes that explain why the data sharing environment was not accessible or up-to-date to them are the lack of time due to pushing deadlines and skills that were perceived to understand how the digital tools work for digital data exchange. Or, it is simply too much effort to use the data sharing environment as other work priorities also needed to be finished. The project work did not allow the team members to take the time to develop new skills as deadlines and milestones put extra pressure on the team. The second statement that received the most negative feedback regards external support and incentives from higher management. Higher management barely triggered the project team to improve data sharing. It was indicated that the extra benefit was limited due to a lack of coordination.

6.2.2 Analysis: data sharing behavior

In this section, the overall structure of the project network is first compared with the most occurring root causes mentioned by the interviewees. What root causes have determined the data sharing behavior in the project and therefore formed the structures and patterns of the network? Secondly, the individual data sharing behavior of the interviewees is analyzed by comparing their personal root causes and their positions in the network. For this analysis, a power/interest grid is used to define what kind of roles the interviewees have in the project and distinguish the gatekeepers (high betweenness, low degree), the visible figures (low betweenness, high degree), and the central figures (high betweenness, high degree) as mentioned before in the SNA. The data sharing network of project A is centralized around a group of connected nodes and shows a relatively high-density level. The high clustering level indicates that many team members are interconnected and results in a bigger group of visible figures (chart 14). The most occurring root causes of limiting and enabling factors for data

sharing are listed below. The trust level in the project was sufficient due to the open and transparent environment. Trust is known to be an essential factor in project-based organizations (Killingsworth et al., 2016) and should be stimulated. Too much trust, however, can lead to uncontrolled data streams, resulting in redundant information (Wise, 2014) which appears to have happened in project A. The interviewees all mention that the drive for change in data sharing was absent. Triggers are important in the construction sector, as people are inclined to resist to change (Sategna et al., 2019). The lack of time due to pushing deadlines limited data sharing. Unintegrated systems do not encourage employees to participate, and people stick to familiar and conventional tools (Westin & Sein, 2014).

Top root causes of enabling factors

- Open and transparent

Top root causes of limiting factors

- Missing drive to change
- Pushing deadlines

Zooming in on the data sharing behavior of the interviewees shows that A18, the drafter, has the highest power and interest in the network and is therefore a very central figure. A20, the project manager, is a visible figure as better replaceable regarding data sharing. A2 has both limited power and interest and belongs to the peripheral figures, just as the majority of the team members. Conducting in-depth interviews has provided insights on the root causes of their sharing behavior. Node A18 is of high importance due to his responsibility to control and maintain the internal document and data flows of the project. This responsibility was assigned to him by A20 because A20 was missing digital skills to maintain the desired work speed. A18 mentions that he was 'compelled to teach himself better data sharing skills in the interest of the project but not because it was offered to him'. This was also highlighted by A20; he was willing to learn about digital ways of working but his constant work pressure did not allow it. His higher interest regarding data sharing in the network is due to his awareness and dedication as the project manager. A2 has lower importance in the network which had to do with his lower involvement in the project. He was only responsible for some draft work, worked at another office, and had other projects running simultaneously. Therefore, he was less dedicated to contributing to sharing data in the project.

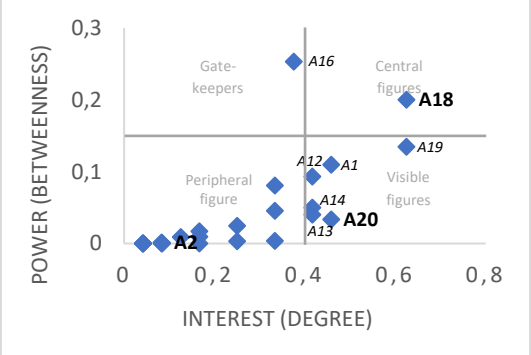


Chart 14: Power/interest grid project A

6.3 Project B network: The Ethiopia brewery

Project B started in The Netherlands but halfway through it was decided to transfer detailed design work to the Vietnamese office. This was requested by the client to lower the project costs and increase the work capacity. While this enabled faster project delivery, the effort for managing a mixed team is higher. During this project, the client also specifically requested to raise the digital workflows, increase efficiency, work more economically and improve

sustainability. Both these requests asked for a change in data sharing among team members of the project. These requests activated the team but also became aware by higher management of RHDHV. Still, the network shows a strong division between the Dutch and Vietnamese offices.

6.3.1 Results: enabling and limiting factors

Table 23: Root causes in project B

Reading guide

Agree with statement and applies to me in the project because [Root cause of enabling factor]	Disagree with statement but applies to me in the project because [Root cause of enabling factor]	Agree with statement but does not apply to me in the project because [Root cause of limiting factor]	Disagree with statement and does not apply to me in the project because [Root cause of limiting factor]

STATEMENTS ABOUT DATA SHARING ENHANCEMENT

INTERVIEWEES	1 Accessibility	2 Incentives	3 Practicality	4 Development	5 Trust	6 Impact	7 Interaction	8 Alignment	9 Expertise	10 Involvement
B3	Too fast changes	Shared goals	Information overload	Competitive advantage	Experienced personnel	Simplicity in communication	Fast problem solving	Shared agreements	Missing work speed	Feeling responsible
B30	Central point of contact	Competitive advantage	Available budget	Missing budget	Physical presence	Simplicity in communication	Fast problem solving	Integration of work	Eager to learn	Feeling responsible
B19	Conveniently accessible tools	Wrong timing	Adjustable structure	Eager to learn	Experienced personnel	Collective commitment	Conveniently accessible tools	Shared agreements	Feeling responsible	Central point of contact

6.3.1.1 Root causes of enabling factors

The project indicated many root causes of enabling data sharing factors in the project. It was said that, by keeping it simple and limited to only the necessary data streams, the highest impact was achieved in data sharing. This could also be realized due to the trust in the project, which was mostly caused by being able to rely on experienced personnel in the team. Feeling responsible for sharing project data has also contributed to this project for all the interviewees. Since this project had to collaborate between The Netherlands and Vietnam, it would have been plausible that more data sharing issues would have occurred. Nevertheless, the interviewees indicated that most interaction between offices went well due to shared agreements that had been made and conveniently accessible tools that enabled fast problem-solving and the integration of work. The interviewees all agreed that the interaction and the alignment between the offices resulted in better data sharing within the project.

6.3.1.2 Root causes of limiting factors

In this project, only five root causes of limiting factors occurred, which indicates that the overall data sharing in this project is perceived positively. The problems that did occur had to do with fast changes in implementing new data sharing systems. The client requested to raise the digital workflows, but this has not been implemented as the bar was raised too high. In Vietnam, they were not aware of this and got the support of the document controller in organizing all their files to keep the system accessible. An employee indicated that a digital implementation request from higher management was suggested at the wrong timing when the project was already fully operating. Another root cause of a limiting factor was the perceived information overload by the amount of redundant data sharing systems and tools. All these extra 'practical tools' cause more confusion and information overload were mentioned as a resulting pitfall. One interviewee said that more budget was missing for training and self-development. One tried to improve self-development on its own initiative to create a competitive advantage and stay ahead of other

construction companies. The other was eager to learn by himself or learn directly from other colleagues. But in general, this should be organized more equally among employees to monitor aligned skill levels. Lastly, one interviewee mentioned that he did not have enough digital expertise to improve his data sharing. He preferred conventional tools since they saved him time in his everyday tasks.

6.3.2 Analysis: data sharing behavior

In project B, a sparse network structure was observed with centralization around one prominent node, the project manager B3. In general, the interviewees were positive about data sharing in the project. It is assumed that B3 covered most of the work as the single central figure, and therefore left the Vietnam office with fewer issues. The feeling of being responsible for sharing data has been the most prominent enabler for data sharing. Connecting the right people with each other to ensure valuable data exchange or inform younger engineers about previous project experiences. The few root causes were almost all time related but did not address significant limiting data sharing factors due to the low number of these root causes in the project.

Top root causes of enabling factors

- Feeling responsible

Top root causes of limiting factors

- Time-related root causes

The power/interest grid is shown in chart 15. B3, the project manager, scores highest in both power and interest, which makes him the most central figure. B30, the Vietnamese project manager, is a typical gatekeeper with high power but lower interest. B19 covers the role of financial controller and both her interest and power are moderate. Conducting in-depth interviews has resulted in the root causes of their sharing behavior. The project manager B3, has a very high level of involvement and possesses all project knowledge. Due to his feeling of responsibility, B3 admits that he faced difficulties in delegating tasks to others. B3 loses work speed in adopting new technologies and therefore holds on to conventional methods. This is rather inefficient and makes it more difficult to decide who is responsible for the data, he indicates. B30 is the structural project manager at the Vietnam office. His data sharing behavior is proactive but focused on his own team. B30 emphasizes the importance of sharing the experience with younger colleagues to exchange knowledge and help grow the team. His data sharing improved by learning from others, by available budget, and by keeping communication simple and efficient. B19 has moderate power in the project as her position only covered a small part of the project scope. In the project, she did not have to be aware of all the engineering details but needed to write general reports for communication towards higher management. Her role will be moving to the front seat in the future instead of the back seat.

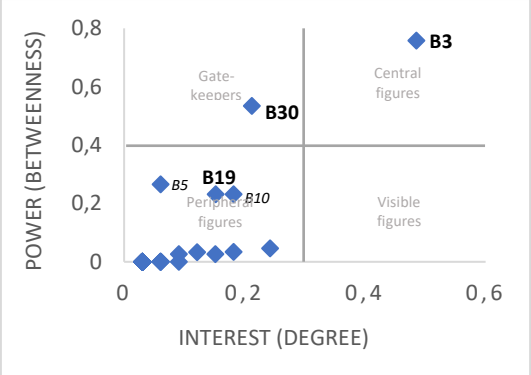


Chart 15: Power/interest grid project B

6.4 Project C network: The Vietnam brewery

The Vietnam brewery is by far the biggest case project involving a greenfield brewery complex build next to an existing brewery on site. The capacity of the brewery was large, keeping in mind the doubling extension in the next phase. This should have influenced data sharing and storage, as reusing information increases efficiency and can minimize rework. Most work was conducted in Vietnam, and some Dutch employees temporarily joined the team in Vietnam or stayed there for the long term. An exchange in knowledge and experience resulted from this collaboration, increasing local expertise in Vietnam and making them more independent professionals.

6.4.1 Results: enabling and limiting factors

Table 24: Root causes in project C

Reading guide

Agree with statement and applies to me in the project because [Root cause of enabling factor]	Disagree with statement but applies to me in the project because [Root cause of enabling factor]	Agree with statement but does not apply to me in the project because [Root cause of limiting factor]	Disagree with statement and does not apply to me in the project because [Root cause of limiting factor]

STATEMENTS ABOUT DATA SHARING ENHANCEMENT

INTERVIEWEES	1 Accessibility	2 Incentives	3 Practicality	4 Development	5 Trust	6 Impact	7 Interaction	8 Alignment	9 Expertise	10 Involvement
C2	Central point of contact	Too fast changes	Adjustable structure	Lack of coordination	Experienced personnel	Central point of contact	Simplicity in communication	Simplicity in communication	Eager to learn	Feeling responsible
C42	Central point of contact	Missing drive to change	Adjustable structure	Missing skills	Experienced personnel	Information overload	Confusing tools	Too fast changes	Information overload	Physical presence
C32	Central point of contact	Missing drive to change	Simplicity in communication	Available coordination	Physical presence	Conveniently accessible tools	Missing drive to change	Shared agreements	Open and transparent	Physical presence
C13	Central point of contact	Missing drive to change	Adjustable structure	Lack of coordination	Simplicity in communication	Conveniently accessible tools	No sharing barriers	Wrong timing	Eager to learn	Feeling responsible

6.4.1.1 Root causes of enabling factors

The statements that obtained most root causes of limiting factors for data sharing are assigned to the accessibility and practicality of the data sharing environments. Having a central point of contact in the form of a document controller, the project assistant carried the responsibility to keep an overview of all data streams, improved data sharing in the project. Due to her work, the reliability of data increased. The team could count on having the latest files and approach her for questions regarding project data. A practical system enabled easy switching between tools that were most convenient at a certain moment. Other enabling root causes where found in soft factors. The level of trust in the project was high and added to improved data sharing. This was mostly caused by the perceived experience of other team members, which made it more reliable to share project information with them. Knowing that other people are committed to their role and responsibility by being often in their physical presence also improved data sharing and could simplify communication as frequently checking their work was not necessary.

6.4.1.2 Root causes of limiting factors

In project C, two statements have been indicated with the most root causes of limiting factors. The main problems occurred in incentives from higher management in enhancing data sharing. The project manager mentioned that these triggers asked for too fast changes while other team members mention that they completely missed a drive for change. The second statement that resulted in limited data sharing was about training and self-development. Either a lack of

additional coordination made introduction training useless, or skills were missing to adopt it in practice. Available coordination was identified by one employee who received BIM training from a direct colleague, which is considered to be a bottom-up approach to reinforce team spirit by sharing expertise. Lastly, it was found that global interaction and alignment between remote offices was not optimal and limited data sharing.

6.4.2 Analysis: data sharing behavior

The network of project C shows multiple hubs with a high density of data streams and implies that there is a greater division of disciplines. The most occurring root causes of enabling factors for data sharing are having a central point of contact and the simplicity in communication. This project relied on the document controller that made it simpler to share information between employees, as experts had to worry less about organizing information flows. They were able to focus on being information users and therefore were able to put less time and effort into being information controllers. However, the question is whether this is the most optimal scenario. Research shows that interdependent project activities need the collective involvement of team members to ensure coherent decisions and solutions (Rauniar, Rawski, Morgan, & Mishra, 2019). The limiting root cause that was the most prominent was the 'missing drive to change' which limited the intrinsic motivation of employees to change their sharing behavior.

Root causes of enabling factors

- Central point of contact
- Simplicity in communication

Root causes of limiting factors

- Missing drive to change

The power/interest grid below shows the four interviewees in this project. C2 has the highest power and interest, which makes him a central figure. C42, an isolate with the role of engineer, is the opposite with low interest and low power regarding data sharing. C13, from construction management and C32, have both been selected based on their positions in which C32 is an isolate in the and C13 serves as a central figure.

C2's ability to guide projects in the right direction is high and he emphasizes that controlling project data and information is the key to pulling off successful projects. His responsibility and commitment to keep a full overview of the project determined his central role. But he also points out the importance of transferring responsibilities to others by making them feel accountable too. Especially in a large project, this is essential to distribute the workload. C32 and C13 both have high importance within their role-specific networks but give various explanations for this. C32 emphasizes the high level of trust within his discipline, retrieved by a being in physical presence at the office with a mix of young and experienced employees. C13 felt intrinsic motivation to utilize data sharing systems, teach other colleagues to do so too and take on a pro-active role to recover unalignment in the project. He was an important link between the construction management team and other disciplines within the team.

The final interviewee joined the team in Vietnam for three months and therefore has a less prominent position in the data-sharing network. He applied his experience from other projects in the project but argued that every project is unique, so transferring specific project data is quite difficult. Building up trust with the Vietnamese colleagues was important to him to minimize sharing barriers. The available tools helped him to share necessary information, but he emphasizes the urge to keep it simple, limit unnecessary data flows to prevent overloads.

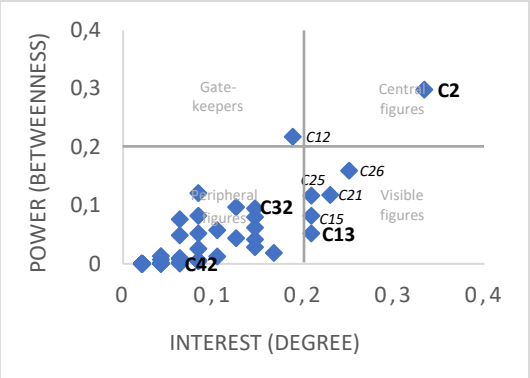


Chart 16: Power/interest grid project C

6.5 Portfolio network: The multinational client

The final conclusions of the in-depth RCA are focused on the total portfolio. Like in the SNA, the three separate case projects are again combined to determine what are the most accurate problems and potential solutions. The multinational client portfolio of RHDHV consists of many local projects, and this study aims to find overarching recommendations that have a positive effect on the whole portfolio. Also, role-related findings are being discussed that can contribute to tailor-made solutions based on role specifications.

6.5.1 Results: enabling and limiting factors

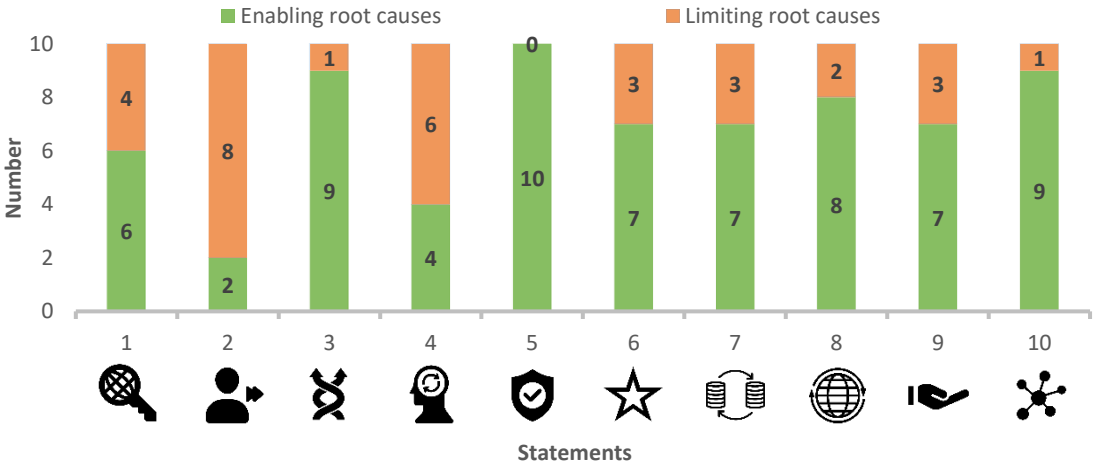


Chart 17: Overall statement evaluation

6.5.1.1 Root causes of enabling factors

Chart 17 gives an overview of the statement evaluation for the three case projects in the portfolio. Most statements regarding data sharing have been evaluated positively. This offers valuable insights into what team members consider as helpful elements in establishing effective data sharing. In the total portfolio, three statements had none or only one limiting root cause. The most beneficial for data sharing in the portfolio has been the level of trust between employees which was most often the result of either having experienced personnel or being in the physical presence of employees. Thereafter the practicality of the data sharing infrastructure contributes to enhancing data sharing, which mostly has been dedicated to having an adjustable but remaining recognizable structure for saving data. The last most positive evaluated statement concerns the level of involvement of employees, caused by feeling responsible towards colleagues and in a certain project role.

6.5.1.2 Root causes of limiting factors

At the portfolio level, incentives and triggers by higher management were mostly missed while employees believed that it contributes to effective data sharing. The triggers were most often completely missing or did not change anything because they were not supported by extra coordination. It was claimed that simply imposing change is not enough and that it requires a change of management and support to make a difference in the projects. The other statements that resulted in the most limiting root causes concerned having the room for self-development and training to improve data sharing skills. A variety of causes were mentioned, such as not having the time due to project deadlines, missing budget to offer more training and again the missing additional coordination that enables adopting the new gained skilled in practice. Employees mention that it is not clear whom to approach for further questions and practical application of new digital ways of working.

6.5.2 Analysis: enhancing data sharing

The network showed a moderate density rate and exposed a division between the Dutch and the Vietnamese office. A group of project managers and some engineers link the two groups together. From all 41 respondents, 36,6% mentioned to share data with employees from other projects. Of all 224 data streams, 15,6% have been between team members from different projects. The question is whether these numbers indicate a sufficient level of data sharing within the portfolio. When asking the interviewees on adopting project data from one project into another, it was indicated that it is hard to transfer project data directly and that valuable information does not reach all corners of the portfolio. The power/interest grid in chart 18 shows that most employees are positioned as peripheral figures, which assumes that locally generated data is not exchanged extensively. These insights indicate that forms of data silos exist as data sharing does not take place efficiently. The portfolio barely consists of visible figures or gatekeepers that connect dispersed groups. All root causes present in the portfolio are listed in Appendix F4; the most important root causes are explained here.

Simplicity in communication and having a central point of contact are most often indicated as enabling root causes which implies that employees prefer making data sharing as easy and practical as possible. It was often mentioned that new systems need to be kept understandable for everyone in the project and to limit the number of systems and implement new systems in manageable steps. It should be noticed here that the most conveniently accessible tool in the eyes of the employee is still email, which is not the most traceable way of data sharing. The following most indicated root causes related to the soft factors of data management. Having the eagerness to learn new digital ways of working, feeling responsible for contributing to better data sharing all both important reasons for employees to improve their own data sharing or transfer it to others. These root causes are harder to transfer to other employees who lack these intrinsic motivations. Therefore, it is needed to come up with a strategy on how to motive and engage people and create commitment to digital change. Lastly, being in the physical presence of colleagues increases trust and improves data sharing.

The most prominent root cause of limited data sharing is a lack of drive to change. It was most often mentioned that employees continued with their conventional ways of sharing data because nobody suggested changing their data sharing behavior. That was often the case when the

project was running well enough; also, implementing change takes time, effort, and money. The following prominent root causes show some overlap. The information overload is in line with change that is pushed too fast. People block when too much is happening at once or when they have to implement new ways of working instantly. Lack of time due to pushing deadlines makes people fall back into their old and familiar work habits. This might be a quick solution at the project level but does not increase success in the long term. The lack of collective coordination also limits a holistic adoption of digital ways of working. A lot of interviewees argue that if training was organized, it only concerned a brief introduction, and employees were inequitably considered 'experts' after.

Root causes of enabling factors

- Simplicity in communication
- Central point of contact
- Eager to learn
- Feeling responsible
- Physical presence

Root causes of limiting factors

- Missing drive to change
- Information overload
- Lack of coordination
- Pushing deadlines
- Too fast changes

The power/interest grid is shown in chart 18. X21, the project manager of the Vietnam brewery project, is one of the most connected nodes in the portfolio. He has the highest betweenness and, therefore, the network depends on him as he holds the most unique data streams. The other central figure in the portfolio is X69, the project manager of the Ethiopia brewery project. He also carries great responsibility when it comes to data sharing in the portfolio as he is connected to most employees. It is interesting to see that in the whole portfolio the level of active data sharing contributors is significantly low. Most employees are peripheral figures with limited (unique) data streams. Only three employees fall into the visible figures category, and none of the employees can be categorized as a gatekeeper. This provides multiple insights into data exchange in the portfolio network. Central figures are highly involved in the network and have the ability to influence groups quickly but can also turn into potential bottlenecks if they do not use their position effectively. Besides that, these portfolios are widespread and include multiple continents. The network cannot build on solely two central figures. Gatekeepers create bridges between isolated groups to transfer non-redundant information. Without them, information is only shared locally (McDowell et al., 2016). Organizing more visible figures in centralized groups and appointing gatekeepers to communicate via bridging data streams will create stronger and more efficient networks. It is assumed that balancing the different role types (gatekeepers, central, peripheral and visible figures) will increase the effectiveness of the network as a whole.

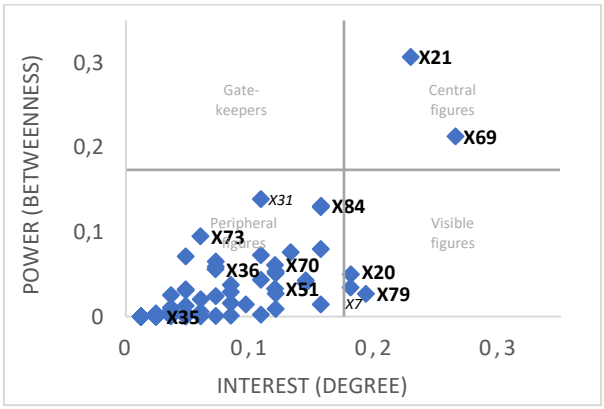


Chart 18: Power/interest grid portfolio

6.5.2.1 Role analysis

The in-depth interviews also included findings from interviewees that were selected based on their position in the role-specific networks. The P/DM roles are the most central group of employees in the portfolio and often are the most connected nodes in the project networks. Project teams often rely on their ambition and motivation to incorporate digital plans, while the majority of the P/DMS miss essential digital skills. Therefore, it is important to either improve their digital capabilities or to ensure that the responsibility to develop digitally is divided over more employees. In that sense, the project manager is inclined to work on a digital plan together with people that support him and engage more team members.

In the SNA, it was found that the CM network in the portfolio operates as a dispersed group of employees. Data sharing between early phase disciplines and construction teams can improve both of their work. Failure data that occurs during construction needs to be communicated to design and engineering teams to prevent such mistakes in future projects. Also, during construction, it is essential to have good data sharing in case any re-engineering needs to be done. In the interviews, it became clear that role-specific teams often do not feel the urge to share outside their own disciplines; data silos are a result of this behavior. In the costing network, data is being shared among the costing employees effectively since there is a social relationship and willingness to help others in their team. Outside their disciplines, data sharing only takes place when it is directly needed for the benefit of the project. The insight given by a financial controller was remarkable here. Higher management decided to change their roles from being overall financial controllers, to project focused controllers. She mentioned that her team now steps from the back seat to the front seat and be more involved. Acknowledgment of their value and giving them more responsibility creates a sense of importance and activates them to contribute to data sharing in their projects.

6.6 Discussion

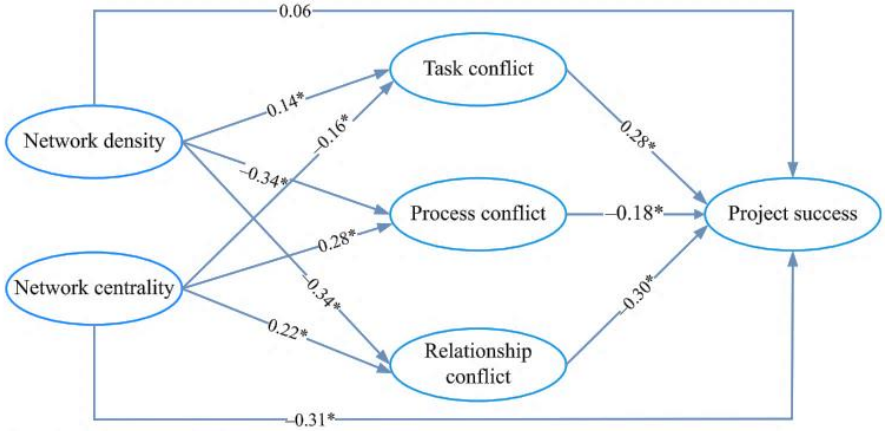
This chapter analyzed the underlying root causes of the data sharing behavior of ten employees with interesting positions in the data sharing networks. The aim was to understand why and how these employees established data streams within and between the case projects. As a result, a list of root causes that most enabled and limited data sharing was identified. These insights are the result of subjective explanations of the interviewees. They therefore need to be compared to the results of existing literature and the networks to generate validated interpretations.

6.6.1 Cross-case comparison

Conclusions can be derived when comparing the three separate case projects based on the emerged root causes identified by the interviewees. Project A has the most root causes of limiting data sharing factors with 13 out of 30, followed by Project C with 13 out of 40. Project B has the least limiting root causes with only 5 out of 30. Not enough interviews were conducted per project to directly conclude that Project A indeed has the least effective data sharing and project B the best. Existing literature sheds extra light on the retrieved findings.

Blackburn (2002, page 203) claims that project managers see themselves as the heroes of their project, 'yet their performance depends on choreographing the contributions of heterogeneous actors'. This implies that network success is determined by team operations guided by the

intentions of the project manager. With the RCA it was found that the structure of the network graph is highly dependent on the data sharing behavior of the project manager as he sets the rules or at least has a strong influence on shaping them. In project A, the project manager recognizes that he lacks sufficient digital skills and assigns two drafters to take on document controller tasks. Still, the project manager should be responsible for guiding those activities and realize better projects by delivering innovation in favor of the organization. In project C, the project manager felt like he was the only person who took responsibility for implementing digital strategies, and that the team often relied solely on his initiative. In project B, where presumably most data sharing successes occurred, the project manager also set the standard for data sharing. The team was strongly centralized around him, as he also admits finding it hard to delegate work to others. Therefore, fewer information flows were established in delivering the project which decreases the network density. Research (figure 36) investigated the effect of network structure characteristics and found that network centrality has a significant negative influence, and network density has a relatively positive influence on project success (Wu, Hu, Zheng, Zhao, & Zuo, 2019). This is in contrast to the results of this research, where the most centralized project B implies the most root causes of enabling data sharing factors in practice.



Note: *Significant at the 0.05 level

Figure 36: The effect of network structure characteristics (Wu et al., 2019)

6.6.2 Less is more?

The observations mentioned above provide different insights. The interviewees assessed their data sharing behavior against their personal belief systems and experiences with data sharing possibilities. Probably many of them are not aware of how it could improve. As discussed in the SNA chapter, the network density level determines team potency, and the centralization level the team performance, but excessive levels undermine the effectiveness (Tröster et al., 2014). Research by Wiewiora, Smidt, & Chang (2019) draws similar conclusions on organizational structures and provides additional explanations for the findings obtained in this chapter.

Project A shows a dense and decentralized structure and has the highest number of limiting root causes. Management in decentralized networks delegate a significant amount of decision-making to others and the implementation of new ideas is more likely to be institutionalized (Wiewiora et al., 2019). But it is important to maintain some level of separation to prevent overexposure or earlier referred to as information overload. Presumably, the state of overexposure is reached in this team, which explains lower effective data sharing. In project B, the data sharing statements have mostly been positively assessed but expose a highly centralized

network. Centralized networks result in reinforcing past behavior and being more efficient but less adaptive (Wiewiora et al., 2019). Providing the team vague directions and limited role clarity creates more hierarchy dependence and discourages the team from exploring new ideas (Sense, 2004). The team was highly dependent on the project manager and more work could have been delegated to the rest of the team to become more innovative and use less conventional work methods. The reached level of efficiency explains the high amount of enabling root causes for data sharing, but sub-optimal solution often results from that to 'speed things up'. Project C exposed fragmented hubs of data sharing, with a moderate density and centralization level. Wiewiora et al. (2019) conclude that mostly decentralized, composed of loosely coupled, isolated teams, enable feed-forward learning flows. In order to achieve that, project leaders should facilitate linkages between individuals and teams. In project C the project manager argues that he is often the designated person to implement digital initiatives. He mentions to experience too fast changes, while the RCA shows that the rest of the team does not feel the drive to change. Apparently, incentives to change are not shared widespread with the team which but get stuck at higher management and project managers. This mostly had to do with the wrong time of initiating change, and therefore postponed. Still it is important to engage all employees by distributing responsibility, set clear goals and let everyone learn and grow.

This research states that the investigated data sharing networks and information flows currently are highly dependent on the style of the project manager. Wiewiora et al. (2019) found that organizational structures influence learning dynamics by shaping patterns and communication between organizational layers. Research states that network structures can manage the balance between exploration and exploitation of novel ideas and solutions (Fang, Lee, & Schilling, 2010). The obtained root causes in this research and insights into role type influences can be used to accommodate effective network structures and understand what factors can be incorporated in digital strategies.

6.7 Wrap up

This section provides the concluding remarks of the performed root cause analysis. Based on their network positions, ten RHDHV employees have been interviewed to understand their data sharing behavior. By discussing ten statements with them, an overview of root causes was exposed that enabled and limited data sharing within and between their project teams.

Comparing the projects shows that the least dense and mixed team of project A, is the most positive about data sharing. This was most often caused by a feeling of responsibility to share data with colleagues. None of the statements had more root causes of limiting data sharing factors than others. In project A, with a dense network and a higher number of visible figures, the most problems in data sharing were addressed. Causes were mostly the missing drive for change and the lack of time due to pushing deadlines. The interviewees often mentioned that there was redundant data traffic and information overload. In project C, more mixed signals were given about data sharing in the project. This can be explained by the multiple data sharing hubs in the network. A constant factor was the central point of contact in the form of a document controller and the simplicity in communication that improved data sharing in the project.

Combining all results exposed the root causes of enabling data sharing factors (table 25) and root causes of limiting data sharing factors (table 26) at portfolio level. The overview shows how

often certain root causes are mentioned and therefore the level of influence they have on data sharing in the portfolio. Data sharing went well because of simplicity in communication and having a central point of contact. The root causes of limiting data sharing factors were mostly the missing drive for change and information overload. These insights are important to understand how data sharing can be enhanced in multinational engineering companies at project, portfolio and organization level.

Roles within the project show different behavior regarding data sharing and also mention different root causes. People that feel more involved in the project experience higher responsibility towards data sharing being constantly aware of the progress of the projects and also encourage others to do so too. If they do not have the digital skills themselves, they appoint others to take over this role, and if they do have the skills and reserve time for it, they help others to improve. This sense of responsibility decreases as the involvement of the team member is lower but can be increased when the responsibility is specifically addressed by managers. Lastly, it is observed that the Vietnamese team members were more positive about data sharing in general, which addresses a difference in cultural mindset and being critical.

Root causes of enabling factors	#	%	Cum. %
Simplicity in communication	8	12%	12%
Central point of contact	7	10%	22%
Eager to learn	6	9%	30%
Feeling responsible	6	9%	39%
Physical presence	6	9%	48%
Conveniently accessible tools	5	7%	55%
Adjustable structure	5	7%	62%
Open and transparent	5	7%	70%
Shared agreements	5	7%	77%
Experienced personnel	4	6%	83%
Fast problem solving	3	4%	87%
Integration of work	2	3%	90%
Competitive advantage	2	3%	93%
Available budget	1	1%	94%
Available coordination	1	1%	96%
Collective commitment	1	1%	97%
Shared goals	1	1%	99%
Taking small steps	1	1%	100%
Total	69	100%	100%

Table 26: Root causes of enabling data sharing factors

Root causes of limiting factors	#	%	Cum. %
Missing drive to change	7	23%	23%
Information overload	4	13%	35%
Lack of coordination	3	10%	45%
Pushing deadlines	3	10%	55%
Too fast changes	3	10%	65%
Missing budget	2	6%	71%
Missing skills	2	6%	77%
Missing work speed	2	6%	84%
Wrong timing	2	6%	90%
Confusing tools	1	3%	94%
Lack of commitment	1	3%	97%
Too much effort	1	3%	100%
Total	31	100%	100%

Table 25: Root causes of limiting data sharing factors

While the majority of the interviewees refer to positive experiences regarding data sharing, the division of nodes over the power/interest grids implies other circumstances. Most of the team members at project and portfolio level are characterized as peripheral figures, disconnected and with less interest and power regarding data sharing. Only a limited number of central and visible figures are present and none of the employees act like gatekeepers that connect non-redundant groups. This indicates unbalanced group dynamics and increased data silos. The findings of this chapter can be used to shape digital strategies that are in line with the needs of employees.

III SYNTHESIS

7 BRIDGING THE GAP

Berck, D.P. (2019) - This picture is blurred due to confidentiality reasons.

7 BRIDGING THE GAP

In this chapter, the research findings will be discussed in relation to the existing literature; in other words, how does the present research contribute to the literature. First, the findings from the exploration and case studies are compared (7.1). Then, the sub-questions and main research question are answered in the conclusion (7.2).

7.1 Discussion

First, the findings are compared, and affirmative and new insights discussed (7.1.1). After that, the limitations of this research are discussed. These might influence the research results (7.1.2).

7.1.1 Research findings

The overview presents which root causes from practice match with the data sharing factors from theory. Based on the occurrence percentage of the root causes, it is assessed to what extent the related factors enable or limit intra-organizational data sharing in networks of multinational engineering companies. The combined impact in practice is presented in yellow.

Table 27: Comparison of theoretical and practical research findings

Root causes	Enabling/limiting data sharing factors	* En. %	Lim.%	Tot. %
+ Simplicity in communication + Central point of contact - Information overload	Perception of control and overview of data streams	22%	13%	16%
+ Open and transparent + Physical presence	Intra-organizational relationships between employees	16%	-	8%
+ Conveniently accessible tools + Adjustable structure - Confusing tools	Operation ability of information infrastructure accessibility	14%	3%	10%
+ Eager to learn - Too much effort	Intrinsic motivation by individuals own incentives	9%	3%	6%
+ Feeling responsible	Role specifications and role responsibilities	9%	-	5%
+ Shared agreements	Organizational compatibility of systems and files	7%	-	4%
+ Integration of work + Collective commitment + Shared goals - Lack of engagement	Global affiliation and integration of teams	6%	3%	5%
+ Experienced personnel	Operation ability by employees' skills and experience	6%	6%	6%
+ Fast problem solving	Increasing detail and dynamic project complexity	4%	-	2%
+ Competitive advantage - Missing work speed	Competitive market causing faster project delivery	3%	6%	5%
+ Available budget - Missing budget	Economic costs and investments	1%	6%	4%
- Pushing deadlines	Perception of personal lack of time and work pressure	-	10%	5%
- Missing drive to change	Extrinsic motivation by external rewarding or incentives	-	23%	12%
+ Available coordination - Taking small steps - Lack of coordination - Too fast changes - Wrong timing	**Use of change management and data governance**	3%	26%	15%

* showing the level of enabling, limiting and total factor impact on data sharing.

‘Perception of control and overview of data streams’ scores high as an enabling and limiting data sharing factor. Engineers tend to spend more time on receiving/providing unrequested information than requested, often not consisting of the right answers (Robinson, 2010). Having control of the right information therefore offers huge benefits, as discovered in this research, but losing control quickly leads to decreasing effects (Almeida & Soares, 2014). Relationships and trust turned out to be an effective factor to enhance data sharing. This is supported by previous studies (see Henke et al., 2016; Lee et al., 2018). Besides, the accessibility of data and tools indicated effective data sharing. This is mostly caused by the convenience level of procedures and work methods. People are inclined to use sources that are most convenient, regardless of the quality (Almeida & Soares, 2014; You & Wu, 2019).

At the lower half, the overview presents the factors that have a limiting effect on data sharing. The factor that caused most problems and was added after reviewing all the root causes is ‘use of change management and data governance’. This result is explicable since it covers a whole series of well thought out procedures and rules. Therefore, applying change management and data governance to control and effect change is often problematic but offers huge productivity benefits when treated as a continuous process (Matthews, Love, Mewburn, Stobaus, & Ramanayaka, 2018). After that ‘extrinsic motivation by external rewarding or incentives’ comes forward having often-recurring problems with enhancing data sharing. It seems easy for employees to lay the problem of motivation in the hands of management but research shows that data initiatives should be adopted with a bottom-up approach rather than top-down (Matthews et al., 2018). Yet, top-down empowerment indeed seems inevitable in order to make employees recognize and understand the need to change (Vass & Gustavsson, 2017). Another factor that often was found to influence limited data sharing was ‘perception of personal lack of time and work pressure’. In project-based organizations and for the client gaining higher profit, this means delivering more assets faster. Still, it is interesting that in none of the cases the lack of time resulted in enhanced data sharing since effective data sharing is supposed to be time-saving. It also improves organizational learning and generates more relevant and available information. This indicates that employees do not acknowledge those benefits yet.

The overview addresses which root causes are in line with the identified data sharing factors from existing literature. Most of them find similarities with one of the 20 data sharing factors obtained earlier in this research. Yet, the root causes do not overlap with seven data sharing factors from theory, and one additional data sharing factor is formulated to cover some remaining root causes. This is explained below and appendix G1 shows the whole overview.

Additional factor

1. Use of change management and data governance

Remaining factors

1. Institution authority by developing information sharing infrastructure
2. Institution authority by establishing legal frameworks and formal policy
3. Perception of information security
4. Personal demographic details
5. Global awareness of remote activity and communication
6. Distinct cultural perceptions of capabilities and mentality
7. Misunderstanding due to cultural differences

The only additional factor that needed to be formulated to cover five remaining root causes is 'use of change management and data governance'. This factor does not seem to be striking, but the emphasis put on this factor in existing literature apparently is not compelling enough. Reexamining the earlier studied articles does provide some references to this factor (Alreshidi et al., 2018; Matthews et al., 2018; Vass & Gustavsson, 2017). As mentioned earlier, use of change management and data governance involve a host of other elements that only separately are being discussed in existing literature. This research found the importance of giving employees coordination and a guided pace of change.

Besides one added data sharing factor, seven identified factors from theory do not match with the root causes in practice. This does not mean that these factors are not important, but apparently, they are not that much recognized in practice. It is assumed that these factors merely operate in the background and are not so obvious to the majority of employees. The first two factors are focused on available infrastructure and legal frameworks or formal policy arranged by institutional authority. While the extrinsic motivation by higher management was often missing, these higher management-related factors are not. It was also remarkable that none of the respondents mentioned the role of the portfolio manager in establishing data sharing procedures or policies, while his influence could be of great value in creating a solid data sharing strategy within the portfolio boundaries. The investigated case projects all had some kind of data sharing infrastructure to their disposal, and frameworks and policies were available but not always implemented.

Secondly, the extent to which employee feel that sharing data is risk-free has a high impact on its effectiveness (Gupta & Dhami, 2015). In this research, none of the respondents mentioned data security as a fundamental element. However, it is assumed that if a company does not implement sufficient security measures, this has a high impact on the data sharing behavior of employees. Therefore, it is still advised to put this factor high on the agenda.

After that, the influence of demographic details of employees was not indicated as that determining for data sharing. Often it was mentioned in relation to other root causes, for example the digital skill level of employees, but it never occurred as a root cause. In existing literature, the factors age and work experience often positively influence the knowledge sharing behavior of employees (Killingsworth et al., 2016; Razmerita et al., 2016). This research assumes that information and data sharing is not necessarily dependent on demographic details.

Lastly, a striking observation is that three factors related to the multinational context of this research do not seem to influence data sharing. The final factors from theory that did not occur in practice all have to do with culture and geographically dispersed teams. All these factors did not seem to limit or enable data sharing in the case projects directly. Existing literature does not have prominent views related to the effect of multicultural dimensions on data and information sharing and merely focus on knowledge sharing (Javernick-Will, 2011). This research finds that if the data sharing conditions such as tools and accessibility are available, the cultural differences do not have a significant impact on the effectiveness of data sharing. But this could also be a result of the moderate diversity of the case project teams. Even though all the case projects have a multinational character, there are way more mixed project teams possible that could show a higher cultural impact on data sharing. This and other limitations of this research will be further discussed in the next section.

7.1.1.1 Critical questions

After completing data collection, data analysis and data interpretation, still some questions remain unanswered. Since science is dynamic, eternal and change is always around the corner it is important to ask critical questions that address uncertainty and new knowledge gaps. In this section the researcher provides critical notes on some emerged questions.

a) To what extent did the social network analysis contribute to the research and how did it influence the results?

The SNA gave quantitative insights about the actual data stream dynamics in construction projects. Centrality measures could identify what nodes contributed the most to data sharing in the networks and with whom, determining who's data sharing behavior to study in detail.

b) To what extent has the use of root cause analysis been useful for answering the main question and filling the knowledge gap?

The RCA qualitatively explored the root causes of data sharing behavior by conducting in-depth interviews. This resulted in factors that enable and limit data sharing in practice and applicable measures to enhance data sharing. However, the interviews gave a subjective view of the respondents on their behavior. The researcher aimed to not directly accept their viewpoints as reality but apply a critical evaluation.

c) To what extent are the findings complete? Has everything been discussed? Have no insights been overlooked that can change the outcomes?

The findings can give answers to all the formulated sub-questions and the main research question. Still, it is not assured that this research contains the complete truth, especially considering the embedded case study design. Also, assumptions had to be made due to time and capability constraints. This may have affected the research outcomes but still the overall conclusions can be considered relevant and useful for practice and future research.

d) To what extent are the conclusions and findings project/portfolio/organization-specific and can they be transferred to other cases?

Even though the research method used three case projects, the networks, root causes and factors findings are recognizable in project, portfolio and organizational situations. Three case projects for the same client have been investigated and together they give a sufficient representation of the multinational portfolio of which they are part. Still the researcher aimed to generalize the results and make the conclusions transferable to other cases. However, this has not been validated yet and should be done first to make any hard statements.

e) To what extent it is decisive that this research was carried out within a construction engineering consultant? Do the results also apply to other types of companies?

Again, it is assumed that the results can be used in other circumstances due to the generalizability of the conclusions. The findings indicate how data sharing can be enhanced in project-based organizations in the construction industry that contain operational, tactical and strategic roles. This translates into the way these roles behave regarding data sharing. The findings of this research define measures that can serve the behavior of all types of roles in the organization.

7.1.2 Limitations of the research

Assumptions made and methods used in this research lead to limitations. These need to be kept in mind when interpreting conclusions.

- **Survey respondents** – the social network analysis depends on the data collection via a survey, and the respondent selection has been a thoughtful process. However, not all relevant team members of each project could be contacted for the survey. Team members who have worked on-site of the concerning case projects often were freelancers or workers from local partners. These people have not been invited for the survey since they could not be contacted anymore via their RHDHV email. Also, a number of team members have already left the company. Not being able to incorporate their input into the SNA influences the outcomes. Pryke (2017) argues that the true dynamics in social networks can only be exposed when all team members have contributed, others argue that 70% coverage is sufficient. This research reached approximately 70% for project A, 30% project for project B, and 40% project for project C based on the spend working hours of the participated respondents (Appendix D2). The findings therefore do not provide a fully complete view on the data sharing dynamics but still expose useful insights.
- **Division of respondents** - respondents were asked to choose one project as survey reference while they might have worked for multiple cases. This resulted in missed opportunities to incorporate their experiences in all case projects, but it was not reasonable to ask them to fill in the survey for multiple projects. In the in-depth interviews, these employees were asked about their cross-case data sharing behavior. Only the relative number of respondents for the Ethiopia brewery project is not in ratio with the size of the project and would have given a more accurate result when a few more respondents would have participated.
- **Network edges** – the survey asked employees to provide at least three and at most ten important connections. The effort taken by these employees determines their connectedness in the network. This can be considered as biased since a node has a high degree of connections when that respondent has taken more effort to fill in many names.
- **Network attributes** – the survey asked respondents to assess the frequency, value, tool use and being the sender or receiver of their data streams. Pryke (2017) emphasizes the essence of these classifications and encourages researchers to use them in their interpretations. Due to limited time, this research did not go into detail on these classifications.
- **Interview consistency** –personal data sharing and general observations were discussed in the interviews. This sometimes resulted in inconsistency at the interviewee's side as some were inclined to always speak about data sharing in general terms. The researcher aimed to steer them in the right direction by asking guiding questions, but sometimes it was hard to distinguish their interpretations on the spot.
- **Interviews subjectivity** – the interviews provided subjective viewpoints on problems and successes in data sharing based on the personal opinion of the interviewees. The researcher aimed to objectively derive at an underlying root cause and validated them by the interviewees. Still, people had to estimate their own behavior, which is sensitive to overestimation, as it is common to forget what went wrong when looking back on a project.
- **Snapshot** – Data collection took place right in the middle of rapid changes at RHDHV regarding digital ways of working. The digital transition at the case company has recently been more activated. The conclusions in this research pick up on project circumstances that lay in the past. Still, the findings respond to what employees currently still find important.

7.2 Conclusions

In this section, the final conclusions are derived from the results and analysis performed in this research. First, is elaborated on all the sub-questions. And after that, the main research question is answered.

7.2.1 Sub-questions

Four sub-questions have been formulated in this report to structure the storyline and contribute to different elements of the overall objective. The results and findings of each sub-question have been discussed in the associated chapters. The conclusions are explained here.

Q1 *What does intra-organizational data sharing in the construction industry entail based on theory?*

The growing volume of profound data offers many opportunities. Especially unique data within a company brings advantages and companies who are data-driven, perform better on achieving business objectives. But the complexity of data also results in organizational issues and challenges in data adoption. Literature states that in the construction industry, data sharing is even harder compared to other sectors due to some typical characteristics. The high fragmented structure, uniqueness, and complexity of projects, the temporary nature of projects, and the mostly unstructured project data make it harder to establish effective data sharing. Data often does not reach all corners of the project-based organization, which is explained as organizational data silos. Still, data sharing is basically the beginning of open communication in construction projects, which has been proven to be essential for project success. Therefore, data needs to be shared during the whole project lifecycle, through different project phases, and between all organizational levels to improve the decision-making process and raise internal collaboration. Effective data sharing enables companies to reduce time delays, limit cost overruns, and ultimately grow business.

Globalization is also becoming more important in the construction industry. Rapid worldwide communication has resulted in construction projects being developed in dispersed locations far away from the actual construction site in a mixed project team. It is key to share data across multinational portfolios and gain data insights of global teams to stay ahead of the competitive global market. But misunderstandings and misinterpretation are common pitfalls due to cultural differences and geographically dispersed offices. This requires well-managed data sharing networks in multinational engineering companies in which everybody contributes. How these networks are shaped and what factors contribute to effective data sharing is further explored.

Q2 *What factors determine intra-organizational data sharing in multinational construction projects based on theory?*

Many different factors influence intra-organizational data sharing in multinational engineering companies. Consulting existing literature retrieved a set of factors that influences data sharing within the defined boundaries of this research. These factors are used to understand better the data sharing behavior of employees in their data-sharing networks. First, the factors are further placed in a grid alongside the axes ‘people-technology’ and ‘individual-collective’. It has been found that most data sharing factors were placed in the collective/people quadrant. This concludes that data sharing is mostly organizationally focused and entails cultural impact,

company-wide policies, and shared procedures. This emphasizes that data sharing takes place in social networks of people, which supports the choice to apply social network analysis to explore further data sharing in multinational engineering companies. The qualitative factor analysis also exposed what factors cluster together and can, therefore, be combined in a single factor. As a result of this qualitative factor analysis, a set of statements is formulated that cover all 20 data sharing factors. These are briefly presented below.

1 Accessibility **2** Incentives **3** Flexibility **4** Development **5** Trust **6** Impact **7** Interaction **8** Alignment **9** Expertise **10** Involvement

Q3 *What are the maps of intra-organizational data sharing networks in multinational construction projects in practice?*

The social network analysis visualized the data sharing networks of three brewery case projects and when combined in a multinational portfolio network. Their maps show who is connected to whom, provide insights about the number of connections of each team member, indicated who are the most connected individuals and revealed the overall density of data streams. All three case projects consist of very different network structures and patterns, but they have in common that in each network the project manager is one of the most connected nodes. Project A shows high density and decentralization. Project B shows high hierarchical centrality around the project manager. Project C shows multiple fragmented data sharing hubs and stronger cohesion within disciplines. The networks imply that there is not a uniform data sharing strategy but also does not show explicit data silos because all team members are connected through one network. However, weaker links are observed between geographically dispersed teams. In all three projects, the most used and preferred tool for data sharing is email, followed by face-to-face meetings. This means that special attention is needed to check whether all data is tracked and stored because conventional emailing is not the most transparent or traceable method to share data.

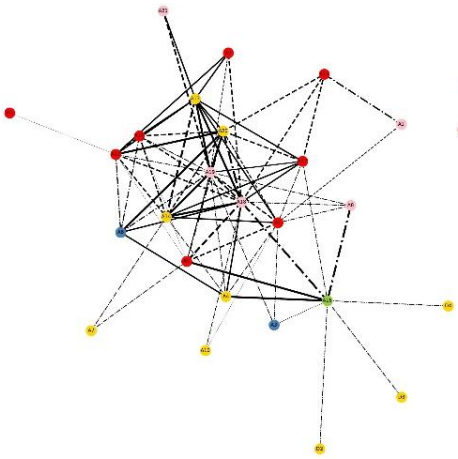


Figure 38: Project A Haiti brewery

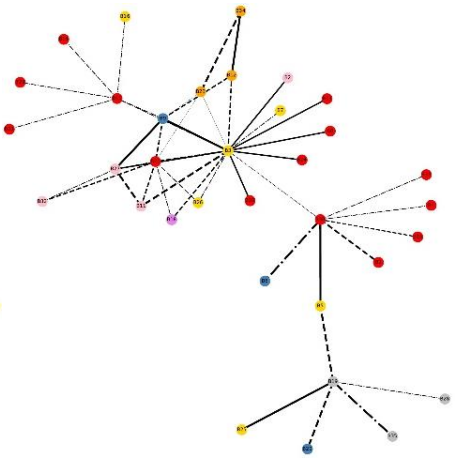


Figure 39: Project B Ethiopia brewery

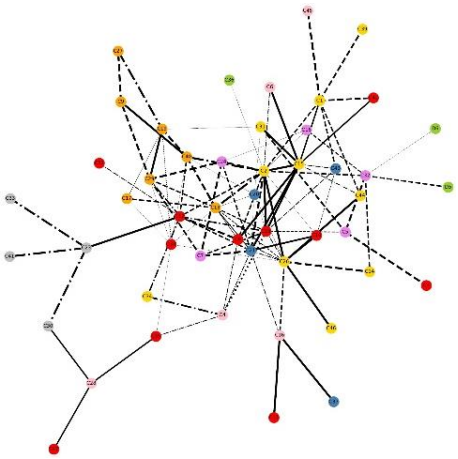


Figure 37: Project A Vietnam brewery

The portfolio network identifies which employees are the linking nodes between the project networks. These gatekeeping nodes have the potential to break through data silos in the portfolio and achieve multilayer learning. From the 224 data streams in the total portfolio network, 15,6% of them are data streams connecting the projects. The network (see chapter 5.5) shows a small group of project managers and engineering that connect the Dutch and

Vietnamese offices. The most external project connections made is six, which is not that high and implies that data silos exist in the portfolio. Employees within the same discipline but working on different projects and at geographically dispersed locations often show data silos in their networks. Many of the role-specific networks show fragmentation. If people of the same role are not sharing data and experiences with each other, organizational learning is limited. The social network analysis asks for additional qualitative research methods that explain the reasons why the patterns and structures of the networks are observed.

Q4 *What enables and limits intra-organizational data sharing in multinational construction projects in practice?*

With a qualitative root cause analysis was found what enabled and limited data sharing in practice. Ten employees with diverse positions in either their project network, portfolio network or role-specific network gave a broad perspective on the perception of effective data sharing in the projects and portfolio. It also emphasized the most determining root causes in enabling and limiting data sharing. The most addressed enabling root causes are practicing simplicity in communication and having a central point of contact for data sharing. Both of the root causes refer to the desire of employees to keep overview and stay in control of their data streams. Tools and environments should be made understandable and reduced to a limited number of optional systems and implementation should be done in manageable steps. The following enabling root causes relate to soft factors in data management. Being in the physical of colleagues, having the eagerness to learn new digital ways of working and feeling responsible for contributing to better data sharing is essential to employees in applying effective data sharing.

The most prominent limiting root cause is the missing drive to change. At the time that the case projects were in execution, the urge to adopt new digital ways of working was not high. It indicates that if people are not encouraged to change their ways of working, they stick to their conventional methods. The following main limiting root causes show overlapping themes. Information overload and lack of coordination conclude that employees need guidance and control. Pushing deadlines and changes happening too fast refers to the lack of time perceived to adopt data sharing. This does not create adaptive environments but instead results in redundancy. A striking conclusion is that factors in line with the multinational context of this research did not directly limit or enable data sharing in the case projects. This research finds that if the data sharing conditions such as tools and accessibility are available, the cultural differences do not have a significant impact on the effectiveness of data sharing.

Main root causes of enabling factors

- Simplicity in communication
- Central point of contact
- Eager to learn
- Feeling responsible
- Physical presence

Main root causes of limiting factors

- Missing drive to change
- Information overload
- Lack of coordination
- Pushing deadlines
- Too fast changes

The positions of the employees in the data sharing networks were also further analyzed using power/interest grids. This identified the division of central figures, visible figures, gatekeepers, and peripheral figures. It was found that all projects consisted of a high level of disconnected peripheral figures and a small number of central figures. In project A, a higher number of visible figures was observed. Conclusions are derived when considering the data sharing behavior and

the structures of the networks. The project manager has a strong influence on how the data-sharing network is shaped. No consistent data sharing framework was available in the project, so the efficiency of data sharing depended on the skills and willingness of the project manager. They are highly experienced and senior project managers who often experience skill gaps in data sharing. Because they already carry a lot of responsibility in managing the project, it is unrealistic also to make them fully responsible for incorporating new digital strategies and initiatives. Literature confirms that network structures can manage the balance between exploration and exploitation of novel ideas and solutions. Decentralized, composed of loosely coupled, isolated teams, enable feed-forward learning flows the most, and in order to achieve that, project leaders should facilitate linkages between individuals and teams to create balanced networks. Measures should be implemented that establish that and, in that way, improve data sharing at project, portfolio and organization level.

7.2.2 Main research question

By combining the conclusions of the sub-questions described above, the main research question can be answered, and the hypothesis of this research can be reviewed.

How can intra-organizational data sharing be enhanced in multinational engineering companies?

This research stated that more benefit is gained when an organization succeeds in establishing and sustaining an effective and efficient data sharing network. After analyzing the data sharing networks and data sharing behavior of employees, it can be concluded that network structures and certain data sharing factors determine the level data sharing. Well-balanced networks seem to and contribute to effective data sharing and open up to novel ideas to keep improving.

To realize well-balanced networks, multinational engineering companies must reshape the way they approach data sharing in their projects, portfolios, and in the total organization. Pressure in adopting new digital ways of working is often put on project managers while they already carry a lot of project responsibility. Measures should be taken to engage all employees in the layers of the organization. Root causes produce an effect; eliminating the cause will eliminate the effect. Factors influence the likelihood of, accelerate, or affect the consequences of an effect. Therefore, it is key for multinational engineering companies to recognize the root causes identified in this research and understand what associated factors have the highest impact on data sharing. This enables them to enhance data sharing by designing appropriate measures. The factors that have the highest impact on intra-organizational data sharing in multinational engineering companies, as stated by this research, are:

Factors with the highest impact on data sharing

- Perception of control and overview of data streams
- Use of change management and data governance
- Extrinsic motivation by external rewarding or incentives
- Operation ability of information infrastructure accessibility
- Intra-organizational relationships between employees

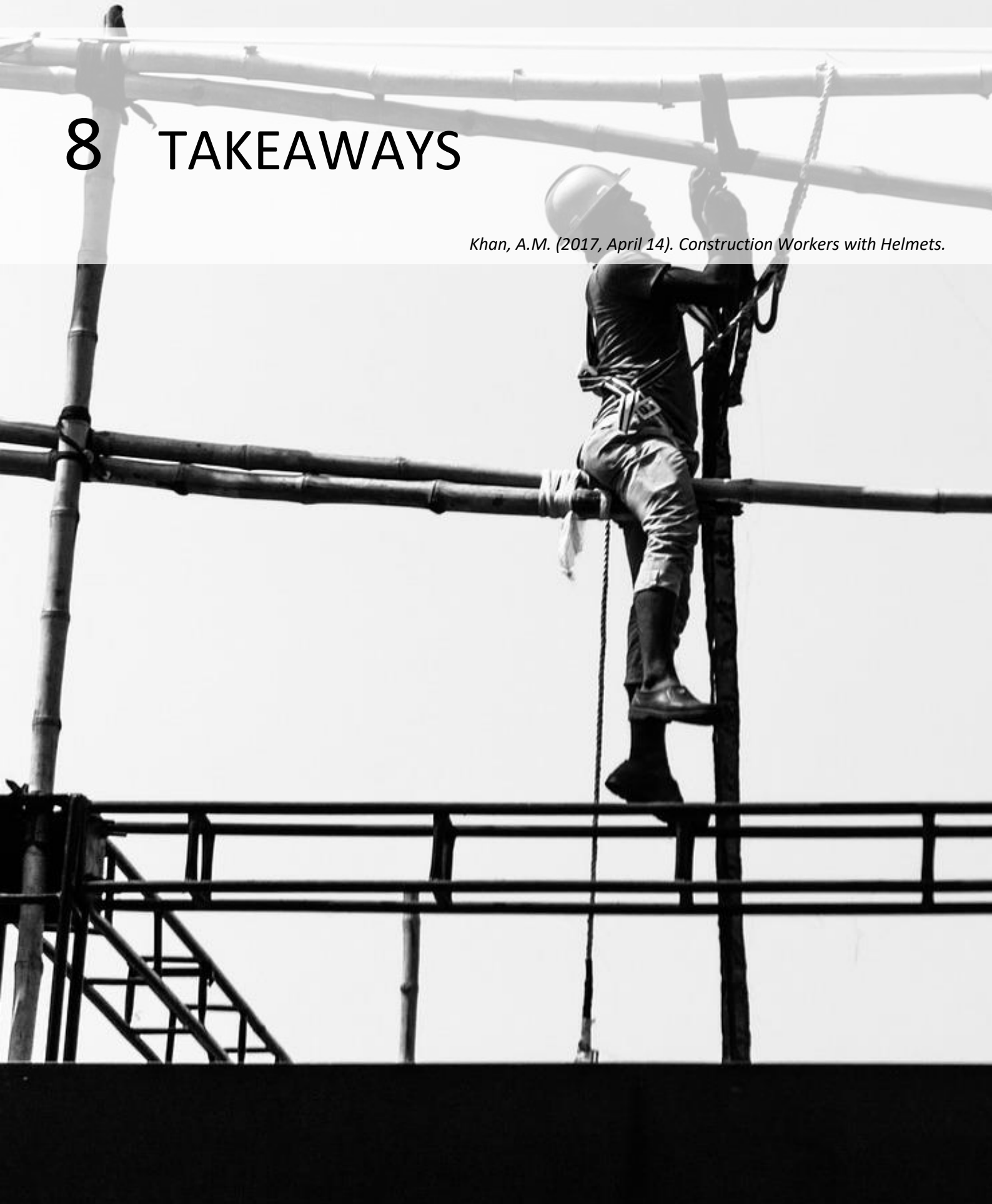
People often tend to spend more time on receiving/providing unrequested information that does not contain the needed answers, perceived as information overload. Being in control and having an overview of data streams by applying simple communication and having a central point of

contact is found to offer high benefits for effective data sharing. Applying change management and setting data governance is not presented compelling enough in current literature. This research found that many problems occur in this domain, and companies need to resolve the lack of coordination, the wrong timing of initiating change, and taking manageable steps. This requires defining the rules of data as an asset. Extrinsic motivation to adopt digital ways of working was often found missing. Research says that initiatives are better adopted using a bottom-up approach. But this research concludes that employees still need the encouragement of higher management to start bottom-up initiatives in data sharing. The accessibility of data and information systems enhances effective data sharing. Accessibility is mostly caused by the convenience level of procedures and work methods perceived by employees, which people incline to place before the quality of these procedures and work methods. This concludes that it is important to increase the convenient accessibility level of the systems that are most profitable. Lastly, the level of trust and relationship between employees turned out to be an effective factor to enhance data sharing, which often comes naturally within project-based organizations but can be further pursued by maintaining an open and transparent environment in which people spend more time in each other's physical presence.

The root causes and data sharing factors, as stated in this research, can be used to revise current data sharing strategies and design new data sharing strategies. Based on the results and findings of this research, it can be concluded that the implementation process should be as follows:

1. Assess the root causes and associated data sharing factors that require to be stimulated or resolved in current digital strategies or to develop new digital strategies.
2. Incorporate measures and actions that seem most feasible and decide whether they are most effective to implement on team, portfolio, or organization level.
3. Share the changes or new strategies with involved employees to engage everyone in the implementation process. Explain why the team/ portfolio/organization decides to put extra attention on certain factors and leave others out.
4. Appoint employees who are responsible for the implementation of these measures and actions and increase their visibility as the central points of contact in the specific domains.
5. Establish balanced decentralized networks that consist of loosely coupled groups. Let responsible employees connect so they can act as gatekeepers in the data sharing networks for controlled data exchange.
6. Monitor and evaluate the effectiveness of the measures to continuously improve the data sharing strategies and make necessary adjustments using an iterative process.
7. Address and discuss successes and problems regarding data sharing with employees and celebrate achievements.

8 TAKEAWAYS



Khan, A.M. (2017, April 14). Construction Workers with Helmets.

8 TAKEAWAYS

Arriving at the final chapter, one of the most connected things always to do is reflecting on the lessons learned. This chapter looks back on the findings of this research and first will dive into the practical and scientific recommendations (8.1). After that, this research closes off with a reflection on the product and the process of this research that resulted from the last eight months of work (8.3).

8.1 Recommendations

This section provides practical recommendations for multinational engineering companies to enhance data sharing (8.1.1). Based on the results and findings discussed in this research, a set of measures and actions are suggested. Secondly, scientific recommendations are provided in the form of further research suggestions (8.1.2). These can support future researchers and graduates that want to further contribute to the body of knowledge in the concerning scientific field.

8.1.1 Practical measures and actions

This section provides practical measures and actions in line with the identified root causes of enabling or limiting data sharing factors that have been obtained in this research (table 28). For root causes of enabling data sharing factors stimulating measures and actions are presented, and for root causes of limiting data sharing factors corrective measures and actions are presented. The company decides what measures have priority, are more feasible given the circumstances, and are more useful to specific people or teams by using the roadmap in figure 40.

Table 28: Practical measures and actions

Root causes	Enabling/limiting data sharing factors	En.%	Lim.%
+ Simplicity in communication + Central point of contact - Information overload	Perception of control and overview of data streams	22%	13%
Practical measures and actions • Agree at project kick-off how, when and with who to share and reuse data to prevent redundancy. • Appoint a document controller and ensure that in larger projects, this is a standalone job. • Limit the number of systems, tools, and processes. Rethink the current data procedures, eliminate unnecessary steps and bureaucratic hassle, and adopt automation where possible.			
+ Open and transparent + Physical presence	Intra-organizational relationships between employees	16%	-
Practical measures and actions • Organize moments of constructive feedback, and open dialogue to increase trust further and ensure that everyone has a voice and contributes. • Plan from where employees work and agree on gatherings. Stimulate the temporary exchange of colleagues within global teams.			
+ Conveniently accessible tools + Adjustable structure - Confusing tools	Operation ability of information infrastructure accessibility	14%	3%
Practical measures and actions • Improve the convenience of innovative information systems and tools with clear guidelines to increase application among all employees and lower the use of conventional tools. • Create global templates in information systems and tools that allow pre-defined adjustments. • Be clear who to contact for support when problems occur with information systems and tools.			

+ Eager to learn - Too much effort *Practical measures and actions* • Persuade employees by arousing an eager want to learn new digital ways of working. • Explain digital technology into terms of the other person's interests and use practical examples.	Intrinsic motivation by individuals own incentives	9%	3%
+ Feeling responsible *Practical measures and actions* • Distribute responsibility by appointing more employees to take responsibility for parts of the data sharing strategy within their discipline. • Track accountabilities and responsibilities to improve personal feedback and team performance.	Role specifications and role responsibilities	9%	-
+ Shared agreements *Practical measures and actions* • Implement more standards and monitor consistent use and compliance with global agreements. • Aim for global repeatability and transferability when developing new standards.	Organizational compatibility of systems and files	7%	-
+ Integration of work + Collective commitment + Shared goals - Lack of engagement *Practical measures and actions* • Engage the whole global team on setting short- and long-term targets of data sharing that enable the integration of work within the team/portfolio with a workshop at project kick-off. • Keep proactively communicating and monitoring the targets to create awareness. • Measure the impact of the achieved targets and reward success.	Global affiliation and integration of teams	6%	3%
+ Experienced personnel - Missing skills *Practical measures and actions* • Reserve time for experienced personnel to share expertise and explain it to others for awareness. • Organize routinely and mandatory training for employees varying between individual, team, and portfolio focused needs.	Operation ability by employees' skills and experience	6%	6%
+ Fast problem solving *Practical measures and actions* • Ensure that employees know where to find specific experts globally by creating exposure of their capabilities and work. • Promote internal units of expertise that enable quick exploitation of what has been done earlier.	Increasing detail and dynamic project complexity	4%	-
+ Competitive advantage - Missing work speed *Practical measures and actions* • Highlight that short-term investments lead to long-term benefits by making use of KPI's. • Keep staying ahead of competition and innovation by incremental and continuous improvements. • Involve the client in the digital development process for support and time during the project.	Competitive market causing faster project delivery	3%	6%
+ Available budget - Missing budget *Practical measures and actions* • Release budget for employees with data initiatives by having them pitch their ideas. • Communicate with employees how investments are spent to create awareness and appreciation. • Divide corporate investments so that the information accessibility is equal worldwide.	Economic costs and investments for coordination, training, and infrastructure	1%	6%
- Pushing deadlines *Practical measures and actions* • Reserve moments when everyone in the team spends the same amount of time on personal development to avoid being criticized for not spending time on the project. • Organize activities after work hours for bonding, learning, and sharing.	Perception of personal lack of time and work pressure	-	10%

- Missing drive to change *Practical measures and actions* • Cultivate a global and tangible vision and mission for digital transformation across the company. • Challenge all organizational layers and employees to contribute to the digital transformation. • Evoke bottom-up initiatives by top-down encouragement and recognition. • Introduce a rewarding system for employees who deliver successful data-driven performance.	Extrinsic motivation by external rewarding or incentives	-	23%
+ Available coordination + Taking small steps - Lack of coordination - Too fast changes - Wrong timing *Practical measures and actions* • Prepare ready to use and feasible data management plans activated at project initiation. • Make clear rules about data quality, security, metadata, accountability, roles, and procedures. • Appoint people to control the implementation process and pace of digital initiatives. • Define how to use data as an asset and what benefits it brings to the team/portfolio/organization.	Use of change management and data governance	3%	26%

8.1.2 Data sharing strategies

Selecting the rights and feasible measures highly depends on the organizational layer to which the data sharing strategy will apply. Based on the most occurring root causes of data sharing factors, this section provides brief data sharing strategy suggestions for RHDHV on project, portfolio, and organizational level. The explanations per level are further elaborated below.

8.1.2.1 Quick wins on project level

This section explains what quick wins can be achieved on project level, and from there can be further extended to portfolio level by involving more projects.

1. **Perception of control and overview of data streams**
   - Agree at project kick-off how, when, and who to share/reuse data to prevent redundancy.
   - Appoint a document controller and ensure that in larger projects, this is a standalone job.
2. **Competitive market causing faster project delivery**
   - Involve the client in the digital development process for support and time in the project
3. **Role specifications and role responsibilities**
   - Distribute responsibility by appointing more employees to take responsibility for parts of the data sharing strategy within their discipline.

First, introduce that for each project, the team sits together at project kick-off to discuss how, when, and with whom data will be shared. This is important to come to shared agreements and prevent unorganized data sharing that might result in information overload. Additionally, a document controller can be assigned who keeps the overview of files and documents and can serve as a central point of contact in case of ambiguity. This adds human supervision to the complexity of data sharing, which many employees appreciate. Beware of assigning employees who also have many other responsibilities, and in large projects, it is wise to have a document controller that is entirely focused on this task. Secondly, the client should be involved in digital innovation and pilots that take place. The client should support the extra effort made and additional risk taken due to learning by doing and trial and error. Lastly, digital responsibilities can be better distributed over the project team and traced for personal feedback and accountability. It is advised to include one digital manager and appoint one additional employee per discipline that supports. This group of people should collaborate and share progress made, especially in dispersed teams, shared responsibility can create integration.

8.1.2.2 Long term strategy on portfolio level

This section explains what long term strategy could be on portfolio level, and from there can be further extended to organizational level by involving more portfolios.

1. **Use of change management and data governance**
   - Prepare ready to use and feasible data management plans activated at project initiation.
   - Make rules about data quality, security, metadata, accountability, roles, and procedures.
   - Appoint people to control the implementation process and pace of digital initiatives.
2. **Operation ability of information infrastructure accessibility**
   - Create global templates in information systems/tools that allow pre-defined adjustments.
3. **Operation ability by employees' skills and experience**
   - Organize routinely and mandatory training for employees varying between individual, team, and portfolio focused needs.

At portfolio level more people are affected, and therefore a more thoughtful implementation of measures is required. Consider long term strategies to protect employees for frequent changing alterations. First, the portfolio management team should apply change management and data governance by preparing data management plans, including all appropriate data rules. Time is valuable in the early phases of a project, therefore ready-to-use data management plans should be available and also ensures consistency across the portfolio. People should be responsible for controlling the implementation process and monitor the performance. Secondly, to further increase standardization and alignment, global templates should be available in the information systems. Only small adjustments are made possible for flexibility, but preferably by pre-defined drag-and-drop or check systems. Lastly, increasing the expertise level equally and in control can be realized by introducing routinely and preferably mandatory training for employees. Training can be tuned to the expertise level of (groups) of individuals and focus on team or portfolio needs.

8.1.2.3 Data-driven mindset on an organizational level

This section explains what can change the mindset of all employees on an organizational level to become more data-driven.

1. **Extrinsic motivation by external rewarding or incentives**
   - Cultivate a global and tangible vision/mission for digital transformation in the company.
   - Evoke bottom-up initiatives by top-down encouragement and recognition.
2. **Intrinsic motivation by individuals own incentives**
   - Persuade employees by arousing an eager want to learn new digital ways of working.
   - Explain digital technology into terms of employees' interests and use practical examples.
3. **Perception of personal lack of time and work pressure**
   - Reserve for all employees the same amount of time for personal development and training to avoid being criticized when spending less time on the project.

Organizational strategies are hard to realize because they ask for a change in mindset for all employees. That demands a consistent and clear message but will generate the most significant impact on enhancing data sharing. As the latest RHDHV employee satisfaction survey addresses, clients still perceive silos in the organization and state that breaking these internal data silos will improve efficiency and builds better relationships with the clients. First, an organizational data-driven mindset can be further stimulated by cultivating a tangible vision and missions for digital transformation executed worldwide. This transition should be evoked top-down so that all layers of the organization feel the urge to commit and start bottom-up initiatives. A two-way effort is

needed. Secondly, this includes intrinsic motivation, which is hard to influence but can be reached by aiming to arouse an eager want by enthusiasts and conservatives. All employees should believe the benefits of data sharing and understand how their daily activities will profit from new measures. Therefore, explaining this in terms of employees' interests and providing practical examples is essential. Lastly, a rigorous but effective measure is to reserve the same amount of time for each employee to spend on self-development or training. For example, by agreeing that each employee should spend 10% of their working hours on training. This will increase the skill level of all employees, protects employees being criticized for using work hours off their project work, and enables monitoring the pace of organizational learning.

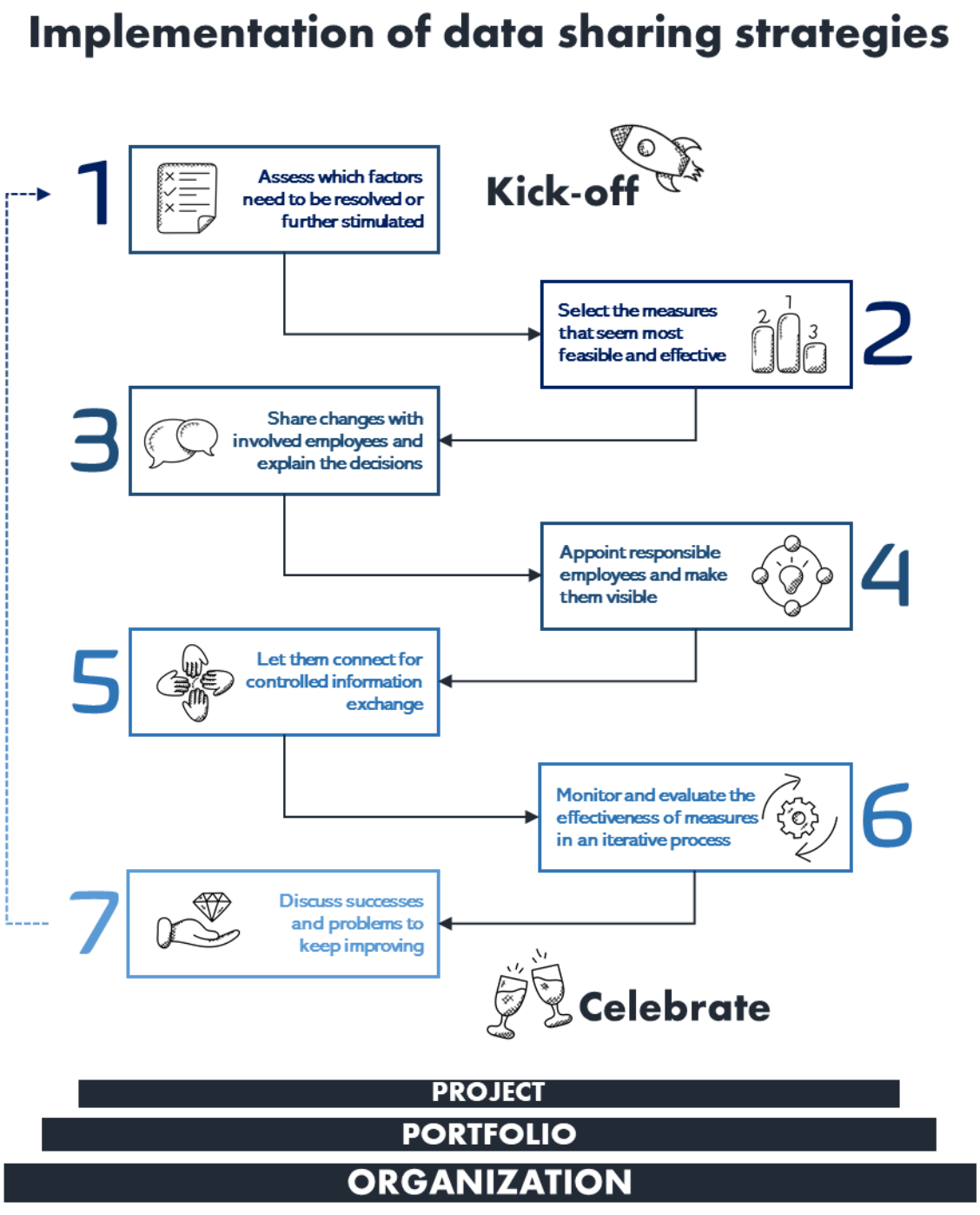


Figure 40: Roadmap for implementation of data sharing strategies

8.1.3 Further research

Because this research has a defined scope that sets specific boundaries of investigation, still more interesting elements are untouched, which can provide additional insights. Based on the work performed in this research more suggestions for further research have been determined. These can be used by researchers or graduate students that want to proceed a study in a similar domain.

- **Network specifications** – Decisions were made that included and excluded certain graph elements, visualization, and attributes. Due to the limited time, not all details have been incorporated that would have given a more accurate representation of reality. Future research could further investigate the effect of using directed graphs instead of undirected graphs, the frequency and value of individual data streams could be assessed further and the effect of applying different network layout types. If this is pursued, please note to collect a larger dataset than was retrieved in this study due to more precise specifications.
- **Longitudinal research design** – This research visualized the overall project and portfolio data sharing networks of the whole project lifecycle. However, future research could also expand the modeling scope by investigating network dynamics over time. Zheng et al. (2016, page 1222) suggest exploring the effect of 'establishment, evolution, maintenance, and even decay of internal stakeholder networks on the outcome-oriented values (e.g. functionality, quality and profitability) of projects' in a longitudinal study.
- **Real-time network tool** – The previous suggestion for further research can even be taken to a higher level. In companies, it would be of great value to develop a tool that visualizes real-time data streams between employees in their organization. Tracking data traffic between individuals teams, departments or business units will give insights on who is collaborating with whom to monitor the needs of additional support/training/motivation to contribute to the overall project success.
- **Project success** – This research made estimations about the success of data sharing based on perceptions of employees. However, further research can include actual project success by measuring project success criteria. Additional advice is not only focusing on the Iron Triangle but also assess other key success criteria identified by Atkinson (1999).
- **Correlation with collaboration** – this research mentioned the correlation between data sharing and collaboration. It would be interesting to explore further what the exact relationship is between these two elements and how do they influence each other.
- **Construction companies** – Besides the construction engineering companies there are many other parties involved in construction projects. Further research is needed to understand data sharing dynamics at the client/contractor/supplier/etc. This will expose the differences between their data sharing behavior and contributes to understanding collaboration issues.
- **Inter-organizational data sharing** – Respondents often mention the determining role of the client and other external parties in establishing good data sharing internally. Without support and defining data requirements from the client measures taken will be like trying to empty the ocean with a thimble. Further research should therefore also be further expanded to the inter-organizational level.
- **Multinational context** – This research analyses data sharing in a multinational context. However, future research could further explore the influence of cultural differences on data sharing. It was seen that the Vietnamese colleagues, in general, were more positive towards data sharing. The cultural dimensions of Hofstede (2011) can provide more explanations about cultural behavior and how that may affect their perception towards data sharing.

8.2 Reflection

This section elaborates on the delivered research and whether the performance of the researcher resulted in the desired outcome by recapping on the project objectives. First, the product-related reflection is discussed (8.3.1), and after that, the process related reflection is discussed (8.3.2.). This part is written in a first-person narrative to express the ideas and opinions of the researcher.

8.2.1 Product

Before kicking off my research, I set some goals for myself. My first goal was to gain knowledge about a topic that interests me. Over the years, I became more interested in the advantages of digitalization and how data-driven decision-making supports human efficiency. This research was perfectly in line with this interest, which increased my motivation. Also, the relevance of the topic was very noticeable when talking to people. Besides that, I truly believe that people are the core of a business and that diversity and collaboration grow impact. I am happy that my research was a good combination of technological and human aspects.

The second goal was to embrace challenges and learn new skills during my research. The application of Python to visualize the data sharing networks gave me much rewarding. Even though it was tough in the beginning, I managed to create the visualizations. I gained new skills in social network analysis using Python and now understand the principles of this programming language. That is something that really made me proud.

I am very pleased with my research deliverables and how they contribute to the scientific field and can be applied in practice. After my greenlight meeting, I felt there was still room for improvement, but now I am very satisfied with the result of this final report. Something that could have been better was the overall validation of the results. Unfortunately, the current corona crisis situation made it rather difficult to set up a final validation workshop.

8.2.2 Process

Regarding the master thesis process, I also set some goals. The first goal was to stay relax and positive during the whole research process. As mentioned in the preface, it even surprised me how much joy I experienced in conducting this research. I am a positive person by nature, but my encouraging committee definitely contributed to this goal. Of course, there were also some points of improvement. In my opinion, I could have balanced my time between individually working on my research and staying open for moments of discussing insights with professionals at Royal HaskoningDHV. Also, it sometimes frustrated me that I did not directly see the impact of hours of hard work and made me insecure whether I was delivering enough. For example, during the literature study, when many hours are spent on searching and reading articles but not much was actually put on paper. Eventually, when elements start to fall into place, that feeling of fulfillment is again reached.

Overall, I believe I can be proud of my results and this final piece of work that completes my master and student life in Delft. I am grateful for all those years of learning and excited about what the future brings. Thank you for reading my master thesis, and please contact me if you want to discuss the content of my research.

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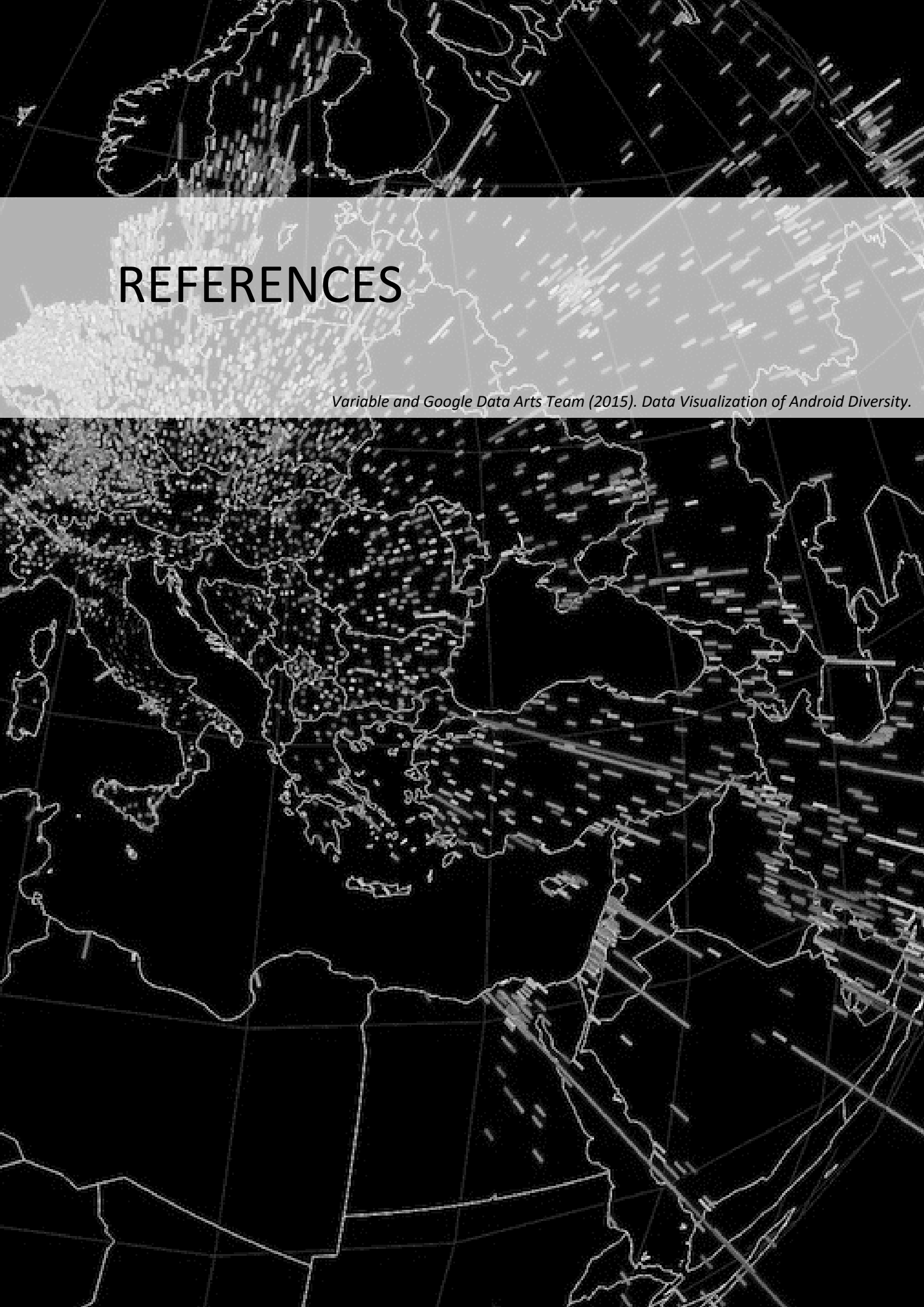

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APPENDICES

Sullivan, J. (Augustus, 2018). *Grey tower crane.*

APPENDICES

A. LITERATURE STUDY

To come to a smaller and more relevant selection of scientific papers, a search plan has been developed. A search plan is needed to ensure the quality, relevance and completeness of the resources used in this research. The process uses inclusion and exclusion selection criteria in each step to converge into a smaller number of relevant scientific papers. Eventually the outcome will be a selection of papers that contribute to the cause of this research and provide suitable information.

A1. Literature search plan

Step 1: Defining the research topic

For this research the following main research question and sub-questions are formulated:
How can intra-organizational data sharing be enhanced in multinational engineering companies?

1. *What does intra-organizational data sharing in the construction industry entail based on theory?*
2. *What factors determine intra-organizational data sharing in multinational construction projects based on theory?*
3. *What are the maps of intra-organizational data-sharing networks of multinational construction projects in practice?*
4. *What enables and limits intra-organizational data sharing in multinational construction projects in practice?*

Step 2: Creating a mind map

In order to get a complete overview of the concepts related to the research questions the technique of making a mind map is applied. This resulted in the overview presented below and supports the search plan process. These terms and concepts can be used to find relevant papers by entering them in scientific search engines.

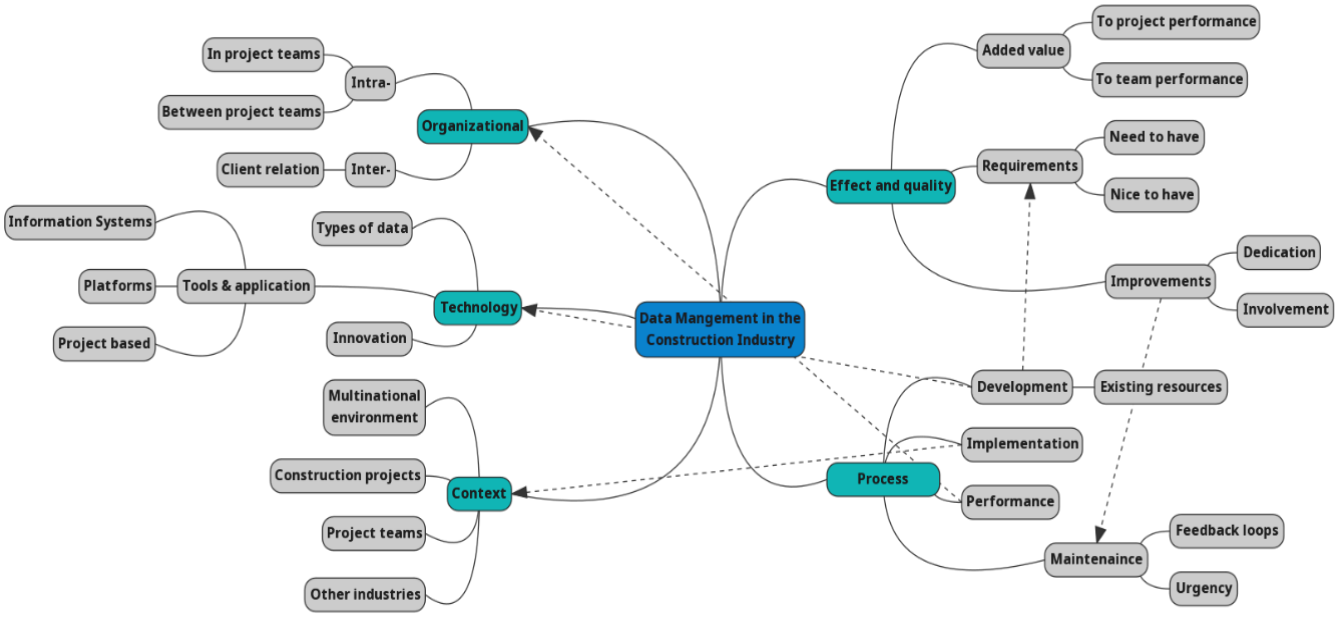


Figure 41: Mind map literature search plan (own illustration)

Step 3: Defining research topics and concepts

Related to the mind map presented in figure 41, the research questions are based on as set of topics and concepts. First the directly mentioned concepts are being listed and thereafter a selection of alternative terms and concepts is provided whom might be used by other authors for the same purpose. All these terms will be applied in relevant search engines or relevant journal archives. This strategy prevents missing important articles that relate to the research topic.

Table 29: Research topics and concepts

Research questions	Research concepts
1. *What does intra-organizational data sharing in the construction industry entail based on theory?*	Data sharing; construction; intra-organizational
2. *What factors determine intra-organizational data sharing in multinational construction projects based on theory?*	Factors; data sharing; intra-organizational; multinational; construction projects
3. *What is the map of intra-organizational data-sharing networks of multinational construction projects in practice?*	Intra-organizational; data sharing; network; practice
4. *What are the maps of intra-organizational data-sharing networks of multinational construction projects in practice?*	Data-sharing; success; failure; factors; intra-organizational; multinational; construction; practice
5. *How can intra-organizational data sharing be enhanced in multinational engineering companies?*	Data sharing

Table 30: Alternative search concepts 1

	Combine the concepts with AND		
Combine the search terms with OR	*Data-sharing*	*Construction*	*Factors*
	Data exchange	(Civil) Engineering	Success
	Information management	Project management	Failure
	Data management	BIM	Determinants
	Information Systems	Building sector	Barriers
	Data application	AEC	Drivers
	Business Intelligence		
	Knowledge management		
	Data innovation		

Table 31: Alternative search concepts 2

	Combine the concepts with AND		
Combine the search terms with OR	*Multinational*	*Intra-organizational*	*Network*
	International	Internal	Dynamics
	Multicultural	Governance	Social network analysis
	Global	Organizational	Structure
	Geographical	Inter-organizational	Connections
	Cross-cultural		Streams

Step 4: Formulating search queries

In this step search queries are formulated combining concepts with “OR” and “AND” commands to specify the search results. This technique will lead to a complete and relevant coverage of the scientific resources available.

Table 32: Search queries

#	Search concepts
search query 1	"data sharing" OR "data exchange" OR "data management" OR "Information management" OR "Information Systems" OR "Data application" OR "Business Intelligence" OR "Data innovation"
search query 2	"Construction" OR "Civil" OR "Engineering" OR "Project management" OR "BIM" OR "Building sector" OR "AEC"
search query 3	"Factors" OR "Barriers" OR "Drivers" OR "Limiting" OR "Enabling"
search query 4	Multinational OR "International" OR "Multicultural" OR "Global" OR "Geographical" OR "Cross-cultural"
search query 5	"Intra-organizational" OR "Internal" OR "Governance" OR "Organizational" OR "Inter-organizational"
search query 6	"Networks" OR "Dynamics" OR "Social network analysis" OR "Structure" OR "Connections" OR "Streams"
search query 9	[search query 1] AND [search query 2]
search query 11	[search query 1] AND [search query 2] AND [search query 3]
search query 12	[search query 1] AND [search query 2] AND [search query 4]
search query 13	[search query 1] AND [search query 2] AND [search query 6]
search query 14	[search query 1] AND [search query 2] AND [search query 4] AND [search query 6]
search query 15	[search query 1] AND [search query 2] AND [search query 5]
search query 16	[search query 1] AND [search query 3] AND [search query 6]
search query 17	[search query 2] AND [search query 4] AND [search query 5]
search query 18	[search query 2] AND [search query 4]
search query 19	[search query 2] AND [search query 5]
Search query 20	[search query 1] AND [search query 2] AND [search query 3] AND [search query 4] AND [search query 5] AND [search query 6] AND [search query 8]

Step 5: Defining relevant scientific journals

Different scientific research engines exist that contain research articles from a wide variety of scientific journals. The most acknowledged Construction Management journals and their impact factor Scientific Journal Ranking (SJR) are:

- International Journal of Project Management (2.2)
- Journal of Management in Engineering–ASCE (1.3)
- Project Management Journal (1.3)
- Building Research and Information (1.3)
- Journal of Construction Engineering and Management–ASCE (1.0)
- Construction Management and Economics (0.8)
- Engineering, Construction and Architectural Management (0.6)

Besides these construction journals also data management (in construction) journals could consist interesting articles. The most relevant journal in data management are:

- International Journal of Computer Vision (3.6)
- Journal for Computing in Civil Engineering – ASCE (1.8)
- International Journal of Information Management (1.7)
- Automation in Construction (1.4)
- Engineering with Computers (0.7)
- Knowledge and Information Systems (0.7)
- Construction Innovation
- Social Network Analysis and Mining (0.3)

Step 6: Trend analysis

Before starting the literature review a trend analysis is performed to visualize the interest in the research topic in existing scientific articles. Below in table 33 and chart 19 is shown how many papers per year have been published with a specific set of keywords in the scientific engine ScienceDirect of Elsevier. When specifying into more keywords, the number of results decreases but the same growing trend of interest over the years is applicable. For each combination of keywords, the trend is likely to continue in the highest number of articles published in 2019. This indicates the growing urge in the scientific and business world to understand more about the power of data in the construction industry and its contribution to collaboration. Now the first step in the literature review will be performed.

Table 33: Literature trend analysis

Trends in scientific research	2015	2016	2017	2018	2019
"data sharing"	1412	1643	1908	2511	3738
"data sharing" & "construction"	295	337	397	553	741
"data sharing" & "construction" & "networks"	212	235	277	430	559
"data sharing" & "construction" & "networks" & "multinational"	10	12	15	21	25
Total	**1929**	**2227**	**2597**	**3515**	**5063**

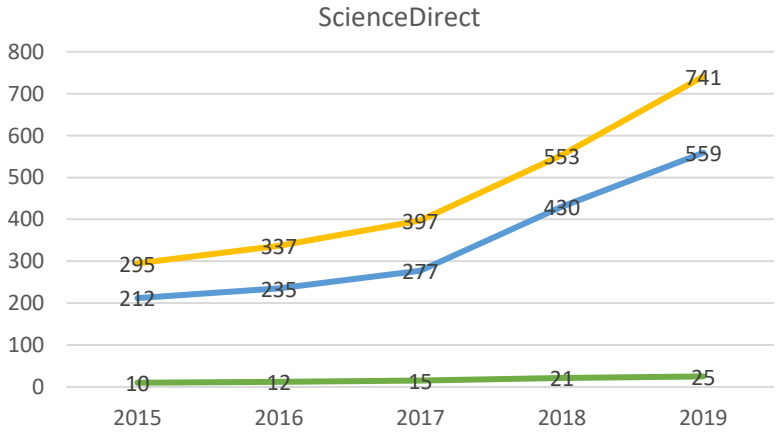


Chart 19: Literature trend analysis (own illustration)

A2. Literature review

The previous steps are all preparations for the actual literature search. The next steps describe the literature search itself and what to consider when potentially relevant literature is found. In table 34 is listed what specific selection criteria are important per step and in what sequence.

First the search queries will be entered in different search engines for scientific journals and scientific journal archives. The most prominent search engines are Science Direct, Scopus and Google Scholar. The second step is to do a quick scan of the filtered articles by selecting on article name, geographical location and number of references. The quick scan is useful to gain more information about the article and to prevent spending too much time on irrelevant articles. The detail scan focusses on the abstract, headers, scope, methodology and the conclusion. This detail scan will determine whether the article was selected rightly in the quick scan. It will decide if the article could contribute to the cause of the research. But still the in-depth review is needed to determine the specific article content that has impact on answering the research questions. In this step cross relationships between selected papers are indicated.

During the whole literature review process, tagging will be applied to all papers to categorize them later easily. From the second step onwards, it is important to keep track of applicable statements and results mentioned in the papers. When applying a systematic approach of collecting relevant information from the articles this information can easily be assigned to the applicable paragraphs.

Table 34: Literature review steps

Step 1: First filter →	Step 2: Quick scan →	Step 3: Detail scan →	Step 4: In-depth review
- Search queries - Published in the last 5 years - Leading scientific journal	- Relevant article name - Relevant geographical location - Number of references	- Relevant abstract - Relevant headers - Applicable scope and methodology - Applicable conclusion	- Contradicting/ supporting arguments - Relevant statements and results - Relevant references - Contribution to research questions

Step 1: First filter

In applying the first literature review step it was found out that all search engines did not allow more than a specific number of characters in the search box and a specific number of Boolean operators. Because of this limitation it was not possible to use the defined search queries as they exceed the limits. Nevertheless, the search queries have been used in separate parts to search for relevant literature.

Entering the created search queries exposes a large selection of potentially relevant articles. It is not possible to read all found articles and would also not be efficient as many revealed articles would not fit in this research topic. Therefore, it is necessary to narrow down the number of articles and make it feasible to start reading. The quick scan will immediately be performed on these generated lists of articles to determine which will be saved in the refence manager Mendeley. After entering a search query, the quick scan immediately takes place before entering a new search query.

Step 2: Quick scan

In the exposed lists of articles shown in the search engines and journal archives a selection of the articles takes place based on indicators. Some indicators are more decisive than others. When based on these indicators the article seems suitable for further examination, the article will be archived in the reference management Mendeley. In Mendeley a few filtering and archiving techniques are applied:

- **Complete information:** all information necessary belonging to the article will be gathered. This includes author(s), journal name, year of publication, volume and issue number, pages, abstract when available, document type and tags.
- **Tagging:** tags as explained above will be added to the article based on the article name and when necessary the abstract of the article. This technique makes it manageable to find certain articles back in the archive.

The determination of relevant articles ensues from the indicators:

- **Relevant name:** the first most important indicator is the name of the article. This is the first element to be checked in the overview and provides a good base to determine whether this is a suitable article to collect. When de name clearly indicates an off-scope topic, the article will not be selected. When the article clearly relates to this research it will be archived in Mendeley applying the techniques described above.

- **Relevant geographical location:** Secondly it happens that the geographical location is mentioned in the name of the article. If this is the case it often emphasizes on the importance of the geographical location in the performed research. When the geographical location refers to a clear off-scope location the article will not be selected. When the name does not share any geographical location and the name of the article relates to the research the article is selected. When the geographical location is in scope and the name of the article is relevant the article is also selected.
- **Number of references:** The last indicator to determine whether the article should be archived is the number of references. When the article name and location are both not highly convincing, but the number of references is high the article will be selected. When in that case the number of references is also low, the articles will not be selected.

After applying the above-mentioned steps, a selection of 100 articles ensued. These articles are aggregated in a Mendeley folder called "Quick scan" including all relevant information such as year of publication, title, author(s), volume, issue, and the source location. The detail scan will be performed in Mendeley and checks if the selected articles are fit-for-purpose.

Step 3: Detail scan

In the detail scan the distinction is made between not relevant articles, semi-relevant articles and highly relevant articles. This distinction is made based on the content present in the abstract, headings, applied methodology and conclusion of the retrieved articles. The determinants of the detail scan are further explained below:

- **Relevant headers:** The heading of the article should indicate a relevant direction of the research. If there are any concepts mentioned that are not in line with the research, the article is deleted.
- **Applicable scope and methodology:** By scanning the abstract it is possible to identify the applied scope and methodology of the article. If the article focusses on irrelevant scope/methodology, the article is deleted from the selection.
- **Applicable conclusion:** By scanning the conclusion it can eb determined if the results from the article can contribute to the research. Articles that seem highly valuable are identified with a 'star'. No articles will be deleted based on their conclusion because articles that might seem less relevant earlier in the research can turn out to more relevant in later phases.

When an article is identified as highly relevant it is transferred to a second folder, called the Detail Scan folder. These articles will be collected for the next step in the literature review, the in-depth review. Also, all articles have been categorized with tags that fit their content so when writing the literature study, articles can easily be recalled. The following list of tags was created:

- Behavior
- BIM
- Blockchain
- Business intelligence
- Collaboration
- Complexity
- Construction
- Data
- Data application
- Data sharing
- Data quality
- Factors
- Governance
- Industry 4.0
- Information management
- Innovation
- Intra-organizational
- Knowledge management
- Multinational
- Ontology framework
- Portfolio management
- Project performance

Step 4: In-depth review

The last step in the literature review consists of an in-depth review of the content of the articles and retrieving relevant information from them that potentially will contribute to the cause of this research. Below first the determinants are explained and thereafter a list is presented of the most valuable articles in the literature study.

The determinant for the in-depth review are:

- **Contradicting/ supporting arguments:** conclusions and arguments that are in line or shows different perspectives in comparison with other articles to gain a broad viewpoint.
- **Relevant statements and results:** unique and specific explanations for certain phenomena in line with the research topic that can serve as guiding arguments.
- **Relevant references:** references to other relevant scientists that are part of the group of researchers that is dedicated to the research topic.
- **Contribution to research questions:** articles that discuss specific elements present in this research and therefore provide valuable insights.

After applying the above criteria, a list of 16 articles was retrieved. These articles where carefully studied and used in the literature study. An addition of more than 100 articles were used that contained sections with relevant arguments and sections.

#	Year	Author(s) and title
1	2019	Zhijia You, Chen Wu - *A framework for data-driven informatization of the construction company*
2	2018	Abiodun Akinyemi, Ming Sun, Alasdair J. G. Gray - *An ontology-based data integration framework for construction information management*
3	2018	Eissa Alreshidi, Monjur Mourshed, Yacine Rezgui - *Requirements for cloud-based BIM governance solutions to facilitate team collaboration in construction projects*
4	2018	André Coners, Benjamin Matthies - *Perspectives on reusing codified project knowledge: A structured literature review*
5	2016	Chuanshen Qin, Bo Fan - *Factors that influence information sharing, collaboration, and coordination across administrative agencies at a Chinese university*
6	2016	Maria Martínez-Rojas, Nicolás Marin, M. Amparo Vila - *The Role of Information Technologies to Address Data Handling in Construction Project Management*
7	2015	Kalle Kähkönen, Jukka Rannisto - *Understanding fundamental and practical ingredients of construction project data management*
8	2015	Rui Wang, Denghua Zhong, Yuankun Zhang, Jia Yu, Mingchao Li - *A multidimensional information model for managing construction information*
9	2014	Soffi Westin, Maung K. Sein - *Improving data quality in construction engineering projects*
10	2013	Mohammed Al Qady, Amr Kandil - *Document management in construction: Practices and opinions*
11	2012	Marjolein C.J.Caniëls, Ralph J.J.M. Bakens - *The effects of Project Management Information Systems on decision making in a multi project environment*
12	2011	Javernick-Will, Amy - *Knowledge-sharing connections across geographical boundaries in global intra-firm networks*
13	2010	Ochieng, E. G., Price, A. D.F. - *Managing cross-cultural communication in multicultural construction project teams: The case of Kenya and UK*
14	2010	Weiming Shen, Qi Hao, Helium Mak, Joseph Neelamkavil, Helen Xie, John Dickinson, Russ Thomas, Ajit Pardasani, Henry Xue - *Systems integration and collaboration in architecture, engineering, construction, and facilities management: A review*
15	2008	Lucio Soibelman, Jianfeng Wu, Carlos Caldas, Ioannis Brilakis, Ken Yu Lin - *Management and analysis of unstructured construction data types*

B. FACTOR IDENTIFICATION

B1. Data sharing factors descriptions

From the literature review an overview of 20 summarizing data sharing factors has been retrieved. Below all factors are explained in more detail consisting of the specific referenced statements from the scientific articles informed.

1. **Institution authority by developing information sharing infrastructure** includes the responsibility of the organization's executives to allow development of information management infrastructure (Qin & Fan, 2016). This could vary from heavy integrated systems realized with large investments (Martínez-Rojas et al., 2016), open source systems for smaller construction companies (Akinyemi et al., 2018), or incorporating all types of projects (Bilal et al., 2019) or all project tasks (Wang et al., 2015) in one server. Without the reliability on institution authority to develop these infrastructures, no DSN can be established.

2. **Operation ability by information infrastructure accessibility** relates to how accessible the information systems are. Accessibility of information systems is needed to share easily, search, store and classify data to increase data re-use (Al Qady & Kandil, 2013) and ensure data quality (Westin & Sein, 2014). Often many different tools and platforms operate in one organization (You & Wu, 2019), and even more when different parties work together (Zhu & Augenbroe, 2006). If people cannot work from a unified platform they will be discouraged to participate (Qin & Fan, 2016). Installation software should be easy and explained in available handbooks. This will reduce the effort people have to make, to start sharing their data and make it more convenient for them.

3. **Organizational compatibility of systems and files** is a very important issue that many studies point out to be a challenge due to the unstructured nature of data formats in construction projects (Coners & Matthies, 2018; Martínez-Rojas et al., 2016; Qin & Fan, 2016; Soibelman et al., 2008; Westin & Sein, 2014; You & Wu, 2019). With the technique of standardization, it will become easier to integrate systems and files and benefit from data sharing which will increase participation.

4. **Economic costs** are always a barrier for implementation of new technologies. Also, to effectively accommodate data sharing costs should be made for employee training, coordination of the system, continuous optimizing developments and initial software and hardware purchase (Alreshidi et al., 2018; Qin & Fan, 2016).

5. **Increasing detail and dynamic complexity** (Hertogh & Westerveld, 2010; Jalali Sohi, 2018) in construction projects can on one hand raise effective data sharing as project managers feel more supported when utilizing available information systems to share data more extensively (Caniëls & Bakens, 2012). But on the other hand, often teams lose control and overview when complexity increases, which leads to uncontrolled ineffective data sharing.

6. **Institution authority by establishing legal frameworks and formal policy** that are set standards throughout the whole organization and are continuously being controlled. There

should be rules about liability of information input and clear regulations about how to handle data carefully (Alreshidi et al., 2018). Business and project management processes should be combined in one framework by institution authority (You & Wu, 2019) including legislation, economic, information and institutional procedures supported by executives (Qin & Fan, 2016).

7. **Operation ability by employees' skills and experience** determine the quality of data sharing operations by the employees. Without proper education of skills on how to operate information systems, employees in the organization will not feel confident applying efficient data sharing activity (Qin & Fan, 2016). Without building digital skills and spreading that across the company, they cannot build experience to improve themselves further. Also the availability of trainings and workshops worldwide will equalize the skill gap between geographically dispersed teams (Javernick-Will, 2011).

8. **Intra-organizational relationships between employees** has a great influence on the willingness of people to share their data with other. Specially to encourage data sharing between teams that do not interact with each other on a regular basis, should be assisted with increasing mutual trust (Qin & Fan, 2016). This can increase acceptance of other people's work and adopting single work procedures (Alreshidi et al., 2018). Engaging people in the transition of becoming data-driven is key in letting them participate in the development of procedures (Gerbert et al., 2016). This makes them feel equally treated and understood (Killingsworth et al., 2016).

9. **Perception of information security** is an important factor that can enable data sharing activity. Employee want to feel that sensitive information is secured and that there are regulations for authorized access (Westin & Sein, 2014)W. Protection of information and data prevents that the content is used against people's will and even beyond their knowledge. When the perception of information security is low, employees will limit data sharing to minimize their risks (Qin & Fan, 2016).

10. **Control and overview of data and information streams** can become hard for employees. A common pitfall is experiencing an overloads with the amount of data and information that is available for processing or the amount of tools and software that can be used to process (Almeida & Soares, 2014). Unorganized and ad how information exchange causes information overload (Dave & Koskela, 2009) that prevents employees to perform their tasks efficiently and calls for structured coordination (Matthies, 2015). Being in control and having overview provides clarity and prevents unmanageable situations.

11. **Global affiliation and integration of teams** is the feeling of social connection and impacts attitude within a group. This factor is assumed as determining in the level of data sharing within an organization (Alreshidi et al., 2018). When getting more busy it is easier to let the people down that are very remote as they are more easy to ignore (Javernick-Will, 2011). However, research also found no significant relation between affiliation and knowledge sharing, probably because global teams have different perspectives on what affiliation means to them (Killingsworth et al., 2016).

12. **Global awareness of remote activity and communication** can positively contribute to stronger data connections between remote teams. Knowing about each other's work contribute to more frequent data sharing of experiences, successes and failures (Javernick-Will, 2011). Geographically dispersed team members should feel and experience that there is equal and consistent communication regardless of the location of work (Ochieng & Price, 2010). Otherwise communication, and therefore data silos will arise. Time zones and less interactions create even bigger distance perceptions for people.

13. **Competitive market causing faster project delivery** takes place due to the pressure of globalization which requires project teams to proceed with partial information (Westin & Sein, 2014). The limited time available is often not spend on data sharing. Due to time constraints, data sharing attempts only take place when there are problem- or project-based issues and not on a regularly basis which could improve overall performance (Javernick-Will, 2011). Companies should adjust their collaborative view to increase global connections to coop with shorter project delivery by utilizing the advantages of data sharing (Shen et al., 2010).

14. **Misunderstanding due to cultural differences** happens in many different forms and has a big influence on the level and quality of data sharing (Javernick-Will, 2011)ja. In multicultural teams' differences exist between perceptions, problem solving, work methods, and insights (Ochieng & Price, 2010). People react differently to opportunities and threats and this can cause misunderstanding which reduces data sharing among team members in different time zones (Killingsworth et al., 2016).

15. **Distinct cultural perceptions of capabilities and mentality** results in team members having different perceptions of their work attitude and what they can establish (Kähkönen & Rannisto, 2015). Team members could feel that their contribution is not worth sharing as they assume that other remote teams know better. Thereby, work consequences and performance implication are not equal in different parts of the world (Ochieng & Price, 2010).

16. **Intrinsic motivation by individuals own perception** should be positive and towards data sharing to increase the level of their participation. A difference exist in collectivists and individualists on their attitude towards data sharing (Killingsworth et al., 2016). Some will find inner enjoyment helping others, some will be reluctant to change (Razmerita et al., 2016). Also subjective assessment on the quality of data varies between people (Pipino et al., 2002).

17. **Extrinsic motivation by external rewarding or incentives** refers to people tend to prefer working on tasks that are recognized by higher management instead of engaging in activities that are not and only take valuable time without any reward (Wiewiora et al., 2010). Providing obliged training and encourage project managers to be role models in data sharing will increase participation in all organizational units (You & Wu, 2019). Reciprocity is a positive incentive to encourage data sharing between team members (Killingsworth et al., 2016). Pro-active tools can also trigger people to incorporate certain data sharing tasks in their work routines (Westin & Sein, 2014).

18. **Personal perception of lack of time and work pressure** is a common phenomenon in current project teams. People feel always busy and captivated with their work and pushing deadlines. This perception of lack of time and pressure results in decreasing data sharing and collective commitment (Razmerita et al., 2016). Since data integration is not yet well established, searching for available data can also be time consuming for employees and therefore not encouraging to participate (Westin, 2014).

19. **Role specifications and responsibilities** have influence on the way employees feel they are responsible for data sharing and how it fits in their everyday tasks (Caniëls & Bakens, 2012). Undefined roles and responsibilities towards data sharing decrease the level of data sharing (Alreshidi et al., 2018), and are different for various organizational units (Martínez-Rojas et al., 2016). Heterogeneity makes it difficult to compare similar projects that are executed by different professionals (You & Wu, 2019). And roles should be better adopted to stimulate data exchange environments (Liu et al., 2017).

20. **Personal demographic details** is the last variable that is assumed to influence the data sharing behavior of employees in an organization (Razmerita et al., 2016). Taken into consideration are age, gender and years of experience. Differences between male and female seem not to influence data sharing (Killingsworth et al., 2016)but generational gaps in digital skills do affect the overall data sharing intensity (Alreshidi et al., 2018).

B2. Qualitative factor analysis

From the 20 data sharing factor a set of eight categorized factors is retrieved by performing a qualitative factor analysis. From the social network analysis two additional data sharing factors are retrieved. Below these ten factors are explained in more detail.

1. **Access to workable data infrastructure** focusses on the accessibility and up to date data sharing infrastructure. Authority of the organizational should constantly invest in improving the systems and keep operations going. Thereby it is important to include a compatibility strategy that works smoothly alongside this infrastructure.

2. **Support and triggers from higher management** are needed for several success components of data sharing. These include approval for investments and organizing frameworks and policy that includes an incentive system to push employees in implementing data sharing. Lacking top-down drive, especially in large and global organizations, the feasibility of integral data sharing is limited.

3. **Reliable and flexible data sharing environment** is required in fast moving and dynamic times. On one hand the data sharing environment should be reliable and serve as a solid backbone for employees when complexity increases, but on the other hand should have the possibility to insert flexible adaptation to coop with project specific variations.

4. **Room for personal development and training in data sharing** is key in developing an organization transcending level of expertise in data sharing. Training should be obliged and elective and personalized on role specifications and personal background. The demographic details factor has been incorporated even though it was not clustered accordingly but was in place with the other factors' targets.

5. **Trust in people and the data sharing environment** should be reinforced and become natural. Creating a trustworthy work ambience can be achieved by organizing encouraging activities and events to let employees feel confident in applying data sharing across the entire organization. Being open and transparent as an organization supports this goal.

6. **Clear and powerful data sharing environment** is an important aspect in times when people feel stressed and experience work pressure. The systems and procedures in data sharing should be understandable for everyone and should provide powerful output that adds value to daily work tasks. Ultimately, the data sharing environment creates a state of being in total control and having total overview.

7. **Facilities for continuous global integration and interaction** should be available and compulsory to stay aware of the developments and related work activities in remote offices or projects. This should prevent that employees keep reinventing the wheel and do not learn from other people's mistakes. This should be established on team, project and organizational level.

8. **Global standardization and alignment in data sharing** creates a global point of reference which is needed to make equal comparisons and create a benchmark that can be incorporated

in all parts of the world. This reduces misunderstanding and it provides measurable guidance for lagging offices to live up to the global standards.

Additional data sharing factor based on observations made in the social network analysis. These are also validated during the interviews.

9. **Level of digital expertise** - In the social networks of the case projects and combined in the portfolio, it becomes clear that team members who seem to have more affinity with digital technologies are more connected in the data sharing networks. They seem to dedicate a significant amount of time being information controllers. Having a certain type of team real might increase the intrinsic motivation of that person to become more experienced in data sharing.

10. **Level of project involvement** – In the data sharing networks was observed that team member with more hierarchical power often are one of the highest connected nodes. It is assumed that their leadership role, responsibilities and affection with the team increases their connectivity as they are driven information users within their projects.

C. EXPLORATORY INTERVIEWS

C1. Exploratory interview protocol

Goal

- Goal: Gathering first experts' viewpoints on data sharing and the existing organizational structure of the data-sharing network at the portfolio.
- Aimed outcome: Selecting the network boundaries for this research, identifying current agreed principles in data management at RHDHV, addressing data management principles.
- Deadline: end of August

Intro

This research is about how data sharing can enhance intra-organizational collaboration in multinational construction projects. The aim is to understand the current state of the data-sharing network at RHDHV and more specific within the client portfolio. In this exploratory interview the goal is to determine what combination of brewery projects to select for this research and their structure. The projects will be mapped in a model by identifying key players, data streams, types of data, intensity and frequency of data.

Questions

Main question interview a: Which running/past brewery projects provide a good representation of the current way of data sharing within the client portfolio and are therefore suitable as case projects for this research?

Main question interview b: How does a typical brewery project life cycle look like and what is the role of data sharing during a brewery project?

Main question interview c: What current practices are being developed or applied regarding data and information sharing within the portfolio and RHDHV?

Part 1: Introduction

1. How many years of experience do you have in the construction industry?
2. When did you start working at RHDHV?
3. Can you explain your role and main responsibility at RHDHV?
4. On what project(s) are you currently working?

Part 2a: Orientation of the organizational structure in the client portfolio at RHDHV.

5. What are the main RHDHV hubs worldwide within the [redacted] portfolio?
6. What specific expertise belongs to these hubs?
7. What set of [redacted] projects is suitable for investigating the current data-sharing network?
8. What project phases can be distinguished in these [redacted] projects?
9. How have organizational structures been determined in these projects?
10. Which people within these projects should be included in the research

Part 2b: Orientation of project phases in portfolio projects at RHDHV.

5. What project phases can be distinguished in a typical [redacted] project?
6. What activities take place in those project phases?
7. How does the timeline of these project phases look?
8. What important milestones take place and when in this time line?

9. Which departments of RHDHV are main responsible in the project phases?
10. What are the main challenges during the project life cycle of a [redacted] project?

Part 2c: Orientation of current practices in data/information management at RHDHV.

5. What is the current strategy regarding data/information at RHDHV?
6. What activities take place regarding data/information management?
7. What procedures are being developed/applied?
8. How are employees aware of the rules and application?
9. Who is responsible for ensuring the quality of data/information management?
10. What is the vision of RHDHV regarding data/information management?

Part 3: Data management in [redacted] projects?

11. How would you explain the concept of data management and data sharing?
    Data in this research is taken as a set of retrieved values, facts or statistics that can be translated into a form that is efficient for movement, processing and analysis.
12. What do you see as the benefit of data management in projects?
13. What is offered towards [redacted] regarding data management?
14. What tools are currently being used for data management in [redacted] projects?

Part 4: Current practices regarding data sharing

15. What data is currently being retrieved from [redacted] projects?
16. What data is currently being used in [redacted] projects?
17. How is data currently being shared within one [redacted] project team?
18. How is data currently being shared between different [redacted] projects team?
19. What is your opinion on the current state of data sharing in [redacted] projects?

C2. Exploratory interviews answers

This section is not publicly available
due to confidentiality reasons.

C3. Exploratory interview findings

Interview 1: Portfolio in general and case project selection

Table 35: Case project selection overview

Project (Continent)	Project type	Project phase	Project size	Project scope
Vietnam (Asia)	Green field	Delivered in 2019	Large	EPCM
Ethiopia (Africa)	Brown field	Delivered in 2019	Large	Design, tender, IFC, PM and CM for extension brewery
Haiti (Central America)	Brown field	Delivered in 2019	Medium	Design, tender, IFC and PM for extension brewery
Cambodia (Asia)	Brown field	Delivered in 2018	Medium	EPCM
Vietnam (Asia)	Brown field	RFQ phase	Large	EPCM
Brazil (South America)	Green field	Planning phase	Large	Client representative, design review of local consultant
Ivory Coast (Africa)	Green field	Delivered in 2017	Small	Design, tender, IFC, PM and supervision of greenfield brewery
Nigeria (Africa)	Brown field	Delivered in 2015	Medium	CM and supervision of complete brewery extension
Myanmar (Asia)	Green field	Delivered in 2015	Small	Integrated consultancy, design engineering, PM & CM services
Il de la Reunion (Africa)	Brown field	Design phase	Small	Client representative, design

Project size (brewing capacity)

Large: >4 mil [hl/year]	Medium: 2-4 mil [hl/year]	Small: 0-2 mil [hl/year]

Criteria score

High condition score	Medium condition score	Low condition score

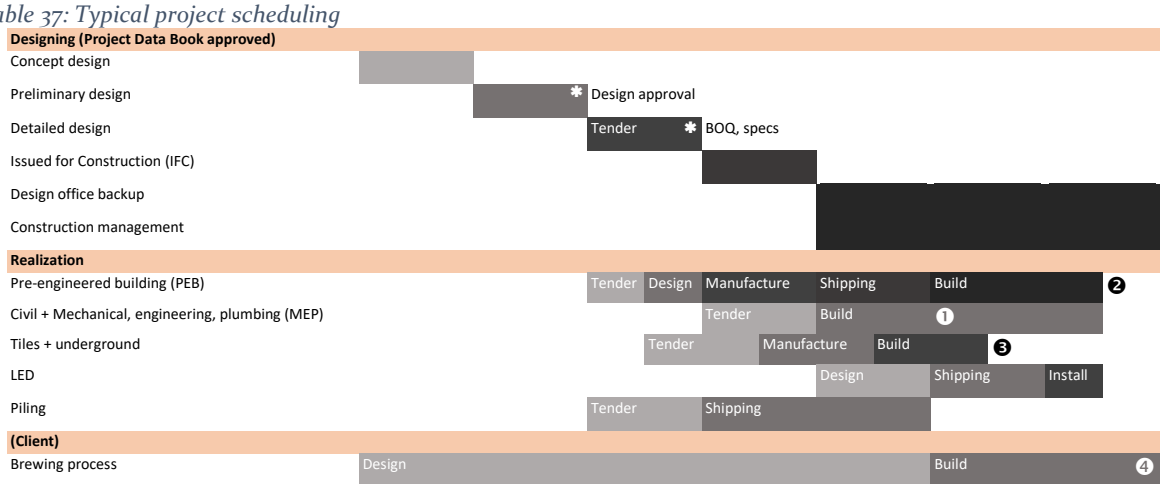
Table 36: Selected case projects and organizational division

Project phase →	Business Plan	Master-plan	Basic Design		Procurement		Realization*	Operation
Consultant phase →			Conceptual Engineering	Preliminary Design	Detailed Design			
Vietnam	NL	VN / NL	VN	VN	VN	VN	VN	VN
Ethiopia	NL	NL	NL	NL	VN	NL	ET	ET
Haiti	NL	NL	NL	NL	NL	NL	HT	HT

* Local partners and freelancers are often involved in the realization on site of the brewery projects. They may operate next to a dedicated team of RHDHV's employees that have been imported from their home countries to work abroad during construction management.

Interview 2: Brewery project life cycle and responsibilities

Table 37: Typical project scheduling



All brewery projects follow a comparable project life cycle based on agreed client standards. In the scheme above the work packages and subdivided units are distinguished by color and the lengths give an indication of the associated time duration. Throughout the whole project life cycle data is generated, stored and preferable re-used. Below a schematic presentation is given of a brewery construction, the numbers indicate which elements of the brewery are linked with the schedule above.

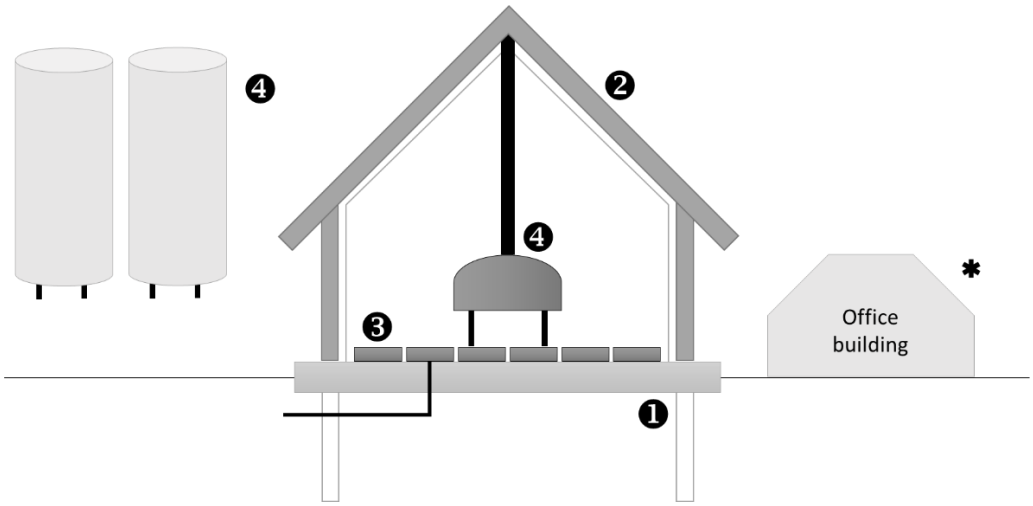


Figure 42: Schematic scheduling of brewery zones

The office building * is part of the CIV + MEP work package and is executed in parallel with the brewery. The works for the office building can be scheduled strategically. For example, when the brewery works can't continue due to late process design/ delayed shipping /other building errors/ change orders, construction can continue with the office building works and delays in planning can be minimized or forced hold downs are prevented.

Interview 3: Common Data Environment management

Table 38: Information responsibility flows (ISO 19650, 2018)

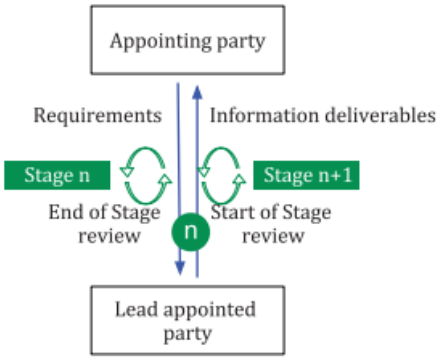


Table 39: Digital information flows (ISO 19650, 2018)

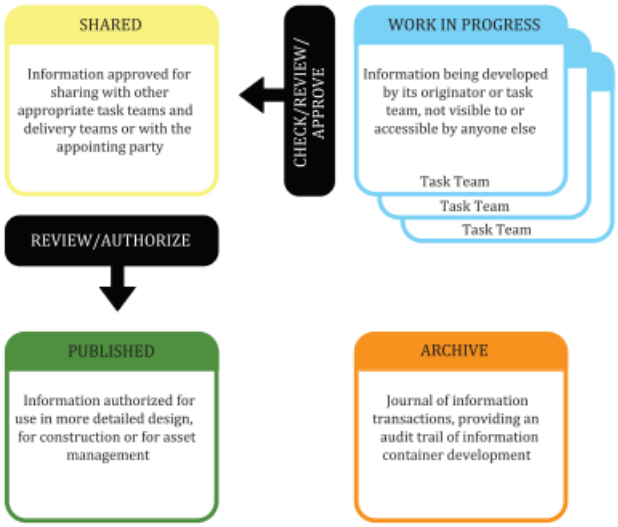
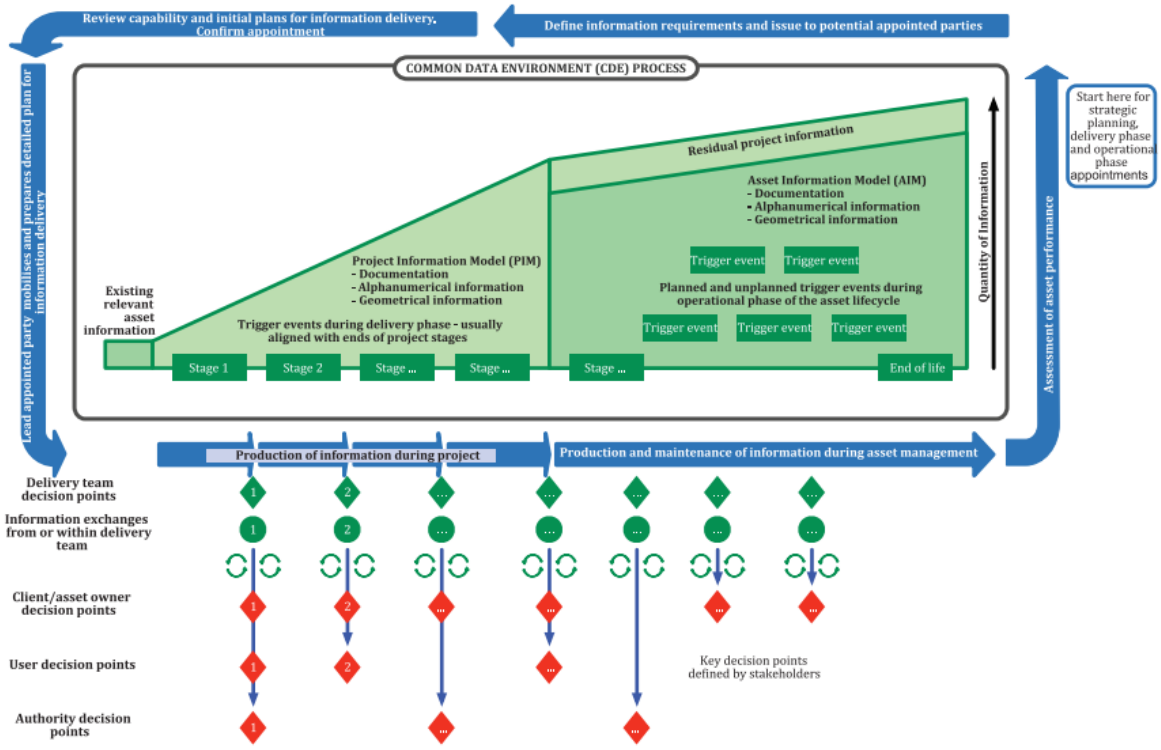


Table 40: Common Data Environment process (ISO 19650, 2018)

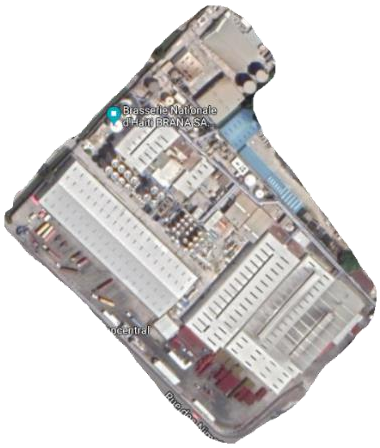


D. DESK RESEARCH

D1. Case projects details

Project A: Haiti brownfield brewery (phase 1-2)

Location:	Haiti
Type of project:	Brownfield
Project size:	2.240.000 [hectoliter/year]
Starting year:	2015
Delivery year:	2019
Client:	CONFIDENTIAL
RHDHV offices involved:	Netherlands, local team
Business line	Industry & Building
Project manager:	André Hulscher
Project team size:	53 RHDHV employees
Project scope:	Design, tender, IFC and PM for extension brewery



Project B: Ethiopia brownfield brewery (phase 3)

Location:	Ethiopia
Type of project:	Brownfield
Project size:	4.500.000 [hectoliter/year]
Starting year:	2017
Delivery year:	2019
Client:	CONFIDENTIAL
RHDHV offices involved:	Netherlands, Vietnam, local team
Business line	Industry & Building
Project manager:	Aad de Jong
Project team size:	120 RHDHV employees
Project scope:	Design, tender, IFC, PM and CM for extension brewery

Project C: Vietnam greenfield brewery (phase 5.1)

Location:	Vietnam
Type of project:	Greenfield
Project size:	5.100.000 [hectoliter/year]
Starting year:	2017
Delivery year:	2019
Client:	CONFIDENTIAL
RHDHV offices involved:	Netherlands, Vietnam, local team
Business line	Industry & Building
Project manager:	Joost Jan Oosterhuis
Project team size:	130 RHDHV employees
Project scope:	EPCM

D2. Case projects staff hours

Project A: Haiti

Table 41: Project A work hours

Project hours	Cumulative	Project package	Role	Located in	Project country
23.15%	23.15%	Haiti Master plan	Project Manager	NL-Rotterdam	Haiti
12.61%	35.76%	Haiti Master plan	BIM Modeler / Revit Architecture	NL-Rotterdam	Haiti
11.20%	46.96%	Haiti Master plan	Architectural Draftsman	NL-Rotterdam	Haiti
5.77%	52.73%	Haiti Master plan	Advisor building services	NL-Nijmegen	Haiti
5.59%	58.32%	Haiti Master plan	Associate Director	NL-Rotterdam	Haiti
4.27%	62.59%	Haiti Master plan	Architectural Engineer	NL-Rotterdam	Haiti
4.23%	66.82%	Haiti Master plan	Structural Engineer	NL-Nijmegen	Haiti
3.69%	70.51%	Haiti Master plan	Structural Engineer	NL-Nijmegen	Haiti
3.53%	74.04%	Haiti Master plan	Electrical Engineer	NL-Nijmegen	Haiti
2.95%	76.99%	Haiti Master plan	Structural Engineer / Senior draftsman	NL-Nijmegen	Haiti
2.60%	79.59%	Haiti Master plan	Senior Structural consultant	NL-Rotterdam	Haiti
2.59%	82.18%	Haiti Master plan	Project Manager / Structural Engineer	NL-Rotterdam	Haiti
2.54%	84.72%	Haiti Master plan	Project / Design Manager	NL-Rotterdam	Haiti
2.38%	87.10%	Haiti Master plan	Structural Engineer	NL-Nijmegen	Haiti
2.30%	89.40%	Haiti Master plan	Project Manager	NL-Eindhoven	Haiti
2.13%	91.53%	Haiti Master plan	Electrical consultant / Lighting Specialist	NL-Nijmegen	Haiti
1.32%	92.85%	Haiti Master plan	Senior Architectural Draftman	NL-Rotterdam	Haiti
1.00%	93.85%	Haiti Master plan	Project Management Assistant	NL-Rotterdam	Haiti
0.99%	94.84%	Haiti Master plan	Structural Designer	NL-Rotterdam	Haiti
0.32%	95.16%	Haiti Master plan	Tendering	NL-Rotterdam	Haiti

Project B: Ethiopia brewery

Table 42: Project B work hours

Project hours	Cumulative	Project	Role	Located in	Project Country
12.58%	12.58%	Ethiopia Phase 3	Drafter	VN-HoChiMinhCity	Ethiopia
8.81%	21.39%	Ethiopia Phase 3	Drafter	VN-HoChiMinhCity	Ethiopia
6.51%	27.90%	Ethiopia Phase 3	Structural Team Leader	VN-HoChiMinhCity	Ethiopia
4.61%	32.51%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
4.61%	37.12%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
4.54%	41.66%	Ethiopia Phase 3	Sanitary & Fire protection	VN-HoChiMinhCity	Ethiopia
4.33%	45.99%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
4.14%	50.13%	Ethiopia Phase 3	Project Manager	VN-HoChiMinhCity	Ethiopia
4.10%	54.23%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
3.66%	57.89%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
3.46%	61.35%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
3.17%	64.52%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
2.98%	67.50%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
2.46%	69.96%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
2.41%	72.37%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
2.34%	74.71%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
2.20%	76.91%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
2.14%	79.05%	Ethiopia Phase 3	Quantity Surveyer	VN-HoChiMinhCity	Ethiopia
2.08%	81.13%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
2.06%	83.19%	Ethiopia Phase 3	Quantity Surveyer	VN-HoChiMinhCity	Ethiopia
1.81%	85.00%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
1.71%	86.71%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
1.66%	88.37%	Ethiopia Phase 3	Quantity Surveyer	VN-HoChiMinhCity	Ethiopia
1.26%	89.63%	Ethiopia Phase 3	Project Assistant	VN-HoChiMinhCity	Ethiopia
1.25%	90.88%	Ethiopia Phase 3		VN-HoChiMinhCity	Ethiopia
1.24%	92.12%	Ethiopia Phase 3	Structural Design Engineer	VN-HoChiMinhCity	Ethiopia
29.05%	29.05%	Ethiopia Phase 3 - CM	Project Manager	NL-Rotterdam	Ethiopia
23.61%	52.66%	Ethiopia Phase 3 - CM	Architect	DE-FrankfurtamMain	Ethiopia
21.64%	74.30%	Ethiopia Phase 3 - CM	Architectural Civil Consultant	NL-Nijmegen	Ethiopia
6.91%	81.21%	Ethiopia Phase 3 - CM	Senior Architectural Draftman	NL-Rotterdam	Ethiopia
6.25%	87.46%	Ethiopia Phase 3 - CM	Project Manager / Architect	NL-Rotterdam	Ethiopia
1.88%	89.34%	Ethiopia Phase 3 - CM	Structural Engineer	NL-Nijmegen	Ethiopia
1.73%	91.07%	Ethiopia Phase 3 - CM		NL-Eindhoven	Ethiopia
1.40%	92.47%	Ethiopia Phase 3 - CM	Senior 3D Modeler	NL-Nijmegen	Ethiopia
1.28%	93.75%	Ethiopia Phase 3 - CM	Advisor building services	NL-Nijmegen	Ethiopia
1.22%	94.97%	Ethiopia Phase 3 - CM		NL-Eindhoven	Ethiopia
22.10%	22.10%	Ethiopia Phase 3 - Engineering	Senior Architectural Draftman	NL-Rotterdam	Ethiopia
20.24%	42.34%	Ethiopia Phase 3 - Engineering	Project Manager / Architect	NL-Rotterdam	Ethiopia
11.10%	53.44%	Ethiopia Phase 3 - Engineering	Project Manager	NL-Rotterdam	Ethiopia
5.47%	58.91%	Ethiopia Phase 3 - Engineering	3D Draftsman	NL-Nijmegen	Ethiopia
4.25%	63.16%	Ethiopia Phase 3 - Engineering	Architectural Draftsman	NL-Rotterdam	Ethiopia
4.20%	67.36%	Ethiopia Phase 3 - Engineering	Senior Draftsman	NL-Nijmegen	Ethiopia
4.00%	71.36%	Ethiopia Phase 3 - Engineering	Structural Engineer	NL-Nijmegen	Ethiopia
3.81%	75.17%	Ethiopia Phase 3 - Engineering		NL-Eindhoven	Ethiopia
3.41%	78.58%	Ethiopia Phase 3 - Engineering	Advisor building services	NL-Nijmegen	Ethiopia
2.52%	81.10%	Ethiopia Phase 3 - Engineering		NL-Rotterdam	Ethiopia
2.50%	83.60%	Ethiopia Phase 3 - Engineering	BIM Modeller / Revit Architecture	NL-Rotterdam	Ethiopia
2.23%	85.83%	Ethiopia Phase 3 - Engineering	Senior Visualisation Specialist	NL-Rotterdam	Ethiopia
2.21%	88.04%	Ethiopia Phase 3 - Engineering		NL-Eindhoven	Ethiopia
2.04%	90.08%	Ethiopia Phase 3 - Engineering		NL-Rotterdam	Ethiopia
1.99%	92.07%	Ethiopia Phase 3 - Engineering	Structural Engineer	NL-Nijmegen	Ethiopia
1.60%	93.67%	Ethiopia Phase 3 - Engineering		NL-Rotterdam	Ethiopia
1.19%	94.86%	Ethiopia Phase 3 - Engineering		NL-Rotterdam	Ethiopia
1.04%	95.90%	Ethiopia Phase 3 - Engineering	Project Engineer	NL-Eindhoven	Ethiopia

Project C: Vietnam brewery

Table 43: Project C work hours

Project hours	Cumulative	Project	Role	Located in	Project Country
4.60%	4.60%	Vietnam Phase 5.1	Construction manager	VN-HoChiMinhCity	Vietnam
4.32%	8.92%	Vietnam Phase 5.1	Onsite SHE manager	VN-HoChiMinhCity	Vietnam
4.30%	13.22%	Vietnam Phase 5.1	Senior Site supervisor	VN-HoChiMinhCity	Vietnam
4.13%	17.35%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
3.55%	20.90%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
3.36%	24.26%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
3.16%	27.42%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
2.92%	30.34%	Vietnam Phase 5.1	Project Manager	VN-HoChiMinhCity	Vietnam
2.88%	33.22%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
2.85%	36.07%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
2.85%	38.92%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
2.82%	41.74%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
2.80%	44.54%	Vietnam Phase 5.1	Consultant Services & sustainability	VN-HoChiMinhCity	Vietnam
2.75%	47.29%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
2.70%	49.99%	Vietnam Phase 5.1	Project Assistant	VN-HoChiMinhCity	Vietnam
2.40%	52.39%	Vietnam Phase 5.1	Project Architect	VN-HoChiMinhCity	Vietnam
2.38%	54.77%	Vietnam Phase 5.1	Structural Design Lead	VN-HoChiMinhCity	Vietnam
2.24%	57.01%	Vietnam Phase 5.1	Quantity Surveyor	VN-HoChiMinhCity	Vietnam
1.98%	58.99%	Vietnam Phase 5.1	Mechanical supervisor	VN-HoChiMinhCity	Vietnam
1.86%	60.85%	Vietnam Phase 5.1	Project manager	VN-HoChiMinhCity	Vietnam
1.86%	62.71%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
1.72%	64.43%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
1.64%	66.07%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
1.42%	67.49%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
1.34%	70.22%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
1.30%	71.52%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
1.24%	72.76%	Vietnam Phase 5.1	HVAC designer	VN-HoChiMinhCity	Vietnam
1.22%	73.98%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
1.13%	75.11%	Vietnam Phase 5.1	HSE manager	VN-HoChiMinhCity	Vietnam
1.12%	76.23%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
1.11%	77.34%	Vietnam Phase 5.1	BIM Coordinator	VN-HoChiMinhCity	Vietnam
1.02%	78.36%	Vietnam Phase 5.1	Civil supervisor	VN-HoChiMinhCity	Vietnam
1.01%	79.37%	Vietnam Phase 5.1	Quantity Surveyor	VN-HoChiMinhCity	Vietnam
1.00%	80.37%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
0.89%	81.26%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
0.87%	82.13%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
0.85%	82.98%	Vietnam Phase 5.1	QS Lead	VN-HoChiMinhCity	Vietnam
0.84%	83.82%	Vietnam Phase 5.1	Drafter	VN-HoChiMinhCity	Vietnam
0.80%	84.62%	Vietnam Phase 5.1	Senior Architect	VN-HoChiMinhCity	Vietnam
0.77%	85.39%	Vietnam Phase 5.1	Quantity Surveyor	VN-HoChiMinhCity	Vietnam
0.77%	86.16%	Vietnam Phase 5.1	Revit Modeler	VN-HoChiMinhCity	Vietnam
0.69%	87.61%	Vietnam Phase 5.1	QS Lead	VN-HoChiMinhCity	Vietnam
0.62%	88.88%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
0.57%	90.03%	Vietnam Phase 5.1	Electrical Lead	VN-HoChiMinhCity	Vietnam
0.53%	90.56%	Vietnam Phase 5.1		VN-HoChiMinhCity	Vietnam
0.51%	91.07%	Vietnam Phase 5.1	Head of HSE	VN-HoChiMinhCity	Vietnam
-	-	Vietnam Phase 5.1	Design manager	NL-Rotterdam	Vietnam
-	-	Vietnam Phase 5.1	Architectural Engineer	NL-Rotterdam	Vietnam
-	-	Vietnam Phase 5.1	Design manager	NL-Rotterdam	Vietnam

E. SOCIAL NETWORK ANALYSIS

E1. Survey respondents

#	Project	Code	Role	Located	Gender	Age	RHDHV years	Brewery projects
1	A - Haiti	A20	Project/Design management	NL-RTM	Male	56-65	30-40	over 10
2	A - Haiti	A6	Project assistant	NL-RTM	Female	25-34	5-9	over 10
3	A - Haiti	A18	Drafting/Modelling/BIM	NL-RTM	Male	25-34	5-9	over 10
4	A - Haiti	A19	Drafting/Modelling/BIM	NL-RTM	Female	35-44	1-4	6-7
5	A - Haiti	A5	Engineering	NL-RTM	Male	35-44	10-19	over 10
6	A - Haiti	A12	Engineering	NL-NIJM	Male	over 65	20-29	8-10
7	A - Haiti	A1	Engineering	NL-RTM	Male	35-44	20-29	8-10
8	A - Haiti	A16	Tender/Contracting	NL-RTM	Male	35-44	10-19	6-7
9	A - Haiti	A15	Engineering	NL-NIJM	Female	25-34	1-4	2-3
10	A - Haiti	A13	Project/Design management	NL-EIND	Female	25-34	1-4	1
11	A - Haiti	A14	Project/Design management	Haiti	Male	45-55	10-19	over 10
12	B - Ethiopia	B3	Project/Design management	NL-RTM	Male	over 65	over 40	4-5
13	B - Ethiopia	B12	Construction management	Ethiopia	Male	25-34	5-9	2-3
14	B - Ethiopia	B10	Engineering	Ethiopia	Female	35-44	1-4	4-5
15	B - Ethiopia	B27	Drafting/Modelling/BIM	RTM-NL	Male	35-44	5-9	4-5
16	B - Ethiopia	B23	Construction management	Ethiopia	Male	56-65	30-40	4-5
17	B - Ethiopia	B19	Other specialist	VN-HCMC	Female	35-44	1-4	over 10
18	B - Ethiopia	B21	Engineering	NL-NIJM	Male	56-65	20-29	6-7
19	B - Ethiopia	B36	Other specialist	NL-AME	Male	45-55	10-19	6-7
20	B - Ethiopia	B30	Engineering	VN-HCMC	Male	35-44	10-19	4-5
21	C- Vietnam	C1	Project/Design management	NL-RTM/VN	Male	56-65	30-40	over 10
22	C- Vietnam	C13	Construction management	VN-HCMC	Male	35-44	5-9	1
23	C- Vietnam	C9	Construction management	VN-VT	male	35-44	5-9	2-3
24	C- Vietnam	C32	Costing	VN-VT	Male	35-44	10-19	over 10
25	C- Vietnam	C2	Project/Design management	VN-HCMC	Male	35-44	5-9	7-10
26	C- Vietnam	C15	Project/Design management	NL-RTM/VN	Male	35-44	1-4	2-3
27	C- Vietnam	C19	Construction management	VN-HCMC	Male	35-44	10-19	6-7
28	C- Vietnam	C10	Engineering	VN-HCMC	Male	25-34	1-4	over 10
29	C- Vietnam	C23	Construction management	VN-VT	Male	35-44	5-9	2-3
30	C- Vietnam	C26	Project/Design management	VN-HCMC	Male	35-44	10-19	4-5
31	C- Vietnam	C28	Drafting/Modelling/BIM	VN-HCMC	Male	25-34	1-4	2-3
32	C- Vietnam	C5	Engineering	VN-HCMC	Male	35-44	5-9	4-5
33	C- Vietnam	C18	Costing	VN-HCMC	Male	56-65	10-19	4-5
34	C- Vietnam	C12	Engineering	VN-HCMC	Female	45-55	10-19	over 10
35	C- Vietnam	C4	Drafting/Modelling/BIM	VN-HCMC	Male	25-34	1-4	2-3
36	C- Vietnam	C7	Engineering	VN-HCMC	Female	25-34	1-4	1
37	C- Vietnam	C25	Engineering	VT-VN	Male	35-44	5-9	4-5
38	C- Vietnam	C24	Costing	VN-HCMC	Male	35-44	10-19	4-5
39	C- Vietnam	C38	Engineering	VN-HCMC	Male	35-44	10-19	4-5
40	C- Vietnam	C16	Drafting/Modelling/BIM	VN-HCMC	Male	25-34	1-4	2-3
41	C- Vietnam	C20	Project Assistant	VN-HCMC	Male	25-34	1-4	1

E2. Survey protocol

Goal

- Goal: Gathering data about data networks in the three case projects.
- Aimed outcome: Indicating active team members (nodes) and data streams (edges) that connect them. Gaining more extensive information about the frequency, value, used tools and personal preferences.
- Deadline: end of September

Introduction
Thank you for taking the time to participate in this survey which will take around 15 minutes of your valuable time.

The aim of this survey is to measure data sharing in the portfolio for the projects: **Vietnam, Ethiopia, and Haiti.** This will contribute to my thesis topic: *"How can data sharing enhance intra-organizational collaboration in multinational construction projects?"*

Your participation is of great value and will contribute to a strong data set that enables analysis in data use and behavior within RHDHV. After completion of this research it is possible for all participants to receive individual feedback about their position in the data-sharing network.

Survey goals
My research applies the Social Network Analysis which enables to map the data network in your organization and retrieve both quantitative and qualitative analysis on human connections. The main goal of this survey is to identify who is sharing data with whom. Some participants will be asked later to take part in an interview that focusses on conducting the qualitative analysis of this research.

Your consent
When participating in this survey you will be asked to provide information about your colleagues you regularly share data with such as names and other background information. Once data is collected, all names will be replaced with anonymous codes. Now please check the example question on the right.

You can now confirm that you have read and understand the purpose of this survey. You understand that your name will be replaced with an anonymous code and that you can send me an email if you have any questions.

☐ I choose to participate in this research.
☐ I choose to **not** participate in this research.

Thank you for your interest.

Kind regards,
Dominique Berck
September 20, 2019

Delft University of Technology
MSc Construction, Management and Engineering
[redacted]

Part 1 - Work details (Q1 - Q7)

1. What is your full name? *

2. What is your business line and organizational unit? *

3. Please indicate on which [redacted] project you spent the most time on and therefore use for this survey? *

Vietnam	Ethiopia	Haiti
☐	☐	☐

4. Who was your direct line manager when working on this [redacted] project? *

5. What city and country were you located in when working on this [redacted] project? *

6. What was your role when working on this [redacted] project? *

7. Under what category do you place your role when working on this [redacted] project? *

Project / Design management	Project assistant	Engineering	Tender & Contracting
☐	☐	☐	☐
Drafting / Modelling / BIM	**Costing**	**Construction management**	**Other specialist (HSE/Sustainability/etc.)**
☐	☐	☐	☐

Part 2 - Social Network Analysis (Q8 - Q19)

Next you will be asked to identify people you share project data with within RHDHV. In my research project data is defined as *"numbers, facts, statistics and documents in information flows that can be interpreted and used for examination".* You can think of any type of data when filling out this survey but to provide you with some examples the following categories can be considered: time data, cost data, design data, resources data, quality data. Do **NOT** focus on personal experiences.

8. Identify people you connected with **MOST** when it comes to data sharing within your own RHDHV [redacted] team or one of the two other [redacted] teams. Please share at least **THREE** people but preferably as many as possible up to **TEN**. *

Person	Full name	Role	Located in	[redacted] project *
1*				
2*				
3*				
4				
5				
6				
7				
8				
9				
10				

* Select from one of the case projects: Vietnam/Ethiopia/ Haiti.

9. A. Please indicate for each person you identified how frequently you shared data with that person in which you are the **RECEIVER** of the data shared.

#	Occasionally	Every month	Every week	Every day
1*	☐	☐	☐	☐
2*	☐	☐	☐	☐
3*	☐	☐	☐	☐
4	☐	☐	☐	☐
5	☐	☐	☐	☐
6	☐	☐	☐	☐
7	☐	☐	☐	☐
8	☐	☐	☐	☐
9	☐	☐	☐	☐
10	☐	☐	☐	☐

9. B. Please indicate for each person you identified how frequently you shared data with that person in which you are the **SENDER** of the data shared.

#	Occasionally	Every month	Every week	Every day
1*	☐	☐	☐	☐
2*	☐	☐	☐	☐
3*	☐	☐	☐	☐
4	☐	☐	☐	☐
5	☐	☐	☐	☐
6	☐	☐	☐	☐
7	☐	☐	☐	☐
8	☐	☐	☐	☐
9	☐	☐	☐	☐
10	☐	☐	☐	☐

10. Who did you most often rely on when needing data **FAST**? *

11. Please indicate for each person you identified the value of the data that you **RECEIVED** from them in helping to do your work.

#	Low	Moderate	High	Very high
1*	☐	☐	☐	☐
2*	☐	☐	☐	☐
3*	☐	☐	☐	☐
4	☐	☐	☐	☐
5	☐	☐	☐	☐
6	☐	☐	☐	☐
7	☐	☐	☐	☐
8	☐	☐	☐	☐
9	☐	☐	☐	☐
10	☐	☐	☐	☐

12. Who did you most often turn to before making and important decision for your work? *

13. Did you also share data with people from the other two [redacted] projects? *

Yes	No
☐	☐

14. If yes, please share with whom and why. Please share their full name, role, [redacted] project and why you shared data with them. *

Full name	Role	Why	[redacted] project

15. A. Please indicate for each person you identified what tool you used in sharing data when you were **RECEIVER** of the data (you can select more options). *

#	Box	Email	BIM 360 / Revit	Asite	MS Teams	Chat	Skype / Phone	Face-to-face
1*	☐	☐	☐	☐	☐	☐	☐	☐
2*	☐	☐	☐	☐	☐	☐	☐	☐
3*	☐	☐	☐	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐	☐	☐	☐
7	☐	☐	☐	☐	☐	☐	☐	☐
8	☐	☐	☐	☐	☐	☐	☐	☐
9	☐	☐	☐	☐	☐	☐	☐	☐
10	☐	☐	☐	☐	☐	☐	☐	☐

15. B. Please indicate for each person you identified what tool you use in sharing data in which you are the **sender** of the data shared (you can select more options).

#	Box	Email	BIM 360 / Revit	Asite	MS Teams	Chat	Skype / Phone	Face-to-face
1*	☐	☐	☐	☐	☐	☐	☐	☐
2*	☐	☐	☐	☐	☐	☐	☐	☐
3*	☐	☐	☐	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐	☐	☐	☐
7	☐	☐	☐	☐	☐	☐	☐	☐
8	☐	☐	☐	☐	☐	☐	☐	☐
9	☐	☐	☐	☐	☐	☐	☐	☐
10	☐	☐	☐	☐	☐	☐	☐	☐

16. Which tool do you prefer most when sharing data with others? *

17. Please indicate for each person you identified how you would best describe your **EMOTIONAL** relationship when it comes to data sharing (maximum 3 per person). *

#	Professional	Reliable	Obligation	Easily accessible	Mutual trust	Safe	Transparent
1*	☐	☐	☐	☐	☐	☐	☐
2*	☐	☐	☐	☐	☐	☐	☐
3*	☐	☐	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐	☐	☐
7	☐	☐	☐	☐	☐	☐	☐
8	☐	☐	☐	☐	☐	☐	☐
9	☐	☐	☐	☐	☐	☐	☐
10	☐	☐	☐	☐	☐	☐	☐

18. Please indicate for each person you identified how you would best describe your **PRACTICAL** relationship when it comes to data sharing (maximum 3 per person). *

#	Shared goals	Suggested by others	Task instructing	Quality assurance	Problem solving	Common routine	Learning drive
1*	☐	☐	☐	☐	☐	☐	☐
2*	☐	☐	☐	☐	☐	☐	☐
3*	☐	☐	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐	☐	☐
7	☐	☐	☐	☐	☐	☐	☐
8	☐	☐	☐	☐	☐	☐	☐
9	☐	☐	☐	☐	☐	☐	☐
10	☐	☐	☐	☐	☐	☐	☐

19. Which type of relationship do you experience as most **COLLABORATIVE** from the ones mentioned above? (maximum 3) *

Part two – Demographic details

20. What is your gender? *

Female	Male	Other
☐	☐	☐

21. What is your age? *

Under 25	25-34	35-44	45-54	55-65	More than 65
☐	☐	☐	☐	☐	☐

22. How many years have you worked for RHDHV? *

< 1 year	1 - 4	5 - 9	10 – 19	20 - 29	30 - 40	40 years >
☐	☐	☐	☐	☐	☐	☐

23. For how many [redacted] projects have you worked at RHDHV? *

1 project	2 - 3	4 - 5	6 – 7	8 - 10	10+ projects
☐	☐	☐	☐	☐	☐

This is the end of this Thesis Survey. Thank you very much for your participation and you are assured that all your responses will be treated with full confidence. If you have any questions, please contact me via email: dominique.berck@rhdhv.com

E3. Python code

In [1]:
```
#Step 1: Installing necessary libiaries

#step 1.1: Install Python Networkx libriary to work with graph's (adding/adjusting nodes and edges).
import networkx as nx
#step 1.2: Install matplotlib to enable graph visualization within Networkx
import matplotlib.pyplot as plt
#step 1.3: Call the inline magic function to enable graph visualization below the code.
%matplotlib inline
#step 1.4: Install pandas to read and call csv files and dataframes.
import pandas as pd
import csv as csv
```

In [2]:
```
#Step 2: Reading the survey data from csv dataframes.
# Dataframes of all cases (Project A,B,C) read from a csv file. The names of project members are changed into anonymous codes.
# Each row in the dataframe represents a datastream (edge) between two project members (nodes).
# Node attributes (source_color, source_role, source_category, target_color, target_role, target_category)
# and edge attributes (edge_frequency, edge_value) are presented in the dataframe.


#Project X
#step 2.1: Read the csv file with pandas to enable processing of the data.
df_X = pd.read_csv('SNA_X_csv_3.csv', sep=';')
#step 2.2: Show the structure (5 rows sample) and size of the dataframe.
print(df_X.head())
print(df_X.shape)
```

In [3]:
```
#Step 3: Creating the data sharing network graphs with edge attributes.
            #Datastream frequency: edge thickness (stepsize: frequency=occasionally(1.0), every month(4.0), every week(7.0), eve
ry day(10.0))
            #Datastream value: edge style (stepsize: value=low(dotted), moderate(dashdotted), high(dashed), very high(solid))

#Networkx library in Python supports different Graph's. At the moment a normal undirected Graph is used.
#When team members refer to each other the avarage frequency and value is used for the datastream between them.

#Project X
#step 3.1: Create the empty graph.
X = nx.Graph()
#step 3.2: Call edges from pandas dataframe and set edge attributes by associated dataframe columns.
X = nx.from_pandas_edgelist(df_X, source='source', target='target', edge_attr=['edge_frequency','edge_value','edge_weight','edge
_style'])
#step 3.3: Create list of edges.
edges_X = X.edges()
#print(edges_X)
#step 3.4: Create list with 'edge frequency' values from each row in the edge list.
edge_frequency_X= [X[u][v]['edge_frequency'] for u,v in edges_X]
#step 3.5: Create list with 'edge value' values from each row in the edge list.
edge_value_X = [X[u][v]['edge_value'] for u,v in edges_X]
#step 3.6: Create list with 'edge weight' values from each row in the edge list.
edge_weight_X = [X[u][v]['edge_weight'] for u,v in edges_X]
#step 3.7: Create list with 'edge style' values from each row in the edge list.
edge_style_X = [X[u][v]['edge_style'] for u,v in edges_X]
#print(edge_frequency_X)
#print(edge_value_X)
# print(edge_weight_X)
# print(edge_style_X)
```

In [4]:
```
#Step 4: Setting the node roles as attributes to the present nodes in the data sharing network.


#Project X
#step 4.1: Retrieve the node and role information from the csv dataframes for each row and applicable columns.
node_attributes_X = []
for index, rows in df_X.iterrows():
    source_attributes_X = [rows.source, rows.source_role, rows.source_color]
    target_attributes_X = [rows.target, rows.target_role, rows.target_color]
    node_attributes_X.append(source_attributes_X)
    node_attributes_X.append(target_attributes_X)
#print(node_attributes_X)
#step 4.2: Remove duplicates to create a list of unique nodes and their associated attribute.
new_node_attributes_X = []
for item in node_attributes_X:
    if item not in new_node_attributes_X:
        new_node_attributes_X.append(item)
node_attributes_X=new_node_attributes_X
#print(node_attributes_X)
#print(len(node_attributes_X))
#step 4.3: Transform list [] format into dictionary format {key:value} for setting node attributes.
dict_node_roles_X={item[0]:item[1] for item in node_attributes_X}
dict_node_colors_X={item[0]:item[2] for item in node_attributes_X}
#print(dict_node_attributes_X)
#step 4.4: Set node attributes from the created dictionary to present nodes in the network.
nx.set_node_attributes(X, dict_node_roles_X, 'Role')
nx.set_node_attributes(X, dict_node_colors_X, 'Color')
# print(X.nodes(data=True))
```

In [5]:
```
#Step 5: Creating a list with node colors based on their individual team roles.
#Nodes colors extracted from the csv dataframes to assign as node attributes to the nodes in the data sharing network.
            # 1.Project/Design management: yellow
            # 2.Project Assistent: blue
            # 3.Engineering: red
            # 4.Tender&Contracting: green
            # 5.Drafting/Modelling/BIM: pink
            # 6.Costing: purple
            # 7.Construction management: orange
            # 8.Other specialist: silver (HSE/Building Physics/Finance/etc.)

#Project X
# step 5.1: Create empty list for adding node colors.
node_colors_X = []
#step 5.2: Retrieve the node color from each row of the unique node list and add it to the color list.
for item in node_attributes_X:
    node_colors_X.append(item[2])
# print(node_colors_X)
# print(len(node_colors_X))
```

In [6]:
```
#Step 6: Mapping the data sharing networks of each project.
# The data sharing networks visualized are all visualized based upon the survey data retrieved from 40 respondents.
# The Kamada & Kawai graph layout style has been selected to visualize the graph. This layout minimizes the local energy as if
# all the edges are springs that want to keep their attracting nodes as close as possible and distracting nodes away from them.

#Project X
#step 6.1: Set the size of the plot figure being big enough to present the graph.
plt.figure(figsize=(50,50))
# plt.savefig('Project.pdf', format='pdf', dpi=1200)

#step 6.2: Set the layout style of the graph, here the Kamada Style is choosen.
pos = nx.kamada_kawai_layout(X)
#step 6.3: Create the graph including desired graph, node and edge settings.
Graph_X = nx.draw(X, pos, with_labels=True, edges=edges_X, width=edge_frequency_X, style=edge_style_X, edge_color='black', node_
color=node_colors_X, node_size=3000, font_size=25)
#step 6.4: Saving the graph as a PDF file.
plt.savefig('Graph_X.pdf')
#step 6.5: Visualizing the graph.
plt.show(Graph_X)
```

In [7]:
```
# Step 7: Subgraphs of role specific nodes

# step 7.1: Create subgraph of Project / Design management
# step 7.1.1: Create project / design management nodelist
nodelist_X_PDM = []
for (u,v) in X.nodes(data=True):
    if v['Role'] == 'Project / Design management':
        nodelist_X_PDM.append(u)
# print(nodelist_X_PDM)
#print(len(nodelist_X_PDM))

# step 7.1.2: Create project/design management subgraphs
X1 = X.subgraph(nodelist_X_PDM)

#step 7.1.3: Create project/design management frequency and value lists
edge_frequency_X_PDM = [X[u][v]['edge_frequency'] for u,v in X1.edges()]
# print(edge_frequeny_C_PDM)
edge_value_X_PDM = [X[u][v]['edge_value'] for u,v in X1.edges()]
# print(edge_value_X_PDM)
edge_weight_X_PDM = [X[u][v]['edge_weight'] for u,v in X1.edges()]
# print(edge_weight_C_PDM)
edge_style_X_PDM = [X[u][v]['edge_style'] for u,v in X1.edges()]
# print(edge_style_X_PDM)

# step 7. : Draw project/design management subgraphs
plt.figure(figsize=(50,50))
pos = nx.kamada_kawai_layout(X)
nx.draw(X, pos, with_labels=True, alpha=0.1, edges=edges_X, width=edge_frequency_X, style=edge_style_X, edge_color='black', node
_color=node_colors_X, node_size=3000, font_size=25)
nx.draw(X1, pos, with_labels=True, edges=edges_X, width=edge_frequency_X_PDM, style=edge_style_X_PDM, edge_color='black', node_c
olor='gold', node_size=3000, font_size=25)
```

[....]

Codes for the remaining subgraphs of the role specific nodes has been removed from this preview since they follow the same structure as In [7]. Hereafter the same explanation for removed code applies.

In [15]:
```
# Network analysis 1: Info - describes the basic info about the network
print(nx.info(X))
```

In [16]:
```
# Network analysis 2: Density - real number of connections compared to potential number of connections.

print(nx.density(X))
```

In [17]:
```
# Network analysis 3: Clustering - sum of all the local clustering coefficients divided by the number of nodes.

print(nx.average_clustering(X))
```

In [18]:
```
# Network analysis 4: Average frequency of all present data streams (edges) between nodes.

print(sum(edge_frequency_X)/len(edge_frequency_X))
```

In [19]:
```
# Network analysis 5: Average value of all present data streams (edges) between nodes.

print(sum(edge_value_X)/len(edge_value_X))
```

In [20]:
```
# Network analysis 6: Average weight of all present data streams (edges) between nodes.

print(sum(edge_weight_X)/len(edge_weight_X))
```

In [21]:
```
# Node analysis 1a: Degree - number of connections all nodes in the network have.
degree_X = nx.degree(X)
with open("degree_X.csv","w") as f:
    wr = csv.writer(f,delimiter=":")
    wr.writerows(degree_X())
print(sorted(degree_X, key=lambda x: x[1]))

degree_X1 = nx.degree(X1)
print(sorted(degree_X1, key=lambda x: x[1]))
```

[...]

In [22]:
```
# Node analysis 2: Degree centrality - a measure of the number of connections a particular node has in the network.
degree_centrality_X = nx.degree_centrality(X)
with open("degree_centrality_X.csv","w") as f:
    wr = csv.writer(f,delimiter=":")
    wr.writerows(degree_centrality_X.items())
print({k: v for k, v in sorted(degree_centrality_X.items(), key=lambda item: item[1])})

degree_centrality_X1 = nx.degree_centrality(X1)
print({k: v for k, v in sorted(degree_centrality_X1.items(), key=lambda item: item[1])})
```

[...]

In [23]:
```
# Node analysis 3: Eigenvector - decides the importance of a node if it is connected to other important nodes

eigenvector_centrality_X = nx.eigenvector_centrality(X)
with open("eigenvector_A.csv","w") as f:
    wr = csv.writer(f,delimiter=":")
    wr.writerows(eigenvector_centrality_X.items())
print({k: v for k, v in sorted(eigenvector_centrality_X.items(), key=lambda item: item[1])})

eigenvector_centrality_X1 = nx.eigenvector_centrality(X1)
print({k: v for k, v in sorted(eigenvector_centrality_X1.items(), key=lambda item: item[1])})
```

[...]

In [24]:
```
# Node analysis 4: Betweenness - Quantifies how many times a node is part of the shortest path between two other nodes.

betweenness_centrality_X = nx.betweenness_centrality(X)
with open("betweenness_A.csv","w") as f:
    wr = csv.writer(f,delimiter=":")
    wr.writerows(betweenness_centrality_X.items())
print({k: v for k, v in sorted(betweenness_centrality_X.items(), key=lambda item: item[1])})

betweenness_centrality_X1 = nx.betweenness_centrality(X1)
print({k: v for k, v in sorted(betweenness_centrality_X1.items(), key=lambda item: item[1])})
```

[...]

In [25]:
```
# Node analysis 5: Closeness - Determines how close a node is to all other nodes by taking the average of all the shortest paths
of that node.

closeness_centrality_X = nx.closeness_centrality(X)
with open("closeness_A.csv","w") as f:
    wr = csv.writer(f,delimiter=":")
    wr.writerows(closeness_centrality_X.items())
print({k: v for k, v in sorted(closeness_centrality_X.items(), key=lambda item: item[1])})

closeness_centrality_X1 = nx.closeness_centrality(X1)
print({k: v for k, v in sorted(closeness_centrality_X1.items(), key=lambda item: item[1])})
```

[...]

In [26]:
```
# Node analysis 6: Eccentricity - Largest distance between a node and all other nodes.

eccentricity_X = nx.eccentricity(X)
with open("closeness_A.csv","w") as f:
    wr = csv.writer(f,delimiter=":")
    wr.writerows(eccentricity_X.items())
print({k: v for k, v in sorted(eccentricity_X.items(), key=lambda item: item[1])})

# Infinite path lengths
# eccentricity_X1 = nx.eccentricity(X1)
# print({k: v for k, v in sorted(eccentricity_X1.items(), key=lambda item: item[1])})

# Infinite path lengths
# eccentricity_X2 = nx.eccentricity(X2)
# print({k: v for k, v in sorted(eccentricity_X2.items(), key=lambda item: item[1])})

# Infinite path lengths
# eccentricity_X3 = nx.eccentricity(X3)
# print({k: v for k, v in sorted(eccentricity_X3.items(), key=lambda item: item[1])})

# Infinite path lengths
# eccentricity_X4 = nx.eccentricity(X4)
# print({k: v for k, v in sorted(eccentricity_X4.items(), key=lambda item: item[1])})

# Infinite path lengths
# eccentricity_X5 = nx.eccentricity(X5)
# print({k: v for k, v in sorted(eccentricity_X5.items(), key=lambda item: item[1])})

eccentricity_X6 = nx.eccentricity(X6)
print({k: v for k, v in sorted(eccentricity_X6.items(), key=lambda item: item[1])})

# Infinite path lengths
# eccentricity_X7 = nx.eccentricity(X7)
# print({k: v for k, v in sorted(eccentricity_X7.items(), key=lambda item: item[1])})

# # Infinite path lengths
# eccentricity_X8 = nx.eccentricity(X8)
# print({k: v for k, v in sorted(eccentricity_X8.items(), key=lambda item: item[1])})
```

This is a preview of the python code for the portfolio network. For the project networks, the same structure is applied. Jupyter Notebook has been used to create the code, downloaded with Anaconda. The full Python files [.ipynb] and other supporting files can be downloaded here:

E4. Data-sharing networks

The survey answers of the respondents resulted in a large dataset that is used to visualize the corresponding data-sharing networks of the case projects and the total portfolio network.

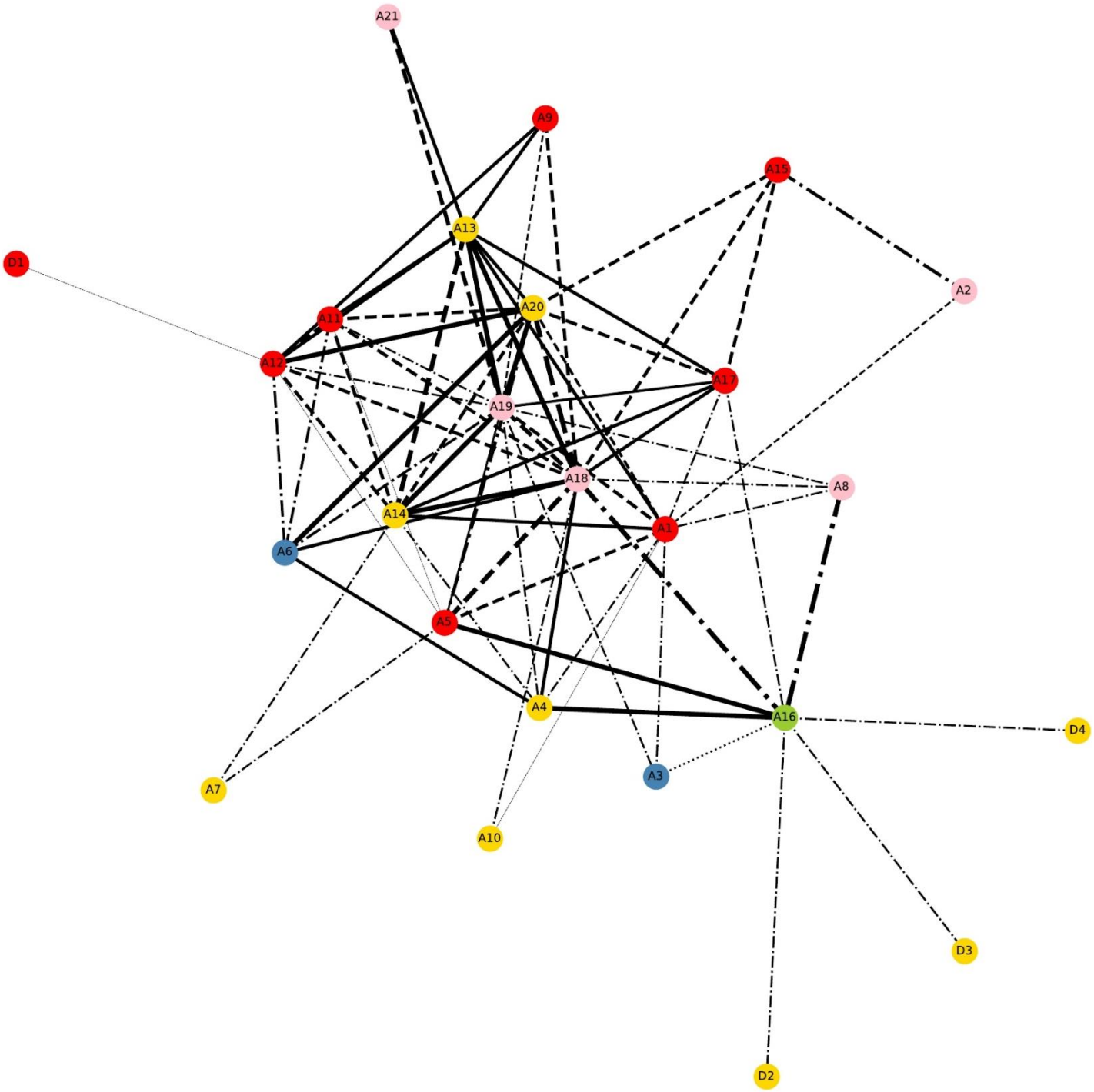


Figure 43: Detailed data-sharing network project A

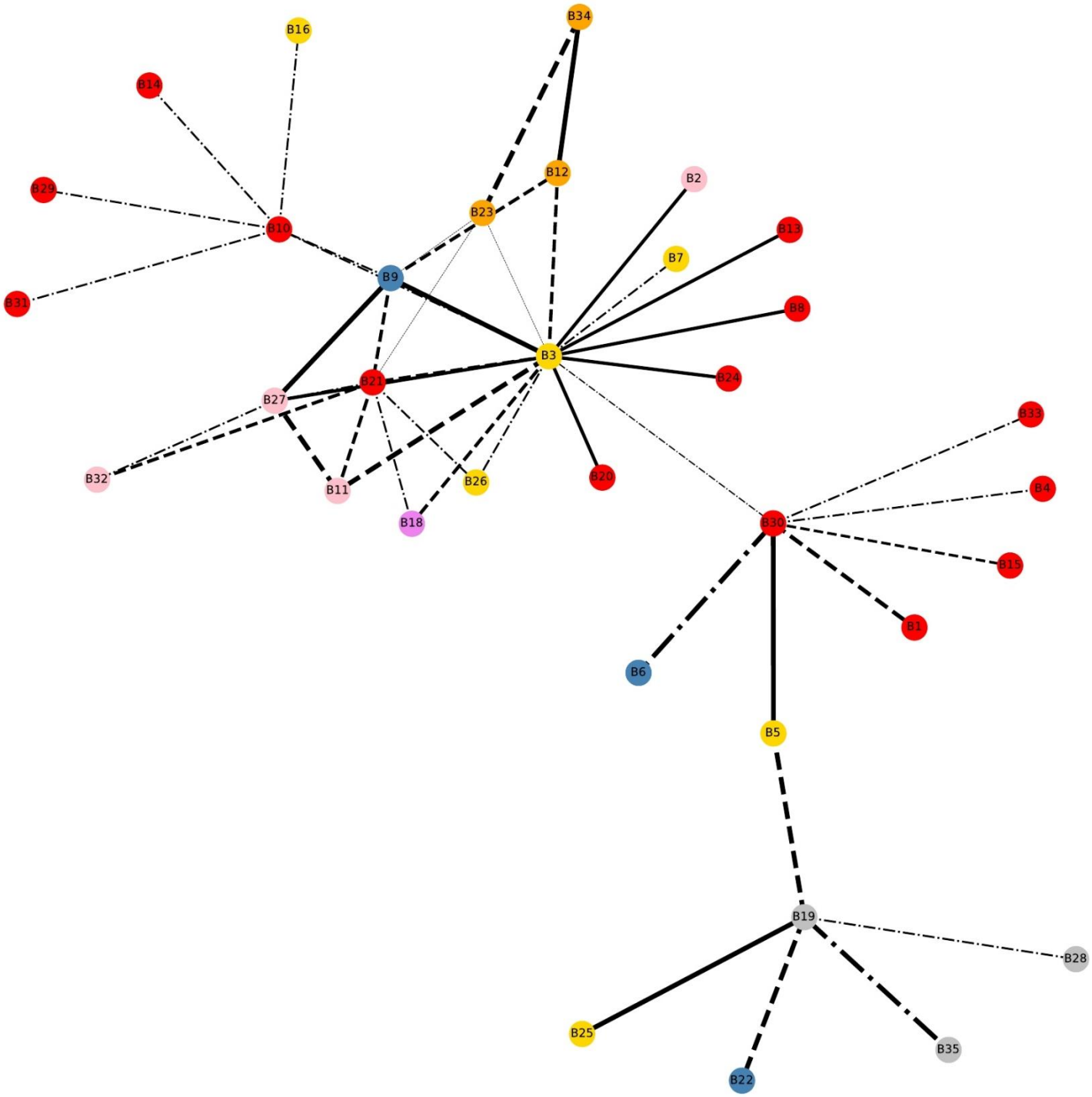


Figure 44: Detailed data-sharing network project B

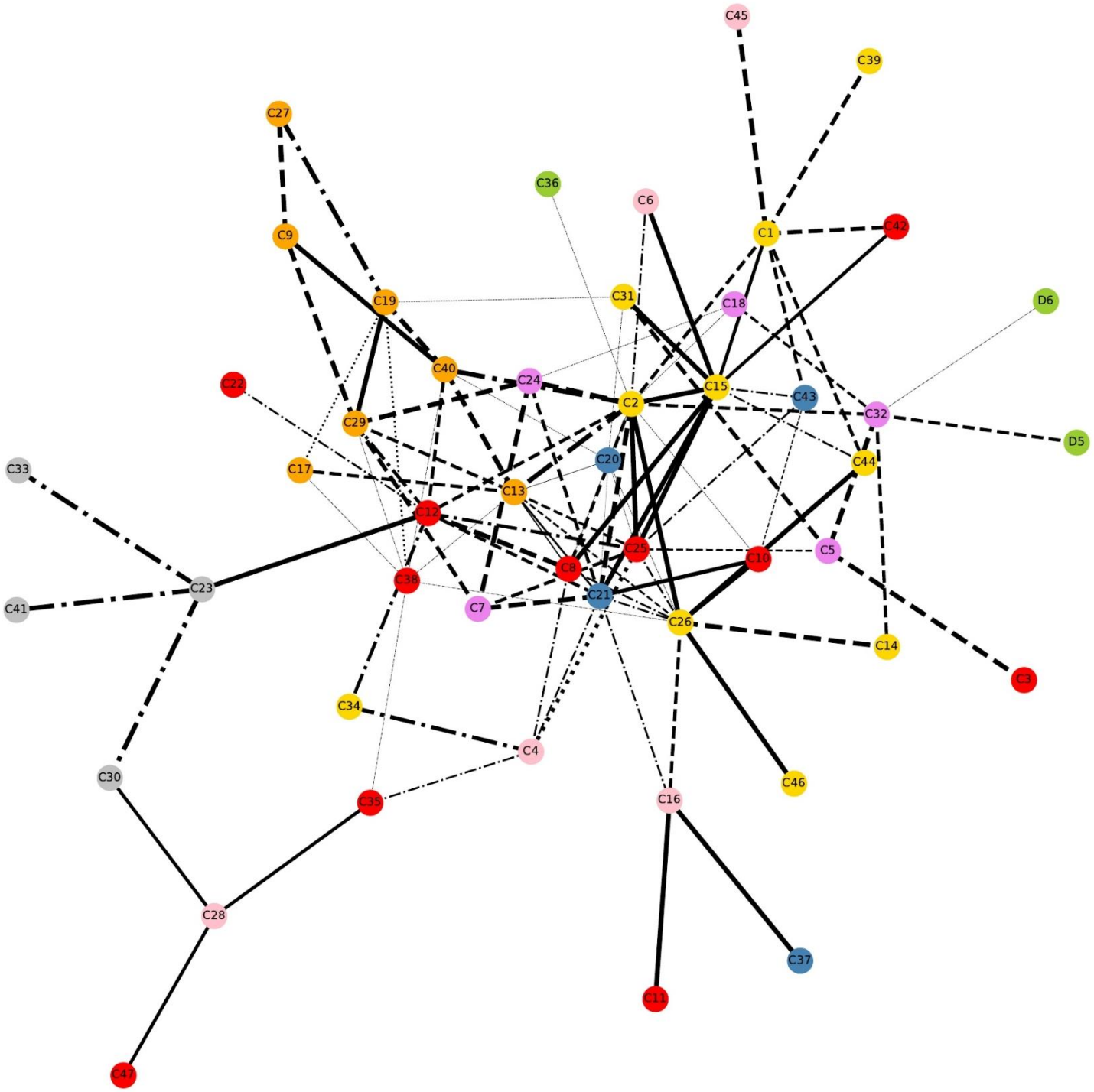


Figure 45: Detailed data-sharing network project C

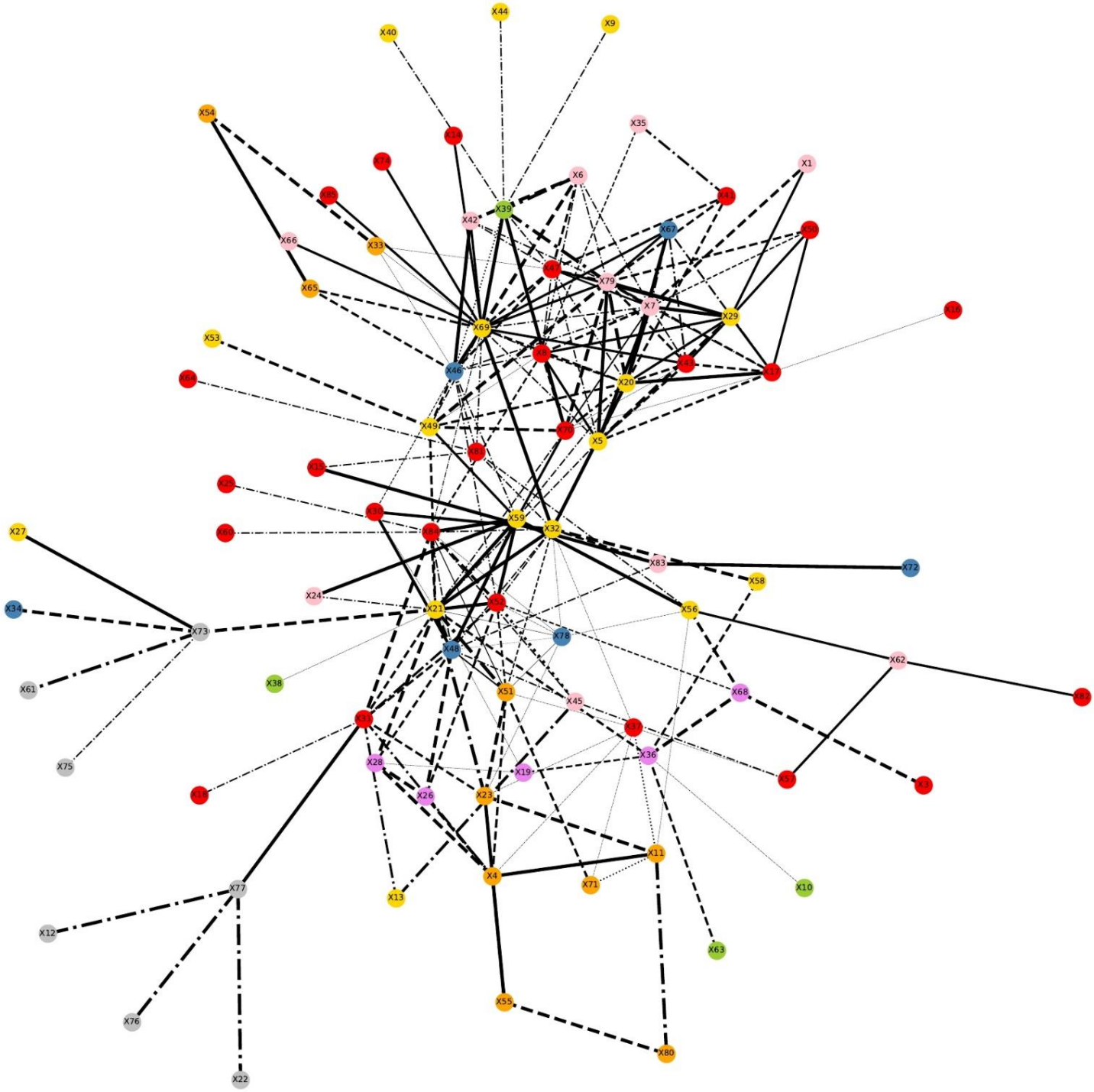


Figure 46: Detailed portfolio data-sharing network

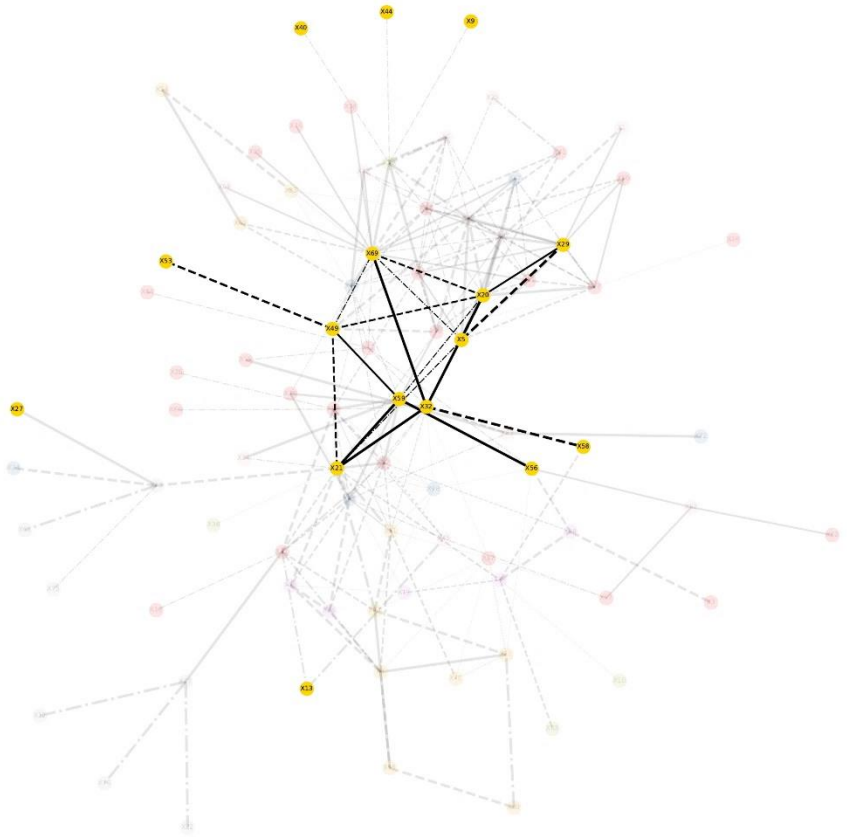


Figure 48: Project / Design management portfolio data-sharing network

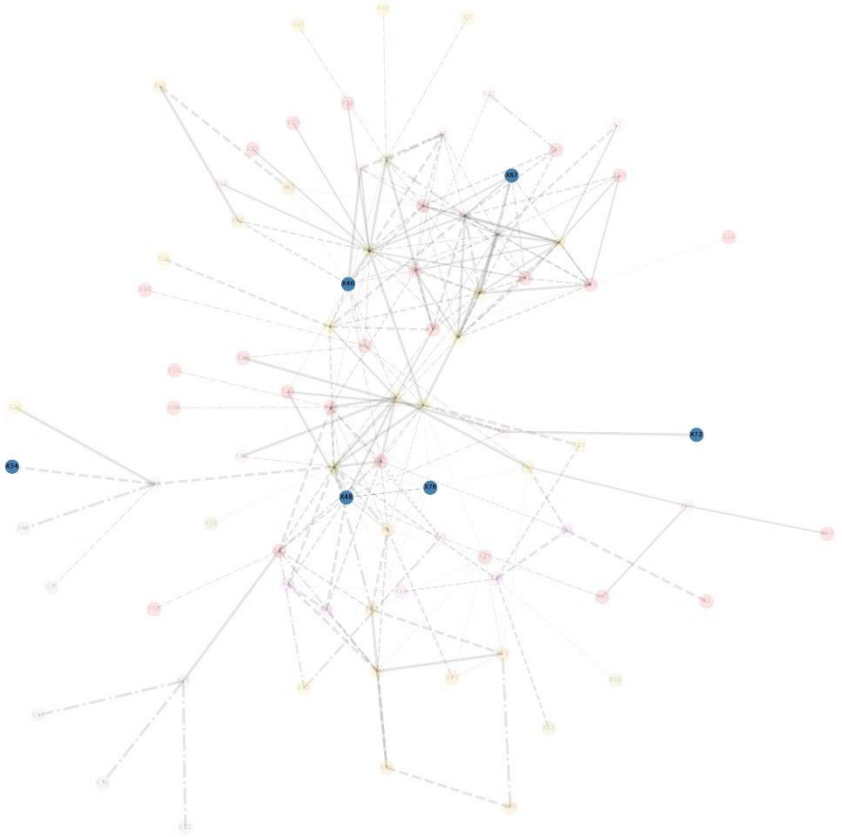


Figure 47: Project assistant portfolio data-sharing network

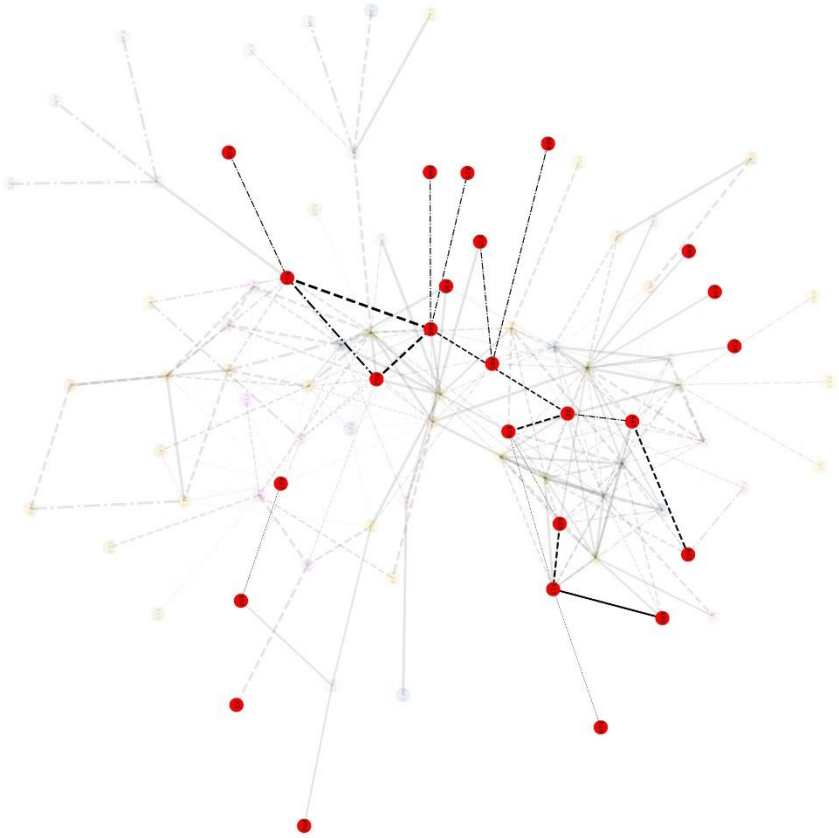


Figure 49: Engineering portfolio data-sharing network

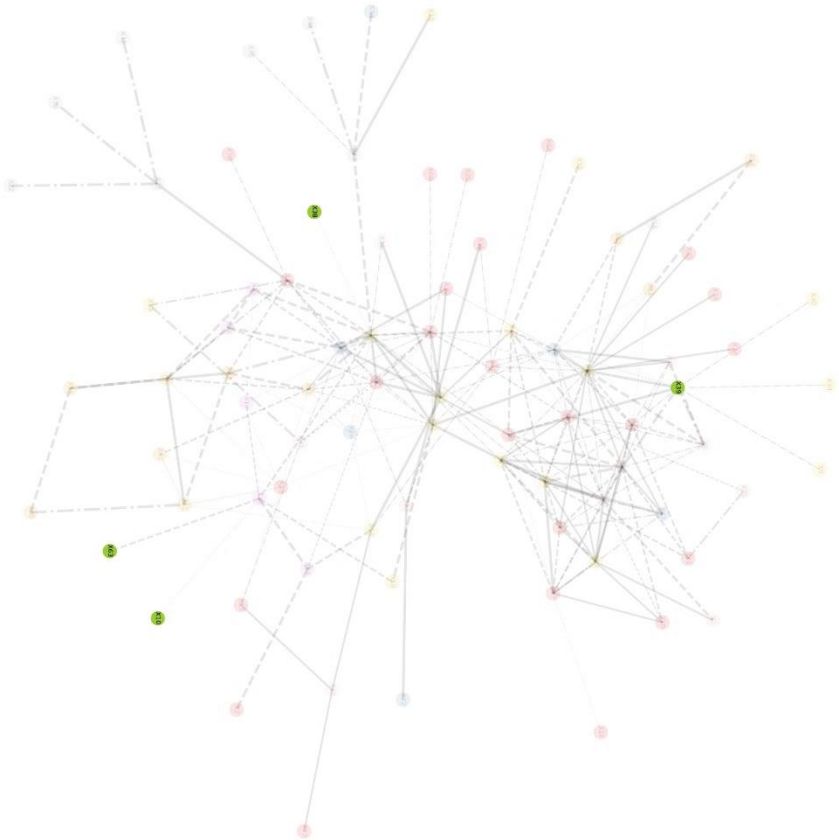


Figure 50: Tender & Contracting portfolio data-sharing network

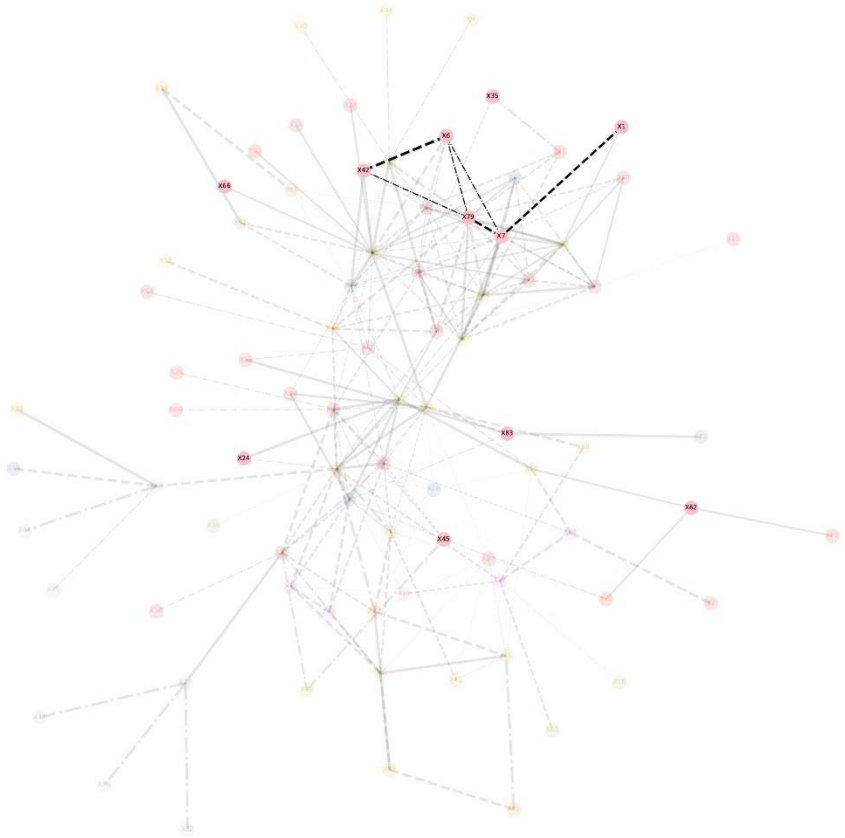


Figure 52: Drafting /Modelling /BIM portfolio data-sharing network

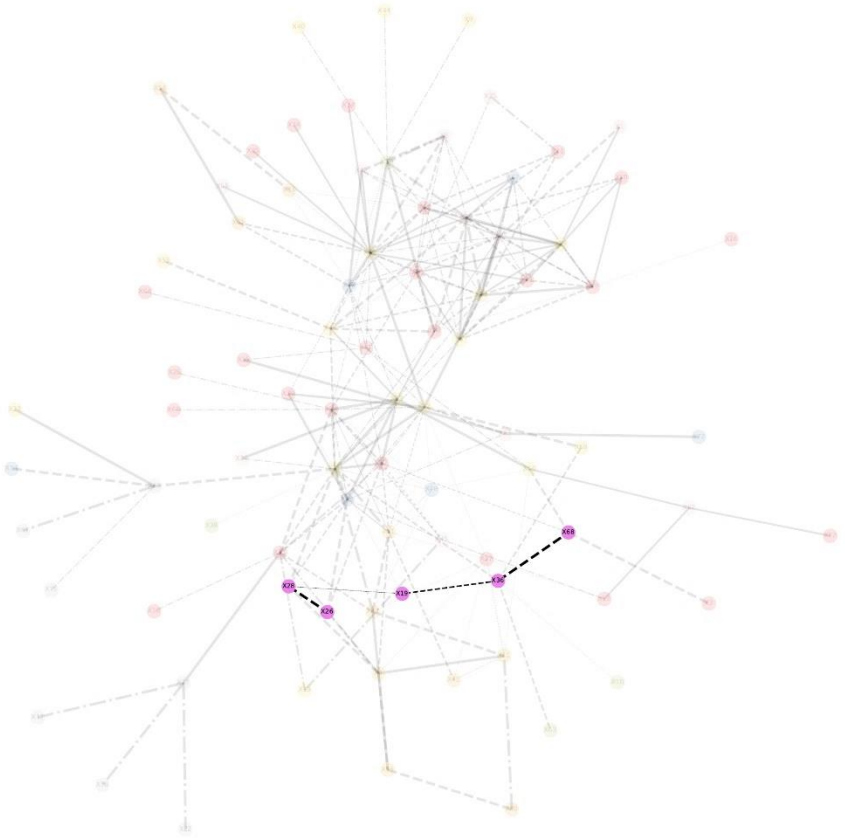


Figure 51: Costing portfolio data-sharing network

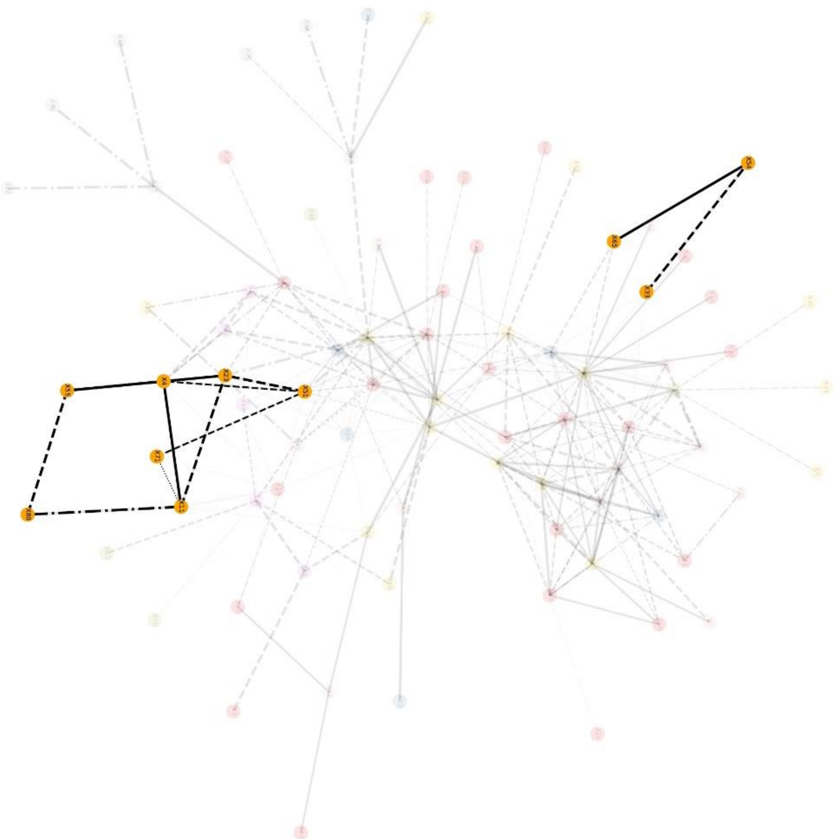


Figure 53: Construction management portfolio data-sharing network

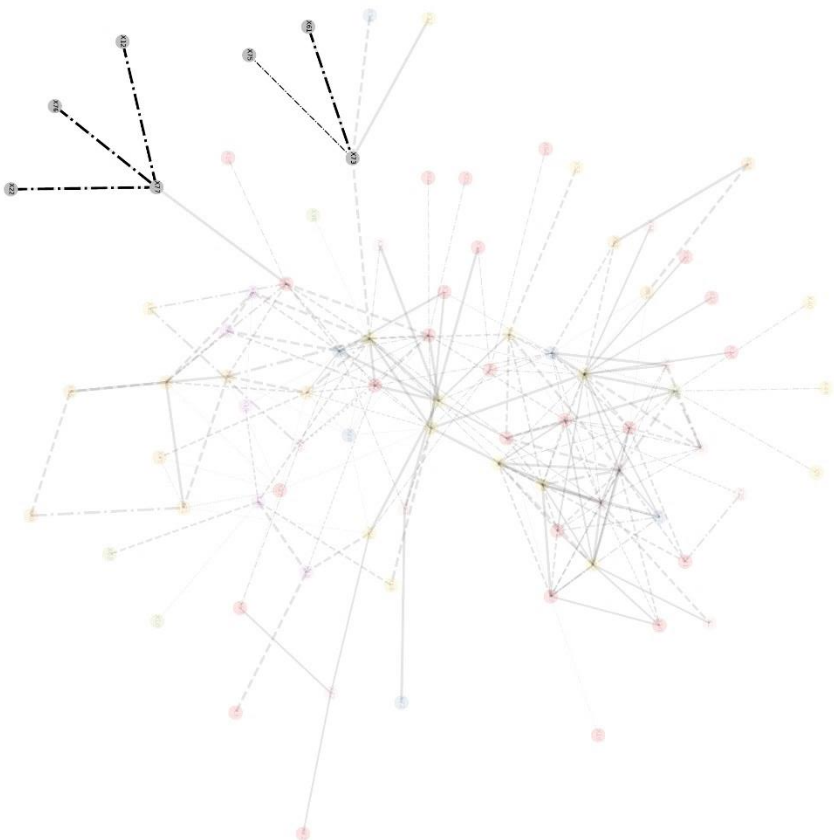


Figure 54: Other specialists portfolio data-sharing network

E5. Network analyses

The following network analyses have been applied in Networkx Python, providing more insights about the structures in the visualized networks:

Network analysis

- **Average degree** - Average degree of all present nodes in the network.
- **Network density** - The real number of connections in the network compared to the potential number of connections.
- **Average clustering** - sum of all the local clustering coefficients, the proportion of connections among its neighbors, divided by the number of nodes.
- **Average frequency and value** - The average frequency and value of all the present data streams (edges) between nodes in the network.
- **Most used and preferred tool** - Most used and preferred tool for sharing data.
- **Most applied and preferred collaboration** - Most used and preferred factors of collaboration in the network.

Node analysis

- **Degree** - The number of connections for each node.
- **Degree centrality** - A measure for the number of connections a node has compared to other nodes.
- **Eigenvector centrality** - A measure for the importance of the node by checking if it is connected to other important nodes.
- **Betweenness centrality** - Quantifies how many times a node is part of the shortest path between two other nodes.
- **Closeness centrality** - Determines how close a node is to all other nodes by taking the average of all the shortest paths of that node.
- **Eccentricity** - Largest distance between a node and all other nodes.

Next, findings are summarized for the three case project networks (Project A, B, and C) and the combined portfolio network. For the portfolio network, additional role specific networks were created.

Project A: Haiti brewery

Network analysis

Network details	#
Graph type	Undirected
Number of nodes	25
Project / Design management	9
Project Assistant	1
Engineering	9
Tender & Contracting	1
Drafting/ Modelling/ BIM	5
Costing	0
Construction management	0
Other Specialists	0

Network details	#
Number of edges	77
Average degree	6.1600
Network density	0.257
Average clustering	0.405
Average frequency	6.318
Average value	6.884
Most used tool	Email
Most preferred tool	Email
Most used collaboration	Professional
Most preferred collaboration	Open & transparent

Node analysis

	Degree	Degree centrality	Eigenvector centrality	Betweenness centrality	Closeness centrality	Eccentricity
A18	15	0.625	0.358	0.200	0.727	2
A19	15	0.625	0.367	0.135	0.667	3
A20	11	0.458	0.317	0.034	0.600	3
A1	11	0.458	0.247	0.110	0.585	3
A12	10	0.417	0.276	0.093	0.571	3
A13	10	0.417	0.286	0.040	0.585	3
A14	10	0.417	0.288	0.050	0.585	3
A16	9	0.375	0.140	0.253	0.571	3
A11	8	0.333	0.258	0.004	0.545	3
A17	8	0.333	0.236	0.046	0.586	3
A5	8	0.333	0.226	0.081	0.600	2
A4	6	0.250	0.178	0.025	0.558	3
A6	6	0.250	0.196	0.003	0.511	3
A15	4	0.167	0.106	0.017	0.471	3
A8	4	0.167	0.124	0.010	0.522	3
A9	4	0.167	0.144	0.000	0.490	3
A3	3	0.125	0.084	0.009	0.500	3
A10	2	0.083	0.068	0.0004	0.462	3
A2	2	0.083	0.039	0.002	0.393	4
A21	2	0.083	0.073	0.000	0.414	4
A7	2	0.083	0.057	0.001	0.414	3
D1	1	0.0417	0.031	0.000	0.369	4
D2	1	0.042	0.016	0.000	0.369	4
D3	1	0.042	0.016	0.000	0.369	4
D4	1	0.042	0.016	0.000	0.369	4

Tool use

Tool	#
Email	63
Face-to-face meeting	56
Skype / Phone call	43
Box	53
Chat	26
BIM 360 / Revit	4
MS Teams	3
Asite	0

Project B: Ethiopia brewery

Network analysis

Network details	#
Graph type	Undirected
Number of nodes	34
Project / Design management	7
Project Assistant	3
Engineering	14
Tender & Contracting	0
Drafting/ Modelling/ BIM	4
Costing	1
Construction management	3
Other Specialists	3

Network details	#
Number of edges	46
Average degree	2.706
Network density	0.082
Average clustering	0.189
Average frequency	6.185
Average value	6.543
Most used tool	Email
Most preferred tool	Email
Most used collaboration	Problem solving
Most preferred collaboration	Professional

Node analysis

	Degree	Degree centrality	Eigenvector centrality	Betweenness centrality	Closeness centrality	Eccentricity centrality
B3	16	0.485	0.542	0.757	0.559	4
B21	8	0.242	0.393	0.046	0.402	5
B30	7	0.212	0.126	0.534	0.478	3
B10	6	0.182	0.188	0.231	0.402	5
B9	6	0.182	0.341	0.033	0.413	5
B19	5	0.152	0.005	0.231	0.287	5
B27	5	0.152	0.300	0.026	0.384	5
B23	4	0.121	0.249	0.032	0.384	5
B11	3	0.091	0.227	0.000	0.375	5
B12	3	0.091	0.177	0.026	0.375	5
B18	2	0.061	0.172	0.000	0.371	5
B26	2	0.061	0.172	0.000	0.371	5
B32	2	0.061	0.128	0.000	0.292	6
B34	2	0.061	0.079	0.001	0.284	6
B5	2	0.061	0.024	0.265	0.363	4
B1	1	0.030	0.023	0.000	0.327	4
B13	1	0.030	0.100	0.000	0.363	5
B14	1	0.030	0.035	0.000	0.289	6
B15	1	0.030	0.023	0.000	0.327	4
B16	1	0.030	0.035	0.000	0.289	6
B2	1	0.030	0.100	0.000	0.363	5
B20	1	0.030	0.100	0.000	0.363	5
B22	1	0.030	0.001	0.000	0.224	6
B24	1	0.030	0.100	0.000	0.363	5
B25	1	0.030	0.001	0.000	0.224	6
B28	1	0.030	0.001	0.000	0.224	6
B29	1	0.030	0.035	0.000	0.289	6
B31	1	0.030	0.035	0.000	0.289	6
B33	1	0.030	0.023	0.000	0.327	4
B35	1	0.030	0.001	0.000	0.224	6
B4	1	0.030	0.023	0.000	0.327	4
B6	1	0.030	0.023	0.000	0.327	4
B7	1	0.030	0.100	0.000	0.363	5
B8	1	0.030	0.100	0.000	0.363	5

Tool use

Tool	#
Email	32
Face-to-face meeting	29
Skype / Phone call	27
Box	22
Chat	4
BIM 360 / Revit	0
MS Teams	0
Asite	0

Project C: Vietnam brewery

Network analysis

Network details	#
Graph type	Undirected
Number of nodes	49
Project / Design management	10
Project Assistant	4
Engineering	13
Tender & Contracting	3
Drafting/ Modelling/ BIM	5
Costing	3
Construction management	7
Other Specialists	4

Network details	#
Number of edges	107
Average degree	4.367
Network density	0.091
Average clustering	0.186
Average frequency	6.383
Average value	6.636
Most used tool	Email
Most preferred tool	Email
Most used collaboration	Professional
Most preferred collaboration	Professional

Node analysis

	Degree	Degree centrality	Eigenvector centrality	Betweenness centrality	Closeness centrality	Eccentricity centrality
C2	16	0.333	0.399	0.299	0.516	5
C26	12	0.250	0.310	0.160	0.462	4
C21	11	0.229	0.305	0.118	0.471	4
C13	10	0.208	0.309	0.052	0.449	4
C15	10	0.208	0.227	0.082	0.425	5
C25	10	0.208	0.279	0.117	0.471	4
C12	9	0.188	0.217	0.218	0.457	4
C20	8	0.167	0.278	0.019	0.429	5
C1	7	0.146	0.116	0.095	0.375	6
C29	7	0.146	0.138	0.042	0.387	4
C38	7	0.146	0.150	0.080	0.400	4
C40	7	0.146	0.194	0.062	0.421	4
C8	7	0.146	0.243	0.029	0.440	4
C19	6	0.125	0.086	0.044	0.366	4
C32	6	0.125	0.080	0.097	0.375	6
C24	5	0.104	0.135	0.013	0.390	5
C4	5	0.104	0.119	0.058	0.375	4
C10	4	0.083	0.146	0.005	0.387	5
C16	4	0.083	0.083	0.082	0.358	5
C23	4	0.083	0.030	0.121	0.340	4
C31	4	0.083	0.085	0.026	0.364	5
C43	4	0.083	0.100	0.006	0.364	5
C5	4	0.083	0.059	0.052	0.361	5
C7	4	0.083	0.112	0.005	0.366	5
C17	3	0.063	0.071	0.001	0.333	5
C18	3	0.063	0.080	0.003	0.366	6
C28	3	0.063	0.005	0.049	0.265	6
C35	3	0.063	0.036	0.076	0.329	5
C44	3	0.063	0.085	0.008	0.348	5
C9	3	0.063	0.046	0.010	0.312	5
C14	2	0.042	0.051	0.008	0.338	5
C27	2	0.042	0.017	0.001	0.273	5
C30	2	0.042	0.005	0.013	0.268	5
C34	2	0.042	0.044	0.002	0.329	4
C42	2	0.042	0.045	0.000	0.306	6
C6	2	0.042	0.082	0.000	0.356	6
C11	1	0.021	0.011	0.000	0.265	6
C22	1	0.021	0.028	0.000	0.316	5
C3	1	0.021	0.008	0.000	0.267	6
C33	1	0.021	0.004	0.000	0.255	5
C36	1	0.021	0.052	0.000	0.343	6
C37	1	0.021	0.011	0.000	0.265	6

C39	1	0.021	0.015	0.000	0.274	7
C41	1	0.021	0.004	0.000	0.255	5
C45	1	0.021	0.015	0.000	0.274	7
C46	1	0.021	0.040	0.000	0.318	5
C47	1	0.021	0.001	0.000	0.211	7
D5	1	0.021	0.010	0.000	0.274	7
D6	1	0.021	0.010	0.000	0.274	7

Tool use

Tool	#
Email	91
Face-to-face meeting	82
Skype / Phone call	82
Box	51
Chat	38
BIM 360 / Revit	19
MS Teams	1
Asite	0

Portfolio network: The multinational client

Network analysis

Network details	#
Graph type	Undirected
Number of nodes	84
Project / Design management	18
Project Assistant	7
Engineering	24
Tender & Contracting	5
Drafting/ Modelling/ BIM	11
Costing	3
Construction management	9
Other Specialists	5

Network details	#
Number of edges	224
Average degree	5.333
Network density	0.064
Average clustering	0.239
Average frequency	6.317
Average value	6.679
Most used tool	Email
Most preferred tool	Email
Most used collaboration	Professional
Most preferred collaboration	Professional

Node analysis

	Interview	Degree	Degree centrality	Eigenvector centrality	Betweenness centrality	Closeness centrality	Eccentricity centrality
Total network							
X69	X	22	0.265	0.316	0.213	0.439	4
X21	X	19	0.229	0.153	0.307	0.466	4
X79	X	16	0.193	0.296	0.027	0.366	5
…		…	…	…	…	…	…
X35	X	2	0.024	0.030	0.0003	0.283	6
X1		2	0.024	0.047	0.000	0.270	6
X9		1	0.012	0.013	0.000	0.263	7
X16		1	0.012	0.018	0.000	0.249	7
Project/ Design Management network							
X20	X	6	0.400	0.475	0.125	0.476	∞
X49		5	0.333	0.392	0.101	0.417	∞
…		…	…	…	…	…	…
X27		0	0.000	4.595e-11	0.000	0.000	∞
X13		0	0.000	4.595e-11	0.000	0.000	∞
Project Assistant network							
X48		1	0.200	0.707	0.000	0.200	∞
X78		1	0.200	0.707	0.000	0.200	∞
…		…	…	…	…	…	…
X67		0	0.000	1.349e-06	0.000	0.000	∞
X46		0	0.000	1.349e-06	0.000	0.000	∞
Engineering network							

X84	X	5	0.208	0.534	0.170	0.251	∞
X17		4	0.167	0.255	0.083	0.190	∞
X70	X	3	0.125	0.302	0.130	0.235	∞
…	…	…	…	…	…	…	…
X85		0	0.000	1.738e-47	0.000	0.000	∞
X30		0	0.000	1.738e-47	0.000	0.000	∞
Tender & Contracting network							
X39		0	0.000	0.500	0.000	0.000	∞
…	…	…	…	…	…	…	…
X38		0	0.000	0.500	0.000	0.000	∞
Drafting/ Modelling/ BIM network							
X79	X	3	0.300	0.537	0.022	0.320	∞
X6		3	0.300	0.537	0.022	0.320	∞
…		…	…	…	…	…	…
X83		0	0.000	1.786	0.000	0.000	∞
X35		0	0.000	1.786	0.000	0.000	∞
Costing network							
X19		2	0.500	0.578	0.667	0.667	2
X36	X	2	0.500	0.500	0.500	0.571	3
…		…	…	…	…	…	…
X68		1	0.250	0.289	0.000	0.400	4
X26		1	0.250	0.289	0.000	0.400	4
Construction Management network							
X11		4	0.444	0.470	0.126	0.500	∞
X51	X	3	0.333	0.374	0.048	0.400	∞
…		…	…	…	…	…	…
X65		1	0.111	3.692e-06	0.000	0.148	∞
X33		1	0.111	3.692e-06	0.000	0.148	∞
Other Specialists network							
X77		3	0.500	0.707	0.200	0.500	∞
X73	X	2	0.333	0.408	0.067	0.333	∞
…		…	…	…	…	…	…
X75		1	0.167	1.538e-05	0.000	0.222	∞
X61		1	0.167	1.538e-05	0.000	0.222	∞

Role specific tool and collaboration analysis

Tool analysis		*Collaboration analysis*	
Project / Design Management			
Most used	1. Email 2. Face-to-face	Most used	1. Professional 2. Reliable / Shared goals
Most preferred	1. Face-to-face 2. Email	Most preferred	1. Professional 2. Reliable
Project Assistant			
Most used	1. -	Most used	1. -
Most preferred	1. Face-to-face 2. Email	Most preferred	1. Professional 2. Reliable
Engineering			
Most used	1. Email 2. Skype / Phone call	Most used	1. Open & transparent 2. Problem solving / Quality assurance
Most preferred	1. Email 2. Skype / phone call	Most preferred	1. Professional 2. Open & transparent
Tender & Contracting			
Most used	1. -	Most used	1. -
Most preferred	1. Email 2. -	Most preferred	1. Open & transparent 2. Professional
Drafting / Modelling / BIM			
Most used	1. Box / Email 2. Face-to-face	Most used	1. Problem solving / Easily accessible / shared goals / Open & transparent / quality assurance 2. -

Most preferred	1. Email 2. BIM 360 / Revit	Most preferred	1. Professional 2. Open & transparent
Costing			
Most used	1. Face-to-face 2. Email	Most used	1. Open & transparent 2. Learning drive / Professional
Most preferred	1. Email 2. Box	Most preferred	1. Professional 2. Open & transparent
Construction Management			
Most used	1. Email 2. Face-to-face	Most used	1. Shared goals 2. Problem solving
Most preferred	1. Email 2. Box	Most preferred	1. Open & transparent 2. Mutual trust / Easily accessible
Other Specialists			
Most used	1. Email 2. Face-to-face	Most used	1. Problem solving 2. Open & transparent
Most preferred	1. Face-to-face 2. -	Most preferred	1. Professional 2. Open & transparent

Total tool use

Tool	#
Email	185
Face-to-face meeting	167
Skype / Phone call	152
Box	126
Chat	67
BIM 360 / Revit	23
MS Teams	4
Asite	0

Total collaboration applied

Soft collaboration factors	
Professional	125
Reliable	98
Open and transparent	86
Easily accessible	64
Mutual trust	37
Obligation	20
Safe	12
Total	*442*

Hard collaboration factors	
Problem solving	108
Shared goals	82
Quality assurance	69
Task instructing	54
Common routine	33
Learning drive	25
Suggested by others	6
Total	*377*

F. ROOT CAUSE ANALYSIS

F1. Interview respondents

Most important nodes

Table 44: Details of most connected nodes

#	Project	Code	Code	Role	Located	Nationality	Portfolio	Project	Role
1	A – Haiti	A18	X79	Drafting/Modelling/BIM	NL-RTM	NL	high	highest	highest
2	A – Haiti	A19	X7	Drafting/Modelling/BIM	NL-RTM	NL	medium	highest	highest
3	A – Haiti	A20	X20	Project/Design management	NL-RTM	NL	medium	high	highest
4	B – Ethiopia	B3	X69	Project/Design management	NL-RTM	NL	highest	highest	medium
5	B – Ethiopia	B30	X84	Engineering	VN-HCMC	VN	medium	high	highest
6	B – Ethiopia	B21	X47	Engineering	NL-NIJM	NL	medium	high	medium
7	B – Ethiopia	B19	X73	Other specialist	VN-HCMC	VN	low	medium	high
8	C – Vietnam	C2	X21	Project/Design management	VN-HCMC	NL in VN	highest	highest	medium
9	C – Vietnam	C26	X32	Project/Design management	VN-HCMC	VN	medium	highest	medium
10	C – Vietnam	C21	X48	Project assistance	VN-HCMC	VN	medium	highest	-
12	C – Vietnam	C32	X36	Costing	VN-HCMC	VN	medium	medium	high
13	C – Vietnam	C13	X51	Construction management	VN-HCMC	NL in VN	medium	medium	high

Least important nodes

Table 45: Details of least connected nodes

#	Project	Code	Code	Role	Located	Nationality	Portfolio	Project	Role
1	A – Haiti	A2	X35	Drafting/Modelling/BIM	NL-NIJM	NL	lowest	lowest	lowest
2	A – Haiti	A7	X21	Project/Design management	VN-HCMC	NL in VN	highest	low	medium
3	B – Ethiopia	B28	X62	Drafting/Modelling/BIM	VN-HCMC	VN	medium	lowest	lowest
4	B – Ethiopia	B35	X61	Other specialist	VN-HCMC	VN	low	low	low
5	C – Vietnam	C42	X70	Engineering	NL-RTM	NL	low	medium	high
6	C – Vietnam	C47	X82	Engineering	VN-HCMC	VN	lowest	lowest	lowest

F2. Interview protocol

Interview introduction

The aim of this interview is to qualitatively understand data sharing in the current data-sharing networks in the multinational portfolio of the brewery projects: **Ethiopia (phase 3), Vietnam (phase 5.1) and Haiti (phase 2).** The specific research problem to be addressed is: *How can data sharing enhance intra-organizational collaboration in multinational construction portfolios?*

Interview goals

This interview will determine what are the qualitative factors that define the level of data sharing in your organization. A list of potential data sharing factors has been retrieved from literature which will be validated by using a set of statements. Together we will discuss if you recognize and acknowledge these statements and what are the underlying reasons for that. Main interview research question: *How does data sharing influence the level of intra-organizational collaboration in multinational construction projects in practice?*

Table 46: Interview statements (EN)

#	Interview statements
1	An accessible and up-to-date data sharing environment enhanced my data sharing.
2	Support and triggers from higher management enhanced my data sharing.
3	A clear and flexible data sharing environment enhanced my data sharing.
4	Personal development and training enhanced my data sharing.
5	Trust in people and the data sharing environment enhanced my data sharing.
6	A reliable and impactful data sharing environment enhanced my data sharing.
7	Facilities for global interaction and awareness enhanced my data sharing.
8	Global standardization and alignment enhanced my data sharing.
9	My digital interest and expertise enhanced my data sharing.
10	My project involvement enhanced my data sharing.

Table 47: Interview statements (NL)

#	Interview statements
1	Een toegankelijk en up-to-date datasysteem verbeterde mijn data-uitwisseling.
2	Ondersteuning en triggers van hoger management verbeterde mijn data-uitwisseling.
3	Een praktisch en flexibel datasysteem verbeterde mijn data-uitwisseling.
4	Persoonlijke ontwikkeling en training verbeterde mijn data-uitwisseling.
5	Vertrouwen in collega's en het datasysteem verbeterde mijn data-uitwisseling.
6	Een betrouwbaar en waardevol datasysteem verbeterde mijn data-uitwisseling.
7	Faciliteiten voor wereldwijde interactie en bewustzijn verbeterde mijn data-uitwisseling.
8	Wereldwijde standaardisatie en afstemming heeft mijn data-uitwisseling verbeterd.
9	Mijn digitale interesse en expertise verbeterde mijn data-uitwisseling.
10	Mijn betrokkenheid in het project verbeterde mijn data-uitwisseling.

Table 48: Interview setup

Agrees with statement and applies to the project because …	Disagrees with statement but applies to the project because …	Agrees with statement but does not apply to the project because …	Disagrees with statement and does not apply to the project because …
Five times why?	Five times why?	Five times why?	Five times why?
Root cause of success	**Root cause of success**	**Root cause of problem**	**Root cause of problem**

F3. Interview answers

Interview 1: A18 / B32 / C45 / X79

Statement 1 Eens maar geldt niet voor het project omdat …	Statement 2 Oneens en geldt niet voor het project omdat …
Waarom? Er heeft te veel informatie uitwisseling plaatsgevonden en dat kwam omdat er juist niet goed gebruik werd gemaakt van een centraal en up-to-date data systeem. Waarom werd er niet goed gebruik gemaakt van het centrale systeem? Het is niet voor iedereen vanzelfsprekend om het centrale datasysteem te gebruiken waardoor er overbodige uitwisseling ontstond en het niet duidelijk was wat de laatste versies waren. Waarom zat dat niet bij iedereen in het systeem? Data ontwikkelingen waren nog nieuw en daardoor niet genoeg bekend bij het team. Hierdoor werd de drempel om alles centraal te organiseren te hoog. Waarom lag die drempel te hoog? De expertise op dat gebied ontbrak nog in het team. Ik als modelleur ben wel ingezet om alle documenten uiteindelijk centraal op te slaan dus het ging uiteindelijk goed maar het had efficiënter gekund. Waarom ontbrak die expertise? Niet iedereen neemt daar dezelfde moeite omdat het veel tijd kost om die expertise op te bouwen. En die tijd was er eigenlijk nooit in het project.	Waarom? In het begin van het project was er een push vanuit hoger management om data systemen beter in te zetten. Maar dit heeft niet voor betere data uitwisseling gezorgd bij mij. Waarom heeft dat niet tot meer data uitwisseling geleidt? Omdat het door hoger management als een plan werd opgelegd en er verder niet veel werd georganiseerd. Hierdoor ontstonden er te veel meningen en weinig direct resultaat of actie. Waarom lukt het niet om dat plan uit te voeren? Er was geen eenduidigheid of iemand die dit coördineerde dus het creëerde geen toegevoegde waarde en werd het hierdoor niet doorgezet. Waarom was er geen coördinatie voor de uitvoering? Niemand in het project kon die rol op zich nemen om ze daar de tijd niet voor hadden of de expertise. -
Root cause **Pushing deadlines**	Root cause **Lack of coordination**

Statement 3 Eens en geldt voor het project omdat ...	Statement 4 Eens en geldt voor het project omdat ...
Waarom? Box was duidelijk en je hoefde niet lang in mappen te zoeken als je bepaalde informatie nodig had, dat maakte het een betrouwbaar systeem omdat je documenten in de toekomst nog terug kon vinden. Waarom hoefde je niet lang te zoeken? Wanneer het document gerealiseerd en goedgekeurd was, werd het in Box in een duidelijke mappen structuur geplaatst. Waarom was die structuur duidelijk? De structuur was herkenbaar van andere projecten en was logisch en netjes opgebouwd. Wel was het soms onduidelijk of het de laatste versies betrof. Waarom was het onduidelijk of het de laatste versie betrof? Dit kwam omdat het mogelijk was dat er werd gecommuniceerd via de mail of face-to-face wat niet altijd centraal werd bijgehouden. Waarom werd dat niet centraal bijgehouden? Omdat het niet allemaal is bij te houden wat men met elkaar bespreekt of mailt, daarom probeerde ik mijn uitwisseling minimaal te houden om zo de duidelijkheid en efficiëntie te vergroten met minder onnodig dataverkeer.	Waarom? Er is geen ruimte voor training of zelfontwikkeling geweest en daarom heb ik mijzelf verder tijdens het project ontwikkeld op dat gebied. Waarom was er geen ruimte voor training? Hier was geen tijd voor en in de projecten leer je ook door er zelf mee aan de slag te gaan zonder training. Dit kan je ook een volgende keer opnieuw toepassen. Waarom heb je jezelf ontwikkelt? Dat was nodig in het belang van het project omdat er door de klant vraag was naar modellen en gebruik van datasystemen. Dit deed ik niet voor mijn eigen belang. Waarom was er dit belang bij de klant? Om efficiënter te werken en meer waarde uit de beschikbare data te halen. Zo had ik minder informatie verkeer nodig om hetzelfde over te brengen. Waarom is minder dataverkeer efficiënter? Veel dataverkeer tussen mensen veroorzaakt ruis in een project en maakt het onduidelijk wat de laatste versies zijn.
Root cause **Simplicity in communication**	Root cause **Eager to learn**

Statement 5 Eens en geldt voor het project omdat ...	Statement 6 Eens maar geldt niet voor het project omdat ...
Waarom? In het project deelde ik makkelijker informatie met de mensen die ik goed vertrouw en dat was bijna met iedereen even goed. Waarom deel je data makkelijker met hen? Omdat ik van die personen beter opmerkingen over mijn werk kan aannemen. In andere projecten heb ik wel eens iemand minder gemogen en daar ontstaat dan toch een kleine barrière. Waarom kan je van hen beter feedback aannemen? Als je langer en vaker met mensen werkt en ze spreekt op kantoor dan groei je echt naar elkaar toe en wordt die drempel om te delen nihil. Waarom was dat zo in het project? Vooral met mensen op hetzelfde kantoor kan dit worden opgebouwd en dit project was bijna volledig vanuit Rotterdam uitgevoerd. Andere projecten waar je met Nijmegen of VN samenwerkt is die samenwerking al moeilijker te bewerkstelligen door afstand, tijdsverschil en taalbarrières. Waarom maakt dat het moeilijker om elkaar te vertrouwen? Vaak weet je niet precies wat er met jouw informatie gedaan wordt op een andere locatie en of informatie überhaupt wel goed overkomt. Hierdoor ontstaat vaak weer te veel informatieverkeer om de controle te proberen te houden.	Waarom? Introduceren van nieuwe systemen lijkt vaak waardevol maar is het niet altijd. In dit project was er geen sprake van het introduceren van nieuwe systemen. Waarom zijn nieuwe datasystemen niet altijd waardevol? Als er nieuwe 'digital ways of working' worden ingebracht moet dit door het hele team en ook vooral door de klant worden ondersteund anders heeft de nieuwe introductie geen zin. Waarom was er geen waardevol systeem in dit project? Tijdens dit project was niets nieuws geïntroduceerd en was het systeem dat we hadden met Box ook niet per se zo waardevol dat ik er beter ben door gaan delen. Waarom was er niets geïntroduceerd? Er wordt nu nog heel vaak in 2D tekeningen gedacht en niet in 3D modellen. Dit moet in de toekomst wel veranderen om het werk te verbeteren. Er moeten systemen komen waar iedereen achter staat en waar men eenduidig mee gaat werken. Waarom is die verandering in mindset nodig? Omdat we dan efficiënter en sneller kunnen werken en een betere afstemming ontstaat binnen het team en extern met de klant. Bij jonge PM's zie je dat zij al wel vaker zulke systemen opnemen in hun projecten.
Root cause **Physical presence**	Root cause **Lack of commitment**

Statement 7 Eens maar geldt niet voor het project omdat ...	Statement 8 Eens en geldt voor het project omdat ...
Waarom? Het zou helpen als er betere faciliteiten zouden zijn om wereldwijde integratie verder te realiseren. Gedurende het project waren er problemen op dit gebied. Waarom waren er problemen? Doordat er in het buitenland slecht internet of minder software capaciteit was konden zij onze grote bestanden en modellen niet altijd openen. Waarom hebben zij slechtere faciliteiten? Op de locaties waar de projecten plaatsvinden zijn vaak niet de gelijke mogelijkheden om op hetzelfde level als in NL te werken. Hierdoor ontstaat er onnodig meer informatieverkeer tussen locaties. Waarom ontstaat er meer onnodig dataverkeer? Wij maken 3D modellen die zij vervolgens moesten opzetten naar 2D modellen en dan weer naar NL stuurden. Zo ontstaat er een dubbele hoeveelheid aan informatie met dezelfde inhoud wat niet efficiënt is. Waarom hebben zij geen gelijke mogelijkheden? Hier wordt geen budget voor vrijgemaakt maar kan ook simpelweg nog niet overal gerealiseerd worden.	Waarom? Ja er ontstond tijdens het project een manier van werken die voor de verschillende locaties en teamleden bekend en duidelijk was. Hierdoor kon er beter en efficiënter data met elkaar worden uitgewisseld via het Box systeem. Waarom is dat ontstaan tijdens het project? Eerst werden er te veel e-mails rondgestuurd die het team en ook mij van mijn daadwerkelijke werk afhielden. Ik heb toen gecommuniceerd voorgelegd naar het team dat dit anders moest. Waarom moest het data uitwisselen anders? Er waren geen eenduidige afspraken over hoe we informatie zouden gaan uitwisselen met elkaar. Iedereen deed in het begin eerst wat voor hem/haar zelf het beste uitkwam en beperkte de efficiëntie. Waarom waren er geen eenduidige afspraken? Dit hadden we niet besproken met elkaar en daarom deed iedereen wat voor haar/hemzelf het beste werkte. De een stuurde lange mails en de ander deelde informatie pas als de laatste beslissing werd gemaakt. Waarom waren er verschillende in communicatie? De werkwijze die mensen aannemen is heel persoonlijk en verschillend per leeftijd, ervaring en rol als je er geen afspraken over gemaakt worden.
Root cause **Missing budget**	Root cause **Shared agreements**

Statement 9 Eens en geldt voor het project omdat ...	Statement 10 Eens en geldt voor het project omdat ...
Waarom? Ja ik heb tot zekere hoogte expertise op het gebied van data delen en dat helpt mij om er handig mee om te gaan. Waarom helpt jou dat in het gebruik? Ik heb de expertise om mensen info te sturen waarvan ik denk dat ze het nodig zullen hebben in plaats van dat zij altijd aan mij om die informatie moeten vragen omdat ik me daar verantwoordelijk voor voel. Waarom voel jij je daar verantwoordelijk voor? Bij het modelleerwerk wat ik doe hoort het dat ik mijn ik mijn werk blijf delen ter controle en om te bespreken. Waarom heb jij die expertise? Omdat ik altijd durf te vragen om uitleg en hulp wanneer nodig. Maar mijn expertise gaat niet zo ver als IoT of Big data. Waarom gaat jouw expertise niet zo ver? Ik interesseer me niet zo voor die hele digitale ontwikkelingen en houd mij daar niet heel erg mee bezig. Er is wel training geweest maar daar wist ik niet altijd waar het over ging en dat heeft het merendeel.	Waarom? Ja en het is een wisselwerking tussen teamleden en hoe betrokken iedereen zich voelt. In dit project was dat heel hoog dus er werd veel gedeeld met elkaar. Waarom was de betrokkenheid hoog? Er zijn een aantal factoren die elkaar positief hebben beïnvloed; het vertrouwen was goed, we zagen elkaar vaak en daarmee deelden we makkelijk en snel met elkaar. Waarom waren die factoren zo positief? We werkten met het hele team in Nederland dus we zagen elkaar veel op kantoor. Hierdoor wordt de teamspirit beter en was er nauwelijks een drempel om te delen. Waarom? - Waarom? -
Root cause **Eager to learn**	Root cause **Physical presence**

Interview 2: A20/ B18/ C44/ X20

Statement 1 Eens maar geldt niet voor het project omdat ...	Statement 2 Eens maar geldt niet voor het project omdat ...
Waarom? Voor mij heeft dat niet tot betere data uitwisseling geleidt. Ik hield vaak de informatie vast bij mijzelf voordat ik het deelde. Waarom hield je de informatie vast? Ik werkte niet prettig met Box en het plaatsen van documenten in die omgeving. Dat vroeg ik vaak aan de BIM modelleurs om dat 'administratief' werk bij te houden. Waarom vroeg je dat aan hen? Zij kunnen dat veel sneller en makkelijker dan ik en ik maakte meer gebruik van de bestanden op mijn eigen computer. Terwijl offline info veel kwetsbaarder is en mensen daardoor ook info missen. Waarom gebruik je de offline omgeving? Ik vind dat niet alles gedeeld hoeft te worden omdat dat ruis veroorzaakt en slechts de definitieve conclusies het belangrijkst zijn. Maar daarmee maak ik ook niet genoeg gebruik van de mogelijkheden om veiliger en open te delen. Waarom maak je niet gebruik van de mogelijkheden? Ik mis de kennis en expertise om snel met Box te werken. Andere mensen zijn daar beter in, ik heb niet te tijd om mezelf heel erg bij te training en ben daar ook wellicht te oud voor.	Waarom? We moesten Box gebruiken maar verder waren er niet meer triggers vanuit hoger management om meer data te delen. Waarom waren er geen triggers? Dat was toen niet aan de orde en iedereen in het team kreeg de data die hij/zij nodig had op tijd. Wel zijn er scrum sessies geweest voor vroegtijdige afstemming in het team, maar dat kwam niet van hoger management. Waarom was het niet aan de orde bij hoger management? Het project liep goed en er was geen aanleiding toen om dingen te veranderen op het gebied van data-uitwisseling. Hoger management zag dat waarschijnlijk niet als een prioriteit. Waarom waren er wel scrum sessies georganiseerd? Dit was een pilot tijdens ons project om te kijken hoe dit voor een NL projectteam zou werken. De meningen waren verdeeld, maar uiteindelijk is er een minder intensieve variant doorgezet met goed resultaat. Waarom was de scrum opzet veranderd? Dit paste beter bij de flow van het project en het team. Bij dagelijkse scrum meetings was er regelmatig niets nieuws te melden en werd tijd verspild. De mildere variant was een goede tussenweg.
Root cause **Missing skills**	Root cause **Missing drive to change**

Statement 3 Eens en geldt voor het project omdat ...	Statement 4 Eens maar geldt niet voor het project omdat ...
Waarom? We hadden een flexibel Box systeem maar wel met een herkenbare structuur. Dat heb je nodig anders is er te veel flexibiliteit en is niets terug te vinden voor anderen. Waarom was het herkenbaar? Deze basisstructuur in Box is ook organisatie breed afgesproken en hebben wij daarom ook toegepast in ons project. Het is enigszins mogelijk om de structuur flexibel op het project af te stemmen. Waarom heb je die flexibiliteit nodig? Het project bestond uit veel complexe onderdelen en fases. Je wil dat het makkelijk in te delen is tijdens het project maar ook terug te vinden is na het project. Waarom heeft dat jouw uitwisseling verhoogd? Anderen hebben voor mij mijn bestanden opgeslagen tijdens het project. Daarna kon ik goed gebruik maken van de traceerbaarheid van de data. Waarom? -	Waarom? Er was geen extra training of ruimte voor persoonlijke ontwikkeling voor mij tijdens het project. Het had mij wel erg kunnen helpen omdat ik juist een achterstand heb. Waarom heb je een achterstand? Ik was 10 jaar werkzaam op een andere locatie en voor een andere werkgever. Hierdoor ben ik achtergelopen op de ontwikkelingen die zich hier afspeelde en was er geen ruimte na terugkomst om dit in te halen. Waarom was er geen ruimte meer later? Ik had tijdens het project geen tijd om bezig te zijn met persoonlijke ontwikkeling en het volgen van trainingen. Dit werd ook niet direct aanbevolen. Waarom werd dit niet aangeboden? Je kan wel zelf training oppakken met online courses maar ik heb dat niet gedaan omdat het altijd druk was met het project Waarom? -
Root cause **Adjustable structure**	Root cause **Pushing deadlines**

Statement 5 Eens en geldt voor het project omdat ...	Statement 6 Oneens en geldt niet voor het project omdat ...
Waarom? In het project was er veel vertrouwen onderling bij de teamleden en ook had ik het vertrouwen dat ons datasysteem goed genoeg werkte. Waarom was het vertrouwen goed? Het contact was goed, we zagen elkaar dagelijks en ik wist wat we aan elkaar hadden. Hierdoor werk je samen naar een beter projectresultaat. Waarom heeft dat de uitwisseling verhoogd? Het heeft de uitwisseling verbeterd maar niet per se verhoogd. Ook als ik collega's minder zou vertrouwen moet er data uitgewisseld worden om het project te leveren. Waarom heeft het de uitwisseling verbeterd? Als je vertrouwen hebt in je collega's hoef je niet meer te delen dan nodig is. Mensen worden zo niet overdonderd met informatie waar ze niets mee kunnen. Waarom is dat van belang? Om zo mensen beter hun werk te kunnen laten doen zonder onnodige afleiding. Het is wel lastig om een keuze te moeten maken in noodzaak en snelheid.	Waarom? Tijdens het project heeft een datasysteem daar niet voor gezorgd bij mij. Ik heb mijn data gewoon via de mail uitgewisseld en dat gaf niet meer impact. Waarom gaf heeft een datasysteem jou niet meer impact? De datasystemen die nu worden geïntroduceerd zijn niet per se voor iedereen waardevol en gebruiksvriendelijk omdat ze te ingewikkeld zijn voor sommigen. Waarom is het te ingewikkeld? Ik heb nooit geleerd hoe ik daar goed mee om moet gaan en het zijn allemaal nieuwe tools wat juist ook meer verwarring kan veroorzaken in een project. Waarom ontstaat er meer verwarring? Omdat er meer onnodig dataverkeer ontstaat als niet iedereen dezelfde middelen gebruikt. Dat moet juist voorkomen worden. Waarom? Te veel data verkeer geeft ruis aan het team en het resultaat. Je wil data systemen die makkelijk en snel te gebruiken zijn en gebruiksvriendelijk voor iedereen.
Root cause **Simplicity in communication**	Root cause **Information overload**

Statement 7 Eens en geldt voor het project omdat ...	Statement 8 Eens en geldt voor het project omdat ...
Waarom? Het project werd voornamelijk in NL uitgevoerd maar een onderdeel hebben we in VN gedaan en daar was de interactie goed d.m.v. Skype en Box.	Waarom? Tijdens het project is er naar gestreefd om wereldwijd dezelfde taal te gebruiken en met dezelfde codes en modellen te werken.
Waarom was de interactie goed? Ze zaten er in VN bovenop en hebben in de afgelopen jaren veel geleerd van NL. Vooral op het gebied van brouwerij projecten zijn ze professionals aan het worden, leveren ze goed werk aan ons en is uitwisseling toegenomen.	Waarom heeft dat tot meer uitwisseling geleid? Dit maakt het makkelijker om te delen. Dit heeft de uitwisseling niet verhoogd maar verbeterd en juist het onnodige dataverkeer verminderd door betere afstemming.
Waarom is de interactie toegenomen? Er was elke week overleg en de faciliteiten om informatie en gegevens met elkaar te delen was tijdens het project al enorm en werden goed ingezet.	Waarom heeft dat tot betere uitwisseling geleid? Dat komt door eenduidige processen en het kunnen toepassen van filters/ en zoektermen. Hierdoor ontstaat er ook minder verwarring omdat iedereen elkaar begrijpt.
Waarom was die hoge interactie nodig? Zij willen ook verdienen aan het project en daarom in een zo kort mogelijk tijd het werk leveren. Daarvoor is het van belang om constant op de hoogte te zijn. De taal is wel echt een barrière omdat je elkaar niet goed verstaat.	Waarom is dat nodig? We zijn hier stappen in aan het maken om efficiënter te kunnen werken en die moeten nog veel verder gaan. Het is echter wel van belang dat ze deze stappen niet te snel willen nemen als organisatie wat nu vaak wel het geval is.
Waarom en hoe was er interactie met het uitvoeringsteam? De klant heeft in dit project zelf mensen in dienst voor de bouw van de brouwerij. Wij blijven dan alleen als backoffice actief voor civiele vragen. Dat is tijdens het project wel gebeurd en dan heb je korte directe lijnen met de mensen in de uitvoering en ben je veel heen en weer aan het bellen en communiceren op allerlei manieren om het zo snel mogelijk te kunnen helpen (whatsapp, scherm delen, tekeningen mailen, etc.).	Waarom is te snel werken niet nuttig? Als de organisatie te snel wil gaan en niet iedereen zit op hetzelfde niveau om hierin mee te gaan ontstaat er weerstand vanuit de werknemers. Het is een proces en niet iets wat direct kan worden opgelegd en uitgevoerd.
Root cause **Fast problem solving**	Root cause **Taking small steps**

Statement 9 Eens maar geldt niet voor het project omdat ...	Statement 10 Eens en geldt voor het project omdat ...
Waarom? Mijn expertise is niet hoog maar door te werken met programma's ben ik wel beter geworden. Daardoor ben ik niet meer maar wel efficiënter mijn informatie gaan delen. Waarom ben je er beter in geworden? Omdat je vaker met systemen en programma's werkt word je er handiger in maar dat kost wel tijd. Nu zijn er weer veel nieuwe systemen en daar moet ik nu erg aan wennen. Waarom moet je daar aan wennen? Omdat er dan soms nog zaken fout gaan waar niemand je mee kan helpen of ondersteunen. Of het duurt te lang waardoor je snel terugvalt op je oude gewoontes. Waarom val je dan terug op oude gewoontes? Omdat ik daarmee weet te werken en mijn werk snel voort kan zetten. Ik mis een duidelijke uitleg en goede werking van nieuwe systemen. Waarom? -	Waarom? Als projectmanager was ik zeer betrokken en iedereen die mee werkte aan het project was dat ook voor zijn rol. Daarom deelde ik ook alles wat nodig was met het team. Waarom werd je uitwisseling hoger? Als project manager ben je verantwoordelijk voor het hele project en moet je als een spin in het web zijn en met iedereen communiceren. Waarom moet je met iedereen communiceren? Het is van belang dat je het totaal overzicht hebt en dat je daarmee met de juiste mensen op het juiste moment kan overleggen. Waarom heb je dat vooral als PM? Dat ligt aan je verantwoordelijkheid. Maar ook in andere projecten waar ik mij focuste op de kosten probeer ik het totaaloverzicht mee te krijgen en mij niet alleen op de kosten te richten. Waarom doe je dat ook in een andere rol? Dat is omdat ik daardoor beter werk kan leveren en betere keuzes kan maken. Mijn betrokkenheid is ook in die projecten zeer groot terwijl mijn werkscope kleiner is omdat ik daar ook die verantwoordelijkheid voel.
Root cause **Missing work speed**	Root cause **Feeling responsible**

Interview 3: A2 / X35

Statement 1 Eens maar geldt niet voor het project omdat ...	Statement 2 Eens maar geldt niet voor het project omdat ...
Waarom? Beperkt gebruik gemaakt van een centraal datasysteem bij het uitvoeren van mijn werk, wel werd mijn werk uiteindelijk centraal opgeslagen zodat het voor iedereen up-to-date was. Waarom heb je er beperkt gebruik van gemaakt? Mijn werk kon rechtstreeks en face-to-face besproken worden met de mensen uit mijn directe omgeving op kantoor. Waarom was dat handiger voor jou? Mijn bijdrage aan het project was relatief laag en kwam vanuit een direct verzoek van de PM. Dit kon ik met mijn team snel oppakken, afhandelen en terugkoppelen. Waarom is jouw uitwisseling niet centraal gegaan? De mensen die ik nodig had om mijn werk te doen stonden dicht bij mij omdat het vrij specifiek tekenwerk was. Daar heb ik korte lijnen mee gehouden tijdens mijn werkuitvoering. Extra uitwisseling heeft daardoor niet plaatsgevonden met andere teamleden. Waarom was extra uitwisseling niet nodig? Al mijn eindproducten werden vervolgens gedeeld via de Box en die waren zo beschikbaar voor alle teamleden en was mijn betrokkenheid niet meer nodig.	Waarom? Op dat moment speelde dit onderwerp nog niet genoeg bij hoger management dat er triggers of support werd gegeven, maar nu zie je dat daar wel meer aandacht voor is. Waarom was daar toen geen aandacht voor? Het project liep prima en we werkten met bekende Box omgevingen of deelden via de email. Waarom was dat genoeg destijds? Dit was zoals we al jaren gewend waren om te werken en daar konden we de project goed mee uitvoeren. Het was nog niet een doel om dat anders aan te pakken toen. Waarom? - Waarom? -
Root cause **Too much effort**	Root cause **Missing drive to change**

Statement 3 Eens en geldt voor het project omdat ...	Statement 4 Eens maar geldt niet voor het project omdat ...
Waarom? Het data-uitwisseling systeem dat vooral werd toegepast verliep via Box. Naast Box gebruikten we face-to-face meetings en e-mails om elkaar op de hoogte te houden van de laatste updates. Waarom was het flexibel en duidelijk? Dit werd al jaren toegepast en was in die zin duidelijk, ook kon er flexibel met de Box structuur worden omgegaan. Dit heeft in het project goed gewerkt en was makkelijk. Waarom was het makkelijk? Ik wist wat er van mij werd verwacht en ik kon goed mijn werk en bijdrage overbrengen aan anderen. Waarom kon je jouw werk goed overbrengen? Ik maakt gebruik van de juiste systemen op het juiste moment. Vooral 3D modellen gebruikte ik voor onderlinge communicatie, daarmee kon ik duidelijk een boodschap overbrengen aan het team.	Waarom? Nee er was geen training of zelfontwikkeling op dat gebied gedurende het project. Dit zou wel geholpen kunnen hebben. Waarom was er geen training? Toentertijd was er minder aandacht om mensen op te leiden op het gebied van data delen, daarom heb ik me daar ook niet verder in verdiept. Nu merk ik dat er meer mogelijkheden zijn. Waarom was daar nog geen aandacht voor? De noodzaak was nog niet zo groot en was niet onderdeel van de visie van onze organisatie. Waarom? -
Waarom? -	Waarom? -
Root cause **Conveniently accessible tools**	Root cause **Missing drive to change**

Statement 5 Oneens maar geldt wel voor het project omdat …	Statement 6 Eens en geldt voor het project omdat ...
Waarom? Vertrouwen heeft geen directe invloed in de hoeveelheid data die ik heb gedeeld. Waarom heeft dat geen invloed? Het vertrouwen binnen het team is er sowieso en de data die ik beschikbaar heb deel ik met de mensen die dat nodig hebben. Daar heeft het vertrouwen in die mensen niets mee te maken. Waarom deel je met iedereen makkelijk data? Omdat dat nodig is om je werk goed te kunnen doen. Extern is dat al nauwelijks een issue voor mij maar intern al helemaal niet. Waarom is dat geen issue voor jou? Ik voel geen barrière om openlijk met alle teamleden mijn informatie te delen. Waarom? -	Waarom? Door het actief en snel uitwisselen van data kan er direct worden ingespeeld op de laatste ontwikkelingen in het project. Zo is bijvoorbeeld iedereen op de hoogte van eventuele project wijzigingen, wat zeer waardevol is. Waarom was dat waardevol? Zo kan er voorkomen worden dat er onnodig werk wordt gedaan of kunnen er vroegtijdig fouten worden ontdekt. Waarom kan dat onnodig werk voorkomen? Er waren al wel 3D modellen die gebruikt werden maar vanaf dat moment werd het nut van 3D modellen koppelen nog meer ingezien en dat maakte het nog waardevoller. Waarom? Zo integreer je elkaars werk en zie je de handovers en interfaces duidelijker wat het totaal inzichtelijker maakt. Waarom? -
Root cause **Being transparent**	Root cause **Integration of work**

Statement 7 Eens en geldt voor het project omdat ...	Statement 8 Eens en geldt voor het project omdat ...
Waarom? Skype en mail dragen er aan bij dat het niet meer uitmaakt vanaf welke locaties er gewerkt wordt. Ook tijdens Haïti werd hier veel gebruikt van gemaakt en kon ik mijn werk vanuit Nijmegen goed afstemmen met Rotterdam. Waarom maakt dat communicatie makkelijker? Je kan snel een skype call inplannen of bellen, en dan weet je vrijwel direct wat er op andere locaties afspeelt en heb je duidelijk overleg. Waarom kan je snel iets inplannen met collega's? Eerst wordt er gestreefd een paar keer face-to-face te zitten om te weten wat je aan elkaar hebt. Daarna is er minder direct contact maar kan je elkaar makkelijker benaderen als je iets nodig hebt. Waarom heb je daarna genoeg aan online overleg? Voor mij voelt het alsof je bijna in dezelfde kamer zit als je een skype overleg hebt met iemand en dat kost nauwelijks extra moeite. Waarom? -	Waarom? Minder mee te maken gehad omdat ik vooral één op één werk deed met mensen in Nijmegen. Maar er werd wel op gelet dat ons werk volgens een bekende standaard werd uitgevoerd. Waarom werd daar op gelet? Zodat er een betere uitwisseling van kennis en informatie kan plaatsvinden. Voor het werk als modelleur zijn er minder vaste internationale standaarden, maar voor de constructeurs wel. Waarom kan er betere uitwisseling plaatsvinden? Omdat iedereen in dezelfde taal werkt. Waarom? - Waarom? -
Root cause **Open and transparent**	Root cause **Shared agreements**

Statement 9 Oneens maar geldt wel voor het project omdat …	Statement 10 Eens maar geldt niet voor het project omdat ...
Waarom? Voor mij heeft mijn level van expertise er niet voor gezorgd dat ik meer ben gaan data delen. Waarom niet? De data die nodig is voor het uitvoeren van het project moet hoe dan ook gedeeld worden. Waar dat eerst met een wit papier was en de post gebeurt dat nu met skype of email. Het is nu makkelijker om te delen maar niet meer. Waarom is dat niet meer geworden? De hoeveelheid data in een project is gelijk gebleven, alleen de manier waarop we die data delen is veranderd. Waarom? - Waarom? -	Waarom? Mijn betrokkenheid was relatief laag omdat mij enkel is gevraagd om te assisteren met wat tekeningen. Daarom heb ik minder data uitgewisseld. Waarom wissel je dan minder data uit? Als je slechts voor een klein onderdeel wordt ingezet, beperk je je met het volledig inlezen over en bijdragen aan het project. Waarom beperk je je daarin? Er zijn ook andere prioriteiten en ander werk waar ik mij op moest focussen en je kan niet op al je projecten volledig meedraaien. Waarom kan dat niet? Daar is geen tijd voor. Waarom? -
Root cause **Open and transparent**	Root cause **Pushing deadlines**

Interview 4: A4 / B3 / C46 / X69

Statement 1 Eens maar geldt niet voor het project omdat ...	Statement 2 Eens en geldt voor het project omdat ...
Waarom? In die tijd was er nog geen centraal en gestructureerd datasysteem en werkten we voornamelijk op meer traditionele wijze via meetings of email. Waarom was dat er nog niet? Er waren wel ontwikkelingen maar die vormden nog niet een werkbaar geheel, zowel bij ons als bij de klant niet. Waarom waren die nog geen geheel? Dat komt omdat de initiatieven in de begin fases zaten. Er is standaardisatie nodig en veranderingen in de uitvoering. Stappen zijn al wel gemaakt tijdens dit project maar de werking is nog niet optimaal. Waarom is het nog niet optimaal? Dat kost tijd, geld en moeite vanuit alle betrokken partijen om dat te realiseren en dat was er niet altijd. Waarom was dat er niet? Het gaat ontzettend snel tegenwoordig. Intern zijn we bezig met deze ontwikkelingen maar vaak loop je alweer achter als je bezig bent met de implementatie.	Waarom? Externe triggers hebben er zeker voor gezorgd dat ik meer data ben gaan delen. In overleggen met hoger management bespreek je samen wat beter kan. Waarom heeft dat voor meer uitwisseling gezorgd? Ik liep zelf er ook tegenaan dat het data delen beter kon. Wanneer je dat beiden uitspreekt wordt het een wisselwerking en groeit de noodzaak om er iets aan te doen. Waarom groeit de noodzaak dan wel? Je hebt bepaalde afspraken met je opdrachtgever over het budget en de planning van het project. Er is goede afstemming nodig om te bepalen wat prioriteit krijgt. Gedeelde doelen krijgen sneller prioriteit. Waarom kan er dan meer data worden gedeeld? Er zit een stuk geld tussen die dan nodig is voor het extra delen. Hoger management maakt tijd/geld vrij als ze digitaliseren van belang vinden. Waarom is dat zou in jouw project? Bij de klant bijvoorbeeld proberen ze nu heel erg in te zetten op een nieuwe digitale werkwijze. Een systeem waarbij je dmv parametrisch ontwerp meteen met onderaannemers kan afstemmen welke materialen en hoeveelheden nodig zijn.
Root cause **Too fast changes**	Root cause **Shared goals**

Statement 3 Oneens en geldt niet voor het project omdat ...	Statement 4 Eens en geldt voor het project omdat ...
Waarom? Er moet gewoon één simpel systeem vast worden gezet waar iedereen in werkt. Dit maakt het bijhouden van data een stuk makkelijker. Dat was nu niet zo. Waarom is er één systeem nodig? Zodat iedereen hetzelfde systeem kan gebruiken en er duidelijkheid is. Wel ben ik inmiddels gewend om met een onduidelijk systeem te werken maar dat kan beter. Waarom moet het beter? Het moet zo simpel mogelijk zijn om de toegankelijkheid en de traceerbaarheid van informatie te verbeteren. Anders is data niet te achterhalen en is er twijfel of iets wel de laatste versie is. Waarom is traceerbaarheid van belang? Je komt op dit moment best vaak standaards tegen die je niet eens herkent. Daarmee gaat waardevolle informatie verloren in moeilijk traceerbare documenten. Dit moet ook goed met de klant worden afgestemd. Waarom? Het gebeurt ook dat er intern mensen niet op de hoogte zijn van de laatste updates in projectinformatie. Dit komt omdat men met ander werk bezig zijn en minder betrokken bij andere ontwikkelingen in het project.	Waarom? Ik probeer alle ontwikkelingen bij te houden tijdens het project. Dit doe ik vooral door mezelf te ontwikkelen en niet door middel van training. Waarom heeft dat geholpen bij jouw data uitwisseling? Tijdens het project heeft vooral oefening en bewustwording van de mogelijkheden geholpen om ontwikkelingen beter te begrijpen en daardoor makkelijker data te delen. Waarom heb je dat gedaan? De eisen die de klant stelt zijn katalysatoren voor ontwikkeling in een project en daar moet je zelf in meegaan. Waarom werkt dat als een katalysator? Als de klant eisen stelt aan ons om efficiënter, sneller, economische beter en duurzamer te bouwen dan moeten wij daarin mee gaan anders krijgen we de opdracht niet. Waarom krijgen jullie de opdracht anders niet? Omdat er anders concurrenten zijn die voorop ons lopen en wel aan die eisen kunnen voldoen.
Root cause **Information overload**	Root cause **Competitive advantage**

Statement 5 Eens en geldt voor het project omdat ...	Statement 6 Eens en geldt voor het project omdat ...
Waarom? Tijdens het project heb ik op basis van vertrouwen in collega's meer taken kunnen delegeren. Waarom heeft dat de data-uitwisseling verbeterd? De data-uitwisseling verbeterde omdat we met vertrouwen in elkaar beter gestructureerd informatie kunnen uitwisselen om de taken goed uit te kunnen voeren. Waarom wordt het data delen daardoor gestructureerd? Omdat die collega's goede expertise hebben om die taken goed uit te voeren en daardoor wordt de uitwisseling beter. Waarom? - Waarom? -	Waarom? De basis van ons werk bestaat uit kwalitatieve informatie-uitwisseling tussen de opdrachtgever en de aannemer en onderaannemers. Waarom geeft dat impact? Wij moeten luisteren naar de wensen van de opdrachtgever en die vertalen naar data en informatie. Dit verwerken we en communiceren via SharePoint en Box door naar het team om zo projecten te realiseren. Een grote impact dus. Waarom verhoogd dat de data-uitwisseling? Delen gaat tegenwoordig een stuk snellen en dat maakt ons werk efficiënter en daardoor ook goedkoper. Maar tegenwoordig wordt er ook veel meer data gegenereerd wat het soms moeilijker maakt. Waarom maakt dat het moeilijker? Dan ontstaat er een overvraag naar data en is er geen structuur en overzicht meer. Hierdoor is niet meer duidelijk welke data er beschikbaar is en mensen gaan vragen om het vragen. Waarom ontstaat dat onnodige dataverkeer? De mogelijkheden van datadelen bijna onbeperkt waardoor het te ingewikkeld wordt. Dan moet er eigenlijk weer een stap terug worden genomen en het zo simpel mogelijk houden om zo het overzicht te bewaren.
Root cause **Experienced personnel**	Root cause **Simplicity in communication**

Statement 7 Eens en geldt voor het project omdat ...	Statement 8 Eens en geldt voor het project omdat ...
Waarom? Ja er zijn genoeg faciliteiten die de samenwerking tussen verschillende kantoren mogelijk maakt. Bij dit project is de beginfase in Nederland gedaan en zijn we daarna verder gegaan met hulp van Vietnam. Waarom was die interactie goed gegaan? Het werkt naar mijn idee niet per se kostenverlagend maar het is wel een snelle manier van werken. Waarom is het een snelle manier van werken? Zij hebben daar nu veel engineer ervaring brouwerij projecten opgedaan. De interactie is vooral in de beginfase heel intensief omdat je dan als team goed op één lijn moet komen. Waarom moet je nog op één lijn komen? Je werkt met verschillende culturen en daarom is afstemming en standaardisatie nodig. Onze manier van uitwerken is in Vietnam niet hetzelfde. Hierdoor ontstond een klein conflict soms maar dat gaat nu een stuk beter.	Waarom? In het begin hebben we nog moeten standaardiseren en afstemmen met verschillende kantoren omdat de standaarden en werkwijzen niet gelijk waren. Waarom hebben jullie dat in het begin gedaan? Om vanaf het begin efficiënter te kunnen samenwerken. Onderling moet dit natuurlijk ook nog goed gaan. Je moet er voor zorgen dat je dezelfde datasystemen gebruikt en makkelijk data uitwisselt. Waarom deel je daardoor makkelijker data? Iedereen wilt op zijn eigen manier dingen gestandaardiseerd hebben. Je moet dus hier afspraken over maken zodat je dezelfde taal spreekt. Waarom zijn die afspraken nodig? We werken veel met multinationals die ook veel ervaring hebben met standaardiseren en al processen hebben ingericht. Hier moeten we mee op één lijn zitten.
Root cause **Fast problem solving**	Root cause **Shared agreements**

Statement 9 Eens maar geldt niet het project omdat …	Statement 10 Eens en geldt voor het project omdat ...
Waarom? Ik heb niet zo zeer expertise in een systeem. Ik doe meer aan gegevens wisselen via de traditionele manieren zoals via mail en mondeling. Het is dan wel belangrijk dat er een persoon is die de data bijhoudt en op één plek opslaat waar iedereen bij kan. Waarom wissel jij niet veel via het systeem data uit? Iemand anders heeft daar meer expertise in om met de snelheid van het project mee te gaan. Ik schakel dus anderen met expertise in om de einddocumenten te delen. Waarom vertraagt dat het project? Je hebt snel je data nodig om snel beslissingen te maken. Hier moeten afspraken mee worden gemaakt met alle partijen. Nu is het soms moeilijk te bepalen wie er verantwoordelijk is voor bepaalde data of voor het wijzigen van data. Waarom? -	Waarom? Mijn betrokkenheid is natuurlijk erg hoog. Ik ben dan tijdens een project eigenlijk alleen maar bezig met data delen. Hiervoor zijn verschillende manieren en soorten data waar je op moet inspelen. Waarom moet je op verschillende manieren werken? Je moet er op letten met wie je in contact bent. Verschillende personen hebben natuurlijk verschillende data dus je moet altijd bij de goede persoon aankloppen als je iets te weten wilt komen. Waarom hebben verschillende personen andere manieren? Verschillende bedrijven hebben ook een verschillende ervaringen. Soms heb je contact met minder deskundige mensen wat het delen van data gecompliceerder kan maken. Hier weet ik hoe ik op moet inspelen. Waarom vergroot dat jouw data-uitwisseling? Je blijft wel adviseur. Klanten staan altijd open voor advies en aangezien ik al vaak zo'n soort project hebt uitgevoerd kan ik met goede informatie komen.
Root cause **Missing work speed**	Root cause **Feeling responsible**

Interview 5: B30 / C8 / X84

Statement 1 Agrees and applies to the project because …	Statement 2 Agrees and applies to the project because …
Why? I used Box and the server in Vietnam to store and exchange my information. The client team used SharePoint and the document controller shared those documents with us. Why did that increase data sharing? The document controller helped to keep the information flows between RHDHV and the client up to date and made it easier for RHDHV to find documents by providing links and use structured folders and naming convention. Why was the document controller essential? She was the central point of contact and made it way more efficient for the RHDHV team to work as we did not have to waste time searching for the latest files and agreements. Why was her work so essential? Only she downloaded the documents and stored them in the cloud which is more efficient than if all team members are downloading files individually on their own laptops. Why is that more efficient? She shares the same link with all team members. That helps us save a lot of time, prevents duplicate data and creates certainty for the team.	Why? During the project we got support from higher management in data sharing with investments in better internet, laptops and new software. Why did higher management support? It was necessary to invest as we currently are in the digital transition. As a company we needed to stay ahead of the local competition and follow up with new developments. Why did we need to follow up with local competition? Local companies in Vietnam are also investing in digital ways of working and we need to stay ahead of them. Why do we need to stay ahead of them? If we do not increase our skills, we will lose clients and projects if we cannot offer them the same or more as our competitors. Why? -
Root cause **Central point of contact**	Root cause **Competitive advantage**

Statement 3 Agrees and applies to the project because …	Statement 4 Agrees but does not apply to the project because …
Why? In my work in the project the flexibility and the reliability of the data sharing infrastructure was much better than in the first phase of the project. Why was that? The internet was very bad at the beginning and therefore it was difficult to share data consistently. But this improved in the last phases of the project. Why did this improve? They invested more money in good working systems. Why? - Why? -	Why? We do need extra training to teach us how we must work with new systems, but we don't often get them in Vietnam. Why don't you get them? That depends on the workload and the budget we have for projects here in Vietnam. Often not much time and money are available for training. Why is there no time or money available? The line managers decide where the money goes. And we now have too much work for too few employees. So, there is no time available for training. Why are there not enough employee capacity? Currently there are more projects open and more employees have left the company recently in some disciplines in I&B. Why did they leave? People coming and leaving the company always happens fast and unpredictably. This makes providing training more difficult. We do try to stabilize that better by making it more attractive by engaging employees.
Root cause **Available budget**	Root cause **Missing budget**

Statement 5 Agrees and applies to the project because …	Statement 6 Agrees and applies to the project because …
Why? The level of trust with the other team members during the project was good and this makes it easier to share your work and information with others. Why does that make it easier? If you can easily share socially with team members it also makes it easier to share in your work because there are fewer sharing barriers. Why do you have a good social band with the VN team? We organize activities together. With the Netherland team this is more difficult, but we also have mutual trust and work good together. Why do you have a mutual trust with the NL team? Because we have been working with them in many projects which increases trust. Why does this increase trust with the NL team? They share their knowledge with us and that builds stronger relationships between our offices.	Why? In the project it worked well to share our information on Box and to know that you can always find your information there. Why? This made it clear to the team where to find the latest information. Why? We used basic folder structures and naming convention. Why? - Why? -
Root cause **Physical presence**	Root cause **Simplicity in communication**

Statement 7 Agrees and applies to the project because …	Statement 8 Agrees and applies to the project because …
Why? People from the Netherlands visit Vietnam and help the people in the Vietnam office to develop technical skills. That really increased my data sharing in the past. Why did that increase your data sharing? In the beginning of the project the technical skills of the people in Vietnam were not high enough and by sharing knowledge with the Dutch we could increase. Why did you need to increase your knowledge? First, we didn't have enough experience but now we are also becoming better in brewery projects. But we still must learn more and share more with other teams. Why do you still need to increase? Our structural department for example still must increase expertise and talk more with experienced people because they are not at the same level yet as people in NL. Why does VN need to get on the same level? To improve our work and work more efficient together.	Why? We are still developing standards so we can align globally with other RHDHV offices. This also happened during my work in the project. Why is this necessary? If we do not standardize, we make documents or models that other offices cannot directly use or understand and that would be a waste of effort and inefficient. Why is that inefficient? Than we cannot collaborate properly and profit from each other's input and previous work. Standardization makes sharing data more efficient. Why? - Why? -
Root cause **Fast problem solving**	Root cause **Integration of work**

Statement 9 Agrees and applies to the project because …	Statement 10 Agrees and applies to the project because …
Why? My level of expertise in data sharing has improved my data sharing in the project. My expertise also grew during the project. Why did your expertise increase? Because we give each other internal advice and look at documents together. Indonesia has given us explanations about parametric design. Why did that increase your data sharing? That has given us good starting points to start designing in the project and helps us to become more data-driven. Why do you need help from others? In the project I also learned a lot from the structural engineer in the Netherlands that I worked together with to improve my data sharing. Why did that increase your data sharing? We shared over Skype and Email and discussed a lot regarding the structural design, now I have more knowledge and experience to share data about that more confident.	Why? Yes, my level of involvement in the project has increased my data sharing as my involvement is higher now because I'm a more experienced engineer. Why did that increase your data sharing? Because I can share my knowledge and help younger engineering with their work, give them advice about how to avoid mistakes and give examples from the past. Why do you do that? Because I have practical proof from my previous projects in what went wrong and what went right. So, I am more confident based on my previous experience. Why do you feel more confident? Because it is my responsibility to share and I am now more involved in the project. It is important to share with the young engineers. Why is that important? I can also learn new things from them and by exchanging information we can improve project success together.
Root cause **Eager to learn**	Root cause **Feeling responsible**

Interview 6: B19 / X73

Statement 1 Agrees and applies to the project because …	Statement 2 Agrees but does not apply to the project because …
Why? In the projects we try to keep everything central and up-to-date but sometimes I also have to continue my work with incomplete information as Box is not completed with the latest information. Why is Box sometimes not complete? I need the input of a lot of people to do my work as financial controller, so chances are high I miss some data from one of them. Because I cannot always wait for them all, I proceed and during meetings I directly ask them for the missing information. Why do you proceed and ask them directly in meetings? By asking directly I can get the information faster. The best way of sharing data depends on the moment and situation. Why? - Why? -	Why? That sometimes happens but often only the PM hears it from higher management, and he often decides to wait to tell the rest of the team because he doesn't want to panic the team. Why does he decide to wait? Because he still hesitates if this is going to be the final conclusion, the complete plans or if all information is finalized for the team. He wants to wait for the right timing. Why is waiting for the right timing wise? There is a project review every month where higher management, the PMs and me come together to discuss the latest developments in the project. During this meeting the opportunities and risks are discussed and decided what information and when to share with the whole team. Why? - Why? -
Root cause **Convenient accessible tools**	Root cause **Wrong timing**

Statement 3 Agrees and applies to the project because …	Statement 4 Agrees and applies to the project because …
Why? Yes, because the financial data that I must share between our PM and the client is often confidential information and the system is reliable and flexible enough to work with that. Why is it flexible enough? We exchange files like invoices back and forth between de PM and the client via Email. If the final documents are approved and signed, we store them in Box. This makes the system flexible. Why is it reliable enough? We make use of hierarchical restrictions who can see the confidential documents of the project. Not everyone is dedicated to view all the documents in Box, so we use hierarchical groups to give view permissions. Why does that help you to share data? In every project the permission structure is almost the same. The engineers see only the technical documents and the PMs, costing and higher management all documents. So, I know what the right permissions are, and I can store information without hesitation. Why? -	Why? Recently higher management decided that my team steps out of the role of overall financial controllers of a larger set of projects and focus more on one project. That is much better for my personal developments as I get more involved in my project. Why does that increase you data sharing? Financial controllers can now really jump into the project itself and know more about the projects. We also group colleagues together that will work for the same client to increase better communication. Why has this been changed? We discussed this with the PMs and asked them to change this so we can work closely with the team and monitor all the bookings of the project precisely. Why is this necessary? This way we can really step from the back seat to the front seat of the project and utilize our expertise for better project control. Why is this better for the project? That motivates the financial team as they get a more acknowledged role in the project and their work becomes more important.
Root cause **Adjustable structure**	Root cause **Eager to learn**

Statement 5 Agrees and applies to the project because …	Statement 6 Agrees and applies to the project because …
Why? Everyone is dedicated to do their job and I know that about my team so that gives me trust to extensively share with them. Why does that give you trust to share data? I know who is responsible for what documents and if I see that certain information is missing, I can ask them directly because we work closely together. Why did that help you in the project? I trusted everybody so that also made it easier to understand everybody's role and responsibility in the project. It makes it easier to communicate openly. Why is open communication important? What also happened in the project that if someone was unable to finish its work in time, that you ask someone from the team that you trust to help. Why is that important? That first person is still responsible that the task is finished in time but with trust you can collaborate and make sure to deliver in time together. Together you can deliver projects more efficient.	Why? Eventually all final information will be saved in Box but before that we also use a lot of meetings and communication to really work as an impactful group and make the project a success. Why does that increase data sharing? We really respect the teamwork and aim to constant improve the internal communication as a group and try to remove the distance between people and communicate better together. Why is teamwork important? We want to prevent diffusions as that makes the impact of the group less strong. And at the end of the day we also need to, to make the project work. Why? - Why? -
Root cause **Experienced personnel**	Root cause **Collective commitment**

Statement 7 Agrees and applies to the project because …	Statement 8 Agrees and applies to the project because …
Why? I can pretty easily work with the facilities I have to communicate with other offices. We use email, WhatsApp and skype to discuss information. Why does that makes sharing easier? You always have a tool to reach someone. Only the time difference makes it harder sometimes to communicate fast, but I plan this and make sure I ask for information in time. Why does time difference make fast communication harder? If you need information very urgent it is harder to arrange this within short time, so we make sure all the documents are in Box or shared in time. Why does this help to do your work? Then I can assess the financial documents from any part of the world in Vietnam so there is no problem in doing my work. Why? -	Why? Each country still has different ways of standardizing their work environments which makes it sometimes harder to share. We are changing that, but it takes time. Why does it take time? We are using QMS to standardize globally but it launched only recently and needs global dedication to implement this. But this mostly effects the engineers and not my work. Why does this not affect you directly? Because I can use the same standards for financial control that is already agreed upon. Why? - Why? -
Root cause **Conveniently accessible tools**	Root cause **Shared agreements**

Statement 9 Agrees and applies to the project because …	Statement 10 Agrees and applies to the project because …
Why? My work expertise increased my data sharing because I know how to share my information, and I also must share it with the team because I am responsible for it. Why do you feel responsible? Everything should be stored but I don't expect everyone to understand all the details. But it should be understandable to a certain level for the people that have to use it. Why should it be understandable for everyone? It happens that the project team needs to be squeezed a bit as there are people necessary on other projects. Then the PM takes over parts of their work and therefore the data files should also be understandable for him. Why does that happen? Employees are moved between projects sometimes quite dynamically. That depends on where the people are most needed. Finance is a very general topic so it Why? -	Why? For my own work part in the project I am very involved, and I know all about it and share all the information that is needed. But I don't know all the technical details about the project. Why does that increase your data sharing? I make the reports for higher management about the project on the general level. So, I need to know the overall picture and share that with the PMs and higher management, but the engineer details are out of my scope. Why don't you need to know all the details? It is not necessary for me to know all the details because there are other engineering experts that are dedicated to that work. Why were you so involved for the financial work? In the project I was the central point of contact for the financial review at the beginning before signing of the project and checked the cash flows with the PM in Vietnam during the project alongside the project schedule and payments during the whole project lifecycle. Why during the whole project lifecycle? We refresh the cashflow every month during every monthly project review and conduct the financial close offs of lot of projects in Vietnam. Budget is very important part of a project.
Root cause **Feeling responsible**	Root cause **Central point of contact**

Interview 7: A7 / B5 / C2 / X21

Statement 1 Eens en geldt voor het project omdat ...	Statement 2 Eens maar geldt niet voor het project omdat ...
Waarom? In het project werkten we met drie aparte systemen, de RHDHV server, Box en SharePoint. Hier vond alle data-uitwisseling in plaats. Het was redelijk up-to-date en centraal maar omdat we met verschillende omgevingen werkten ontstonden er soms problemen. Waarom waren er drie omgevingen? De server is een platform waar we met langzaam internet in werken. Box is ons online platform voor het opslaan van goedgekeurde documenten. SharePoint was voor informatie uitwisseling met de klant en hun single source of truth. Waarom waren er soms problemen? Soms was niet alle informatie direct voor ons beschikbaar vanuit SharePoint. Dit zorgde voor miscommunicatie omdat het niet bekend was bij de klant dat hun reviews nog niet bij ons openbaar waren. Hier miste discipline bij de klant. Waarom miste daar de discipline? Nadeel aan meerdere platforms is dat er meer ruimte is voor menselijke fouten. Wij moeten de data van SharePoint halen en werken daar niet op. Als we een notificatie missen kunnen we een niet up-to-date document gebruiken. Wij hadden een document-controller die dat heel goed bijhield. Waarom werkte dat goed? Dan weet je zeker dat je met de goede documenten werkt. In de huidige fase gaan we echter met Asite werken en een connectie met SharePoint maken zodat in- en output data direct wordt geschakeld tussen de systemen.	Waarom? Er is wel een push geweest om BIM op site toe te passen. Hebben we eerder met pilot mee gedaan. On site mensen met iPads rond laten lopen zodat ze opmerkingen kunnen plaatsen in een 3D model. Maar dit is niet doorgezet. Waarom is dit niet doorgezet? Dit kwam op een kritische fase dus kon het alleen kwaad doen omdat alles te snel moest worden opgezet. Er was geen ruimte om het bestaande team daarvoor op te leiden. Dat kost tijd en energie die we niet hadden. Waarom hadden jullie toen geen tijd en energie? Het kwam op een verkeerd moment in het project ergens halverwege, en het moest allemaal te snel gebeuren. Voor de volgende uitbreiding zouden we het nu wel nog kunnen doen. Waarom is het moeilijk om tijdens het project te veranderen? Dat zijn te grote veranderingen als je al volop bezig bent. Daarnaast moet je als PM vaak zelf het wiel uitvinden. Het zou goed zijn als het veel meer centraal wordt aangestuurd. En daardoor lokale kennis kan bijdragen aan totaal. Waarom? -
Root cause **Central point of contact**	Root cause **Too fast changes**

Statement 3 Eens en geldt voor het project omdat ...	Statement 4 Eens maar geldt niet voor het project omdat ...
Waarom? Data-uitwisseling met de klant was heel duidelijk want we maakten gebruik van regels om te delen. Flexibiliteit kwam meer uit hoe we omgingen met beperkingen in het systeem. Waarom was dat flexibel? We konden buiten de systemen om toch met elkaar informatie uitwisselen via email of in meetings. Tweedeling bij de klant, push om strikt SharePoint te gebruiken maar ook mensen in de uitvoering die er soepeler mee om gingen. Hoe was dat intern? Intern gebruikten we dus Box en Server. Werkte soms vrij verwarrend. Maar als ik data per e-mail binnenkreeg, dan stuurde ik het door naar de document controller en die zorgde voor de juiste registratie. Waarom zorgde dat voor betere data uitwisseling? Zij zorgde ervoor dat de juiste documenten en de laatste versies aan de RHDHV kant altijd goed op orde waren. Dit gaf veel duidelijkheid in ons systeem.	Waarom? Persoonlijke ontwikkeling zeker tijdens het project, je kan zelf best veel ondernemen. Er is geen training geweest, behalve een introductie tot SharePoint door de klant. Waarom moest je dat zelf doen? Het is niet zo dat het management mij ruimte gaf voor persoonlijke ontwikkeling, dat deed ik zelf uit noodzaak. Ik heb nooit een Box-training gehad. Wel een Asite training maar die was niet goed en toen was ik “expert”. Daarom moet je er zelf induiken omdat je weet dat het nodig is het voor het project. Een voorbeeld Vanuit BIM22 moeten we bij alle projecten A-site implementeren en niemand weet hoe. De datasnelheid was heel laag dus hebben we zelf initiatief genomen en gaan we nu een andere A-site server gebruiken in India ipv Engeland. Waarom gaat dat zo binnen RHDHV? Binnen RHDHV wordt snel gezegd we willen dit, hier staat hoe het moet, maar dat werkt zo niet. Bij de transitie naar A-site moet verandermanagement komen. Dat heeft tijd nodig en ruimte die niet geboden wordt.
Root cause **Adjustable structure**	Root cause **Lack of coordination**

Statement 5 Eens en geldt voor het project omdat ...	Statement 6 Eens en geldt voor het project omdat ...
Waarom? Door de gedisciplineerde document controller is er vertrouwen. Zij is de spil. Ik vertrouw erop dat door haar wij altijd de laatste input hebben en dat de klant de laatste output heeft. Waarom is haar werk zo goed? Ze werkt al een jaar of 6 op brouwerij projecten met SharePoint en ze werkt goed samen met de document controllers van de klant. Waarom verbeterd dat jouw data-uitwisseling? Ik kan er zeker van zijn dat de data die ik nodig heb bij haar op te vragen is en dat ze mijn documenten ook goed archiveert en communiceert. Waarom? - Waarom? -	Waarom? De data-uitwisseling is niet door het systeem toegenomen maar wel verbeterd omdat het mij toegevoegde waarde gaf in ons werk. Waarom was het systeem waardevol? De data was traceerbaar, er bestond goed revisiebeheer en status van documenten waren inzichtelijk en dit allemaal op een locatie. De document controller heeft hier een groot aandeel in gehad. Waarom deel je daardoor beter data? Omdat het de zekerheid geeft dat je met de juiste gegevens en informatie aan het werk bent. Waarom? - Waarom? -
Root cause **Experienced personnel**	Root cause **Central point of contact**

Statement 7 Eens en geldt voor het project omdat ...	Statement 8 Eens en geldt voor het project omdat ...
Waarom? Ik werk nauw samen met de klant en de portfolio manager van RHDHV in NL en dat gaat allemaal via Skype. Daardoor delen we ook meer informatie via Box. Ook komen er werknemers vanuit NL hierheen om kennis en informatie uit te wisselen. Waarom deel je daardoor meer informatie? De faciliteiten en mogelijkheden om met elkaar samen te werken hebben de data-uitwisseling verhoogd. Deze faciliteiten zijn nu Skype, Box en Email. Er is geen platform om van elkaars ervaring te leren. Waarom werken deze faciliteiten goed? Alle tools werken prima omdat we nu aan deze gewend zijn en er mee weten om te gaan. Aan nieuwe moet je wel de tijd hebben om eraan te wennen. Tot die tijd werkt het niet. Totdat ik het snap verketter ik het ook. Dit is het gevaar als het management zegt “vanaf nu gaan we dit gebruiken”. Waarom is dat een gevaar? Bij werkveranderingen in de organisatie moet ook verandermanagement komen. Dat gebeurt nu vaak niet. We gaan nu met Microsoft Teams werken, dus dat gaat dat meer bewerkstelligen denk ik. Waarom? Omdat het simpel en overzichtelijk is.	Waarom? Er was wel standaardisatie, want er werd gebruik gemaakt van standaard klant/RHDHV documenten. Maar het heeft niet de data-uitwisseling verhoogd maar kwalitatief verbeterd. Waarom is het kwalitatief verbeterd? Hierdoor ontstaat er operationele excellentie waardoor het wiel niet telkens opnieuw hoeft worden uitgevonden. Je hebt minimale input nodig, om maximale output te leveren. Waarom is minimale input nuttig? Hoe minder data er uitgewisseld hoeft te worden, hoe efficiënter je bent. Verhoging van data-uitwisseling is niet het ultieme doel maar wel het effectiever en efficiënter maken. Waarom is minder uitwisseling efficiënter? Vroeger stuurde je 1 fax per dag. Dan moest je ervoor zorgen dat alle informatie daarop staat en dat deze heel duidelijk is. Er wordt nu te veel onzin gedeeld. Waarom? -
Root cause **Simplicity in communication**	Root cause **Simplicity in communication**

Statement 9 Eens en geldt voor het project omdat ...	Statement 10 Eens en geldt voor het project omdat ...
Waarom? Het inzien van het belang van het hebben van een valide systeem heeft mij opengesteld om expertise en kennis te ontwikkelen. Waarom verbeterd dat de data-uitwisseling? Toen SharePoint werd geïmplementeerd bij de klant gingen ze van folderstructuur naar metadatastructuur. Toen zijn we niet gaan klagen, zoals de klant zelf, wij gingen aan de slag en trokken de rest hierin mee. Waarom is meegaan in trends belangrijk? Mijn initiële expertise heeft niet bijgedragen, maar ik heb ingezien dat meer expertise nodig was om optimaal gebruik te maken van data en zo het project te verbeteren. Waarom? - Waarom? -	Waarom? Omdat ik als PM eindverantwoordelijk ben neemt mijn data-uitwisseling toe om het totaaloverzicht te houden. Maar ook dat van het team omdat ik dat belang op hen overbreng. Waarom is verantwoordelijkheid belangrijk? Allereerst moeten we data delen met klanten en onderaannemers, maar ook intern. Iedereen moet weten wat er voor zijn rol en werk nodig is om te leveren. In Asite kan iemand met autoriteit een stempel aan het document geven en dan mag de volgende ermee verder. Waarom is dit nuttig in Asite? Je kan traceren wie verantwoordelijk is voor een document en goedkeuring heeft gegeven. Dan zullen mensen daar een stuk serieuzer mee omgaan omdat alles traceerbaar is. Dit zit niet in Box, dan wordt er een link gedeeld en is het voor iedereen inzichtelijk. Hoe moet Asite verder worden ingevoerd? Ik geloof in A-site. Klanten zouden hierin mee moeten gaan of er moet een link komt tussen A-site en hun datasysteem. Waarom? Zodat je elkaars werk beter kan integreren en minder last hebt van handovers waarin menselijke fouten kunnen worden gemaakt.
Root cause **Eager to learn**	Root cause **Feeling responsible**

Interview 8: A5 / C42 / X70

Statement 1 Eens en geldt voor het project omdat ...	Statement 2 Oneens en geldt niet voor het project omdat ...
Waarom? Er was in het project een goed centraal systeem waarin 1 document controller alle documenten en data bijhield en reguleerde via Box. Je kon altijd naar haar voor informatie. Waarom is het fijn om daar één persoon voor te hebben? Ik kon dan mijn administratieve functie overdragen en meer op mijn eigen functie focussen. Het kost mijzelf veel meer tijd om deze data-infrastructuur goed te gebruiken. Waarom is jouw data-uitwisseling hierdoor verbeterd? De document controller heeft haar eigen structuur in het systeem, en zij kan dat goed/efficiënt gebruiken. Toen ik naar VN trok voor extra ondersteuning kon ik bij haar meteen alle informatie krijgen en snel instromen. Waarom is dat van belang? De details van elk project zijn uniek. Informatie van oude projecten kan alleen tot zekere hoogte gebruikt worden. Daarom is het belangrijk dat alle projectdata centraal staat en te traceren is. Waarom? -	Waarom? Nee hoger management was niet aanwezig in het project tijdens mijn werk en er was ook geen prikkel. Zolang het goed gaat is er geen gehoor van bovenaf. Waarom zou zo'n prikkel niet helpen? Nee dat moet je als hoger management niet pushen bij het projectteam want dan gaan ze tegenwerken. Waarom zou jou dat tegenwerken? Ik weet zelf vaak beter dan een buitenstaander wat er nodig en beter is voor het project. Door de informatie-asymmetrie laat het management zijn functie los. Waarom kan hoger management hier geen rol in spelen? Het meer delen van delen is niet nodig. Iedereen verzandt tegenwoordig in de enorme hoeveelheid data die we hebben en er is sprake van mailvervuiling. Het is niet voor iedereen nuttig om alle data te ontvangen. Waarom is dat niet nuttig? Alleen betrokkenen moeten informatie direct ontvangen en de rest moet centraal opgeslagen worden zodat het kan worden terug gevonden. Delen om het delen gaat het project niet verbeteren, het CC'en moet ophouden.
Root cause **Central point of contact**	Root cause **Missing drive to change**

Statement 3 Eens en geldt voor het project omdat ...	Statement 4 Oneens en geldt niet voor het project omdat ...
Waarom? Box is flexibel maar niet per se heel duidelijk. De document controller heeft het op haar eigen manier ingedeeld zodat zij het zo efficiënt mogelijk kan gebruiken. Waarom helpt die flexibiliteit bij data-uitwisseling? Het is zo overzichtelijk voor het team. In plaats van alle mappen doorzoeken is er slecht een selectie. Het zou goed zijn als Box eens vinksysteem zou hebben om te bepalen wat je in je structuur zou willen. Waarom zou dat handig zijn? Een basisstructuur die nog aanpasbar is naar eigen wens. Nu was het soms lastig in welke mappen precies je databestanden opgeslagen moeten worden. Waarom is dat lastig? Er zijn geen vaste richtlijnen voor dus een eigen interpretatie is snel gemaakt. Regels zijn leuk maar de interpretatie van een document is nog moeilijk. Waar hoort het nou echt bij? Waarom? -	Waarom? Dit soort trainingen waren er wel online maar daar ben ik zelf niet heel erg mee bezig. Tijdens het project was het ook niet echt aan de orde. Waarom was het niet nodig tijdens het project? Omdat er iemand aanwezig is die deze data beheerde en dat goed deed. Dit lijkt mij veel efficiënter dan iedereen trainen. Waarom werken de bestaande trainingen niet? Veel theoretisch gepraat en minder praktijkgericht. Na zo een training weet je eigenlijk nog steeds niet hoe je er precies mee moet werken. Waarom weet je na zo'n training niet genoeg? Eigenlijk is er geen tijd om al deze trainingen te volgen naast gewone werk. Nieuwe ideeën is op zich geen slecht idee maar veel nieuwe tools vervagen omdat het toch niet handig genoeg is. Dan is het zonde om het organisatie breed uit te rollen. Je kan geen expert op elk gebied worden daarom werkt een document controller goed. Waarom is dat handiger? Zij is de expert in databeheer en dat scheelt werkuren van andere werknemers die andere expertise hebben en hun tijd beter daar in kunnen stoppen.
Root cause **Adjustable structure**	Root cause **Missing skills**

Statement 5 Eens en geldt voor het project omdat ...	Statement 6 Oneens en geldt niet voor het project omdat ...
Waarom? Bij collega's waar je in vertrouwd in hun werk weet je wie wat kan en bij anderen weet je dat je juist niet altijd alle data moet delen. Dat maakt het samenwerken een stuk beter. Waarom deel je soms wel en soms niet? Als iemand niet capabel genoeg is om bepaalde data te interpreteren deel ik die liever niet omdat het alleen maar fout kan gaan. Ik kijk dus zeker naar wie er tegenover me zit. Waarom was dat in jouw project zo? Constructie was beste tak in Vietnam dus daar was deze zorg niet zo aanwezig door de hoge van expertise. Het is dus belangrijk om te weten hoe personen met data omgaan. Waarom is het van belang om te weten wat men kan? Data moet niet lekken tussen partijen (contractueel vastgelegd). Je moet dus partijen goed kunnen vertrouwen en zeker weten dat ze professioneel met data omgaan. Waarom moet er professioneel met data worden opgegaan? Als mensen niet zorgvuldig werken kunnen ze standaard documenten klakkeloos overnemen. Er is kennis nodig van de situatie voordat info overgedragen wordt naar anderen.	Waarom? Niet direct. De technologische vooruitgang heeft tijdens het project er wel voor gezorgd dat we met email konden werken maar of dat ook daadwerkelijk beter is. De drempel was vaak te laag om overal informatie van te vragen. Waarom was de drempel te laag? Met email kan je makkelijk mensen bereiken en inboxen vol spammen met vragen. Vroeger werd er nog zelf nagedacht. Nu worden we luier in het zelf nadenken en opzoeken. Waarom worden nieuwe ontwikkelingen misbruikt? Kijk naar de telefoon, je bent constant in contact maar er is nu veel minder aandacht tijdens een vergadering dan vroeger. Is meer data wel beter? Hij gelooft daar niet in, Big Data is helemaal niet nodig. Waarom is er minder aandacht? De systemen hebben er voor gezorgd dat het delen van data nu makkelijker is en er een toename van datastromen ontstaat, waarvan het grootste gedeelte onnodig is. Hierdoor worden we afgeleid van het echte werk. Waarom is het makkelijker geworden? Ja het is ook makkelijker om het goede te delen. In Vietnam viel deze overload aan data wel mee omdat het goed onder controle was met de document controller.
Root cause **Experienced personnel**	Root cause **Information overload**

Statement 7 Eens maar geldt niet voor het project omdat ...	Statement 8 Oneens en geldt niet voor het project omdat ...
Waarom? Globale interactie hangt samen met de mogelijkheden van technologische ontwikkeling. Die zijn wel ingezet tijdens het project maar tijdverschil is nog een groot obstakel als het gaat om globale interactie. Waarom is dat een groot obstakel? Op de ene plek zitten de specialisten terwijl het project aan de andere kant van de wereld zit. Daardoor verlies je eigenlijk gewoon een dag. Op elke plek is ook nog een eigen dataopslag waar de andere partij dan niet meteen bij kan. Waarom kan je daar niet meteen bij? Daar moet je toegang voor krijgen en sommige delen zijn alleen beschikbaar voor die locaties. Dan zoek ik contact met de eigenaar van het document ter plekke en vraag ik om toegang naar deze informatie. Waarom moet je dat zelf regelen? Ja het zou mooi zijn als dat allemaal vanzelf zou gaan maar zo werkt het niet. Je moet altijd zelf met een vraag komen om iets te verkrijgen. De computer is eigenlijk een dom ding en kan niet bepalen welke informatie jij echt nodig hebt. Waarom kan je dan toch wel die interactie zelf opzoeken? De middelen om contact op te nemen met collega's op andere kantoren zijn er wel maar die kunnen nog wel verbeterd worden.	Waarom? Nee er was geen standaardisatie in het project en dat zou ook niet mijn data-uitwisseling verbeteren. Waarom zou het niet je data uitwisseling verbeteren? De vraag is of het mogelijk is om alle datadeling wereldwijd af te kunnen stemmen en of het dan ook daadwerkelijk beter gaat werken. Het is al meer dan 100 jaar het geval dat elke partij met andere tools werkt en dat afstemming daarom nooit echt werkt. Waarom lukt het al die tijd al niet? We willen te snel en te groot. We moeten lokaal en incrementeel beginnen. Waarom moet het in kleine stappen worden gedaan? Als er in een keer een te grote verandering komt gaan mensen met hun hakken in het zand. De klant wil ook nog eens op hun eigen manier een project laten verlopen. Waarom gaan jullie wel mee met de klant? Je moet wel, we zijn dienstverlenend dus moeten luisteren naar wat de klant wil, maar ze ook advies geven.
Root cause **Confusing tools**	Root cause **Too fast changes**

Statement 9 Oneens en geldt niet voor het project omdat ...	Statement 10 Eens en geldt voor het project omdat ...
Waarom? Ik heb zelf weinig expertise dus hier kan ik weinig over zeggen. Ik ben zelf meer een gebruiker. Ik weet ook niet of ik zelf meer data zou willen delen. Het zou mij alleen maar meer afleiden van mijn hoofdtaken. Waarom zou dat je alleen maar afleiden? Je gaat meer delen omdat je meer data vergaart. Je hebt meer bagage om te delen dus dan ga je vanzelf ook meer delen. Niet alleen data vergroot maar er komen ook steeds meer contacten bij om data mee te delen. Maar uiteindelijk is dat niet onze core business. Waarom leidt dit van de core business af? Je hebt uiteindelijk specialisten nodig en daar wordt ook voor betaald. Waar het een klant uiteindelijk om gaat is dat het project afkomt, op welke manier dan ook. De kennis bij over datasystemen is ver te zoeken dus zij hebben ook weinig idee hoe dat bij ons werkt. Hoe zou het moeten? De specialisten meer het specialistisch werk laten doen en niet afleiden met randzaken. Tijdens een project wordt er in de beginfase te gedetailleerd gewerkt zonder dat de nodige informatie aanwezig is. Zo lopen de kosten op. Er wordt niet meer nagedacht. Alles wordt meteen in een programma gegooid.	Waarom? Ik probeer direct betrokken te raken met bepaalde personen met wie contact noodzakelijk is. Op die manier wordt het onderling delen van data makkelijker. Waarom zoek je de mensen op? Eindeloos data delen waar niemand op zit te wachten heeft geen nut. Het moet een efficiënte wisselwerking zijn tussen contacten. Persoonlijke band is hierbij erg belangrijk. Waarom is dat van belang? Het is belangrijk om te weten welke data belangrijk is voor bepaalde partijen. Wanneer er persoonlijk en fysiek contact is kan je dat beter inschatten en samenwerking. Hierdoor wordt data-uitwisseling beter. Waarom?
Root cause **Information overload**	Root cause **Physical presence**

Interview 9: C32 / X36

*Vietnamese respondent had difficulties providing extensive answers to the questions in English.

Statement 1 Agrees and applies to the project because …	Statement 2 Agrees but does not apply to the project because …
Why? There was a document controller that could help me with my data sharing. Why did that help you? She always shared the latest information within the project, so she was a central point of contact. Why? - Why? - Why? -	Why? There were no triggers from higher management that made me share more data during the project. Why were there no triggers from higher management? I think it was not a priority, so I just did my work like I was used to before. Why did you continue the same? That worked well for me and worked well for the project. Why? - Why? -
Root cause **Central point of contact**	Root cause **Missing drive to change**

Statement 3 Agrees and applies to the project because …	Statement 4 Agrees and applies to the project because …
Why? I would always ask the document controller or the project manager for the latest information if I needed anything. Why could you ask them? They both knew everything about the project, so that was the most reliable source for me. Why did flexibility help you with sharing data? I didn't really have anything to do with the flexibility of data sharing in the project. Why? I just did my work like I was used to before. Why? -	Why? I only had some BIM training during the project provided by the BIM team and that helped me to do my job. Why did that help you? BIM was new to me and I didn't know how to use it. The BIM team could explain that to me very well. Why did they explain well? They took the time and I could ask questions later. Why? - Why? -
Root cause **Simplicity in communication**	Root cause **Available coordination**

Statement 5 Agrees and applies to the project because …	Statement 6 Agrees and applies to the project because …
Why? The trust in our team is very high and we work with each other very closely. Why does that help you in sharing data? We work in the same space at the office and see each other almost every day. Therefore, we can help each other easily. Why can you help each other easily? We have a very good mix of very experienced employees and young employees who are eager to learn, and we do not feel any sharing barriers. Why? - Why? -	Why? I have always used Box or email during the project and that worked well for me to share data. Why does that work well? I was familiar with these tools and everybody used these tools too. Why did everybody used these tools? It was the quickest and easiest way to find information. Why? - Why? -
Root cause **Physical presence**	Root cause **Conveniently accessible tools**

Statement 7 Agrees but does not apply to the project because …	Statement 8 Agrees and applies to the project because …

Why? During the project I had no interaction with the office in the Netherlands or other offices. Why didn't you interact with them? That was not necessary for my work or the people from the Netherlands came to Vietnam to work here. Why did they come to the Netherlands? To easier exchange knowledge and work together on the project. Why did that increase your data sharing? That did not increase my data sharing.	Why? I work with the client standards in my work and I have a lot of experience with that so that helps me to efficiently share data that people require from me. Why does that help you to share data? I did a lot of brewery projects in the past, so I know what standards they want me to use. Why are standards useful? If I received new technical standards during the project from the client which made my work easier. Why does that make it easier? If I receive new information from them, I can use the new standards to understand what they share with me.
Root cause **Missing drive to change**	**Root cause** **Shared agreements**

Statement 9 **Agrees and applies to the project because …**	**Statement 10** **Agrees and applies to the project because …**
Why? My previous role in the design team improved my data sharing during the project. Why did that improve you data sharing? I can help the design team with their work and it also helps me to do my own work better as quantity surveyor. Why do you do that? I know well how to share data within my team and who to reach out to. Therefore, I do that often because I feel confident about it. Why? -	Why? I am very involved with the brewery team so I often must share information with them. Why does that increase you data sharing? I work closely together with the client team when there are technical changes or variation orders. I also travel to site to sit together with them. Why is that necessary? This makes it easier to work together and understand each other. Why? -
Root cause **Open and transparent**	**Root cause** **Physical presence**

Interview 10: C13 / X51

Statement 1 Eens en geldt voor het project omdat ...	Statement 2 Eens maar geldt niet voor het project omdat ...
Waarom? We hadden 2 centrale data systemen. SharePoint van de klant en Box tussen ontwerpteam, constructieteam en aannemers. Dat was enigszins centraal en up-to-date. Waarom hielp dit in het uitwisselen van data? De document controller zorgde dat outputdata op Box en op SharePoint kwamen. Er was niet 1 systeem maar de DC zorgde dat dit werd geïntegreerd. Zij was het centrale punt. Of ik vroeg direct aan mensen op site om info. Waarom werkte dit goed voor het delen van data? Voor Box werkte het goed want daar was zij ervaren mee en de controle en daardoor betrouwbaar. Voor SharePoint ben je nog afhankelijk waardoor er beperkingen kwamen. Waarom waren er beperkingen? Dit kwam door bepaalde rechten in SharePoint. Wij hadden soms niet overal toegang toe. Sommige nodige documenten waren dus niet te vinden omdat bleek dat wij geen toegang hadden gekregen. Waarom gebeurde dat? Ja dat kwam omdat mensen op verschillende plekken ([redacted] en op site) langs elkaar heen praten en werd het moeilijk om informatie boven water te halen.	Waarom? Nee ze hebben datadelen niet vergroot. Dit komt omdat deze initiatieven vanuit het project zelf geregeld worden en niet vanuit externe triggers. Waarom niet vanuit externe triggers? Die hebben zich er niet mee bemoeid omdat het op dat moment niet nodig was of een prioriteit was. We beseften onszelf dat we goed met onze projectdata moesten werken en het efficiënt delen daarvan. Waarom ga je er zelf mee aan de slag als projectteam? Omdat bij projecten er wel vaak een vraag wordt opgelegd door de klant. Toen Box nieuw was werd er wel door hoger management gepusht om het te gaan gebruiken. Waarom hebben nieuwe tools wel een push nodig? Ja, bekende dingen worden natuurlijk eerder gebruikt omdat mensen daar handiger in zijn. Omschakelen naar iets niets gaat niet vanzelf gebeuren. Waarom gebeurt dat niet vanzelf? Dat werkt hetzelfde in Vietnam als in Nederland of andere locaties. Nieuwe integratie van tools heeft tijd nodig.
Root cause **Central point of contact**	Root cause **Missing drive to change**

Statement 3 Eens en geldt voor het project omdat ...	Statement 4 Eens maar geldt niet voor het project omdat ...
Waarom? Bij Box is dit zeker het geval. Als het SharePoint systeem flexibeler was er ook wel meer data gedeeld. Waarom was Box zo flexibel en duidelijk? Je kan makkelijk verschillende mensen rechten tot bestanden. Je hebt een handige sync functie die synchroniseert Box met de server. Waarom was Box hierdoor duidelijk? Bepaalde basisstructuur die hetzelfde is voor elk project. Daarnaast kan je nog zelf mappen aanpassen en toevoegen. De hoofdopzet is dus wel bij elk project hetzelfde. Waarom? - Waarom? -	Waarom? Nee die ruimte was er niet. Daarnaast was het voor mij net per se nodig alleen was het handig geweest voor het gebruik van SharePoint. Waarom is het in sommigen gevallen handig en andere niet? Bij nieuwe tools heb je wel een goede introductie nodig als het nodig is om die tool te gebruiken. En er is meer nodig dan alleen een uitleg. Waarom is er meer nodig dan uitleg? Omdat je anders niet weet hoe je nieuwe tools echt moet gebruiken na enkel een introductie. Dat vraagt meer coördinatie. Waarom was dit niet tijdens het project? Er wordt niet over nagedacht en er is maar een klein aantal mensen die dit intensief gebruiken. Daarom was de noodzaak voor dit soort trainingen niet heel hoog. Waarom? -
Root cause **Adjustable structure**	Root cause **Lack of coordination**

Statement 5 Eens en geldt voor het project omdat ...	Statement 6 Eens en geldt voor het project omdat ...
Waarom? Ik wist dat de tekeningen altijd structureel op Box werden gezet. En daarnaast wist ik dat de persoon die dit deed dit ook secuur deed. Ik kon altijd vinden wat ik nodig had. Waarom kon je daar op goed vertrouwen? Ik wist van haar expertise hierin en hoorde ook van anderen dat dit goed gaat. Daardoor hoef je daar niet aan te twijfelen. Waarom is dat vertrouwen nodig? Het maakt het makkelijker met delegeren van werk of doorverwijzen als het vertrouwen goed is tussen je collega's. Je data-uitwisseling wordt daardoor niet meer maar wel beter. Waarom niet meer maar beter? Omdat je met vertrouwen er eigenlijk vanuit kan gaan dat anderen ook zelf data en informatie kunnen vinden. Je hoeft minder te controleren en dus minder uit te wisselen. Waarom? -	Waarom? Het systeem zorgt ervoor dat je sneller dingen uit kan wisselen. Het versturen en ontvangen gaat sneller en makkelijker wat meer impact heeft. Waarom gaat het makkelijker en sneller? Persoonlijk vind ik het makkelijker als je een common data environment hebt. Dan hoef je het zelf niet op te slaan maar de document controller dat voor je regelen. Waarom zorgt dat voor betere data-uitwisseling? Met mailen gaat dit minder goed omdat er dan te veel grote bijlages meekomen die zorgen dat je mailbox vol raakt en er duplicaten ontstaan op verschillende laptops. Waarom wordt er dan alsnog email gebruikt? Onofficiële documenten (vaak tussen engineers) gingen vaak via mail omdat dat sneller was dan via de document controller op Box. Ging dat goed in het project? Ja, je moet wel duidelijk zijn in welke informatie er via officiële kanalen moet gaan en welke niet. Het is belangrijk dat officiële data uiteindelijk traceerbaar is.
Root cause **Simplicity in communication**	Root cause **Conveniently accessible tools**

Statement 7 Eens en geldt voor het project omdat ...	Statement 8 Eens maar geldt niet voor het project omdat ...
Waarom? Zonder Skype was het globale contact bijna onmogelijk geweest. In het project hadden we veel contact met de klant en suppliers in Europa niet met het NL kantoor. Waarom maakte die interactie het mogelijk om data uit te wisselen? Je maakt makkelijk een afspraak en er stonden ook wekelijkse meetings ingepland via Skype. Waarom weinig contact met het NL kantoor? Zij deden weinig voor het project behalve de review van het conceptueel design en ondersteuning bij 3D coördinatie. Waarom? - Waarom? -	Waarom? Dat is globaal niet helemaal goed van de grond gekomen. Intern in Vietnam ging dit wel goed. De uitwisseling van data was erg consistent en daardoor beter. Waarom kwam dat globaal niet van de grond? Sommige nieuwe tools werden nog niet heel lang gebruikt dus dat liep minder. Ook voor de klant en de suppliers was er veel nieuw en daarom nog niet gestandaardiseerd. Waarom was dat nog niet zo? Dat heeft tijd nodig. Voor de volgende uitbreiding zijn we nu al onze protocollen en standaarden aan het delen. Waarom wordt dat nu al gedaan? Het is belangrijk dat dat aan het begin van een project gebeurt. In de vorige fase kregen we vaak niet het juiste bestandsformaat of foute oriëntatie omdat er gedurende het project standaarden veranderden en dan verlies je tijd. Waarom deel je dat met suppliers? Ja als het vanaf het begin wordt opgelegd dan kan het team zich erop voorbereiden. Maar we weten ook dat er sommige suppliers zijn die hier niet aan kunnen voldoen omdat ze niet de juiste programma's hebben. Er wordt aan een oplossing hiervoor gewerkt.
Root cause **Open and transparent**	Root cause **Wrong timing**

Statement 9 Eens en geldt voor het project omdat ...	Statement 10 Eens en geldt voor het project omdat ...
Waarom? Ja dit heeft bijgedragen. Met Box was ik heel bekend dus daar kon ik de weg perfect vinden. Daar heb ik andere mensen ook helpen om mee te gaan werken. Waarom was jij goed in het gebruiken van Box Ik ben het direct veel gaan gebruiken. Box was nieuw toen ik net bij RHDHV kwam dus was het ook mijn eerste systeem. Daarnaast kunnen de jongere collega's zich sowieso iets beter aanpassen met dit soort systemen. Waarom kunnen jongere zich beter trainen? Die hebben niet al jarenlange ervaring met andere manieren van werken en staan daardoor meer open voor nieuwe werkwijzen. Waarom heb je anderen kunnen helpen? Ik heb andere uitleg kunnen geven, omdat vooral veel Vietnamese collega's niet goed wisten hoe met Box om te gaan. Waarom heeft dat geholpen in de data-uitwisseling? Hierdoor konden meer mensen beter met Box werken. Dat scheelde voor iedereen onnodig dataverkeer over email wat minder efficiënt is.	Waarom? Ja, mijn betrokkenheid zorgde voor meer data delen van mijn kant omdat ik me dan verantwoordelijk voel voor een goed verloop van het project. Waarom voel je je dan verantwoordelijk? Vaak moesten er nog kleine zaken afgestemd worden waar ik dan bij kwam kijken. Er mistte informatie van de klant. Dit ga ik dan ophalen uit SharePoint omdat ik wil voorkomen dat hun tekortkomingen in werk ons problemen oplevert. Waarom heb je die verantwoordelijk genomen? Mijn rol was initieel de coördinatie tussen RHDHV kantoor en constructie. Er bleek ook meer coördinatie nodig tussen constructie, de klant en suppliers. Ik toen ben ingestapt. Waarom was dat nodig? Dat komt omdat men het lastig vindt om verder te kijken dan z'n eigen discipline. Dat geldt voor bijna elk team. Die verantwoordelijkheid blijft makkelijk bij de managers liggen. Was dat zo in het project? Ja, als ze zien dat iemand anders dit oppakt trekken ze sneller hun handen ervan af. Terwijl het ontwerpteam ook actief betrokken zou moeten blijven ook tijdens de bouw.
Root cause **Eager to learn**	Root cause **Feeling responsible**

F4. Interview findings

Table 49: Root causes defined per respondent, project and statement

Reading guide

Agree with statement and applies to me in the project because [Root cause of enabling factor]	Disagrees with statement but applies to me in the project because [Root cause of enabling factor]	Agrees with statement but does not apply to me in the project because [Root cause of limiting factor]	Disagrees with statement and does not apply to me in the project because [Root cause of limiting factor]

STATEMENTS ABOUT DATA SHARING IMPROVEMENT

	#	Interviewees	Role	1 Accessibility	2 Incentives	3 Practicality	4 Development	5 Trust	6 Impact	7 Interaction	8 Alignment	9 *Expertise*	10 *Involvement*
PROJECT A	1	A18/ B32/ C45/ X79	D (visible)	Pushing deadlines	Lack of coordination	Simplicity in communica-tion	Eager to learn	Physical presence	Lack of commitment	Missing budget	Shared agreements	Eager to learn	Physical presence
	2	A20/ B18/ C44/ X20	PDM (visible)	Missing skills	Missing drive to change	Adjustable structure	Pushing deadlines	Simplicity in communica-tion	Information overload	Fast problem solving	Taking small steps	Missing work speed	Feeling responsible
	3	A2/ X35	D (peri-pheral)	Too much effort	Missing drive to change	conveniently accessible tools	Missing drive to change	Open and transparent	Integration of work	Open and transparent	Shared agreements	Open and transparent	Pushing deadlines
PROJECT B	4	A4/ B3/ C46/ X69	PDM (central)	Too fast changes	Shared goals	Information overload	Competitive advantage	Experienced personnel	Simplicity in communica-tion	Fast problem solving	Shared agreements	Missing work speed	Feeling responsible
	5	B30/ C8/ X84	E (peri-pheral)	Central point of contact	Competitive advantage	Available budget	Missing budget	Physical presence	Simplicity in communica-tion	Fast problem solving	Integration of work	Eager to learn	Feeling responsible
	6	B19/ X73	S (peri-pheral)	Conveniently accessible tools	Wrong timing	Adjustable structure	Eager to learn	Experienced personnel	Collective commitment	Conveniently accessible tools	Shared agreements	Feeling responsible	Central point of contact
PROJECT C	7	A7/ B5/ C2/ X21	PDM (central)	Central point of contact	Too fast changes	Adjustable structure	Lack of coordination	Experienced personnel	Central point of contact	Simplicity in communica-tion	Simplicity in communica-tion	Eager to learn	Feeling responsible
	8	A5/ C42/ X70	E (peri-pheral)	Central point of contact	Missing drive to change	Adjustable structure	Missing skills	Experienced personnel	Information overload	Confusing tools	Too fast changes	Information overload	Physical presence
	9	C32/ X36	C (peri-pheral)	Central point of contact	Missing drive to change	Simplicity in communica-tion	Available coordination	Physical presence	Conveniently accessible tools	Missing drive to change	Shared agreements	Open and transparent	Physical presence
	10	C13/ X51	CM (peri-pheral)	Central point of contact	Missing drive to change	Adjustable structure	Lack of coordination	Simplicity in communica-tion	Conveniently accessible tools	Open and transparent	Wrong timing	Eager to learn	Feeling responsible

G. DISCUSSION

G1. Overview of all data sharing factors

Table 50: Overview of all data sharing factors

	Total	Impact on data sharing	Acts as enabling/ limiting factor	Identified in theory/practice
1	Operation ability by information infrastructure accessibility	High	Enabling	Both
2	Change management and digital governance	High	Enabling/Limiting	Practice
3	Competitive market causing faster project delivery	Medium	Enabling/Limiting	Both
4	Misunderstanding due to cultural differences	Unknown	Not confirmed in this research	Theory
5	Increasing detail and dynamic project complexity	Low	Enabling	Both
6	Distinct cultural perceptions of capabilities and mentality	Unknown	Not confirmed in this research	Theory
7	Economic costs and investments in infrastructure, training & coordination	Low	Limiting	Both
8	Employees' skills and experience	Medium	Enabling/Limiting	Both
9	Extrinsic motivation by external rewarding or incentives	High	Limiting	Both
10	Global affiliation and integration of teams	Medium	Enabling/Limiting	Both
11	Global awareness of remote activity and communication	Unknown	Not confirmed in this research	Theory
12	Institution authority by developing information sharing infrastructure	Low	Enabling	Both
13	Institution authority by establishing legal frameworks and formal policy	Unknown	Not confirmed in this research	Theory
14	Intra-organizational relationships between employees	Medium	Enabling	Both
15	Intrinsic motivation by individuals own incentives	Medium	Enabling/Limiting	Both
16	Perception of control and overview of data streams	High	Enabling/Limiting	Both
17	Organizational compatibility of systems and files	Low	Enabling	Both
18	Perception of information security	Unknown	Not confirmed in this research	Theory
19	Perception of personal lack of time and work pressure	Medium	Limiting	Both
20	Personal demographic details	Unknown	Not confirmed in this research	Theory
21	Role specifications and role responsibilities	Medium	Enabling	Both